Background Statement for SEMI Draft Document 5556B
Line Item Revision to SEMI S2-0715, Environmental, Health, and Safety Guideline for Semiconductor Manufacturing Equipment Revision to §19 "Seismic Protection" (In Delayed Effective Date Format)

Notice: This background statement is not part of the balloted item. It is provided solely to assist the recipient in reaching an informed decision based on the rationale of the activity that preceded the creation of this Document.

Notice: Recipients of this Document are invited to submit, with their comments, notification of any relevant patented technology or copyrighted items of which they are aware and to provide supporting documentation. In this context, "patented technology" is defined as technology for which a patent has issued or has been applied for. In the latter case, only publicly available information on the contents of the patent application is to be provided.

Note: Additions are indicated by underline and deletions are indicated by ~~strikethrough~~.

Note: Proposed NOTEs will be numbered sequentially within SEMI S2 and the present NOTESs in SEMI S2 will be renumbered as necessary.

Background Statement

The Seismic Protection Task Force proposes the line item change to SEMI S2-0715.

[History]
At the start of this revision activity, majority of global EH&S community seemed to think unanimously that the current seismic forces should be updated as the UBC, which was basis for current criteria, had expired. It was originally agreed, as a result of discussions within Japan and with other regions, that those seismic force values should be updated to the most stringent set of seismic force calculation criteria among applicable local requirements (e.g., regulations, Standards) for regions in which known semiconductor manufacturing sites are located.
TF found, however, that any single requirement of any region, (e.g., ASCE < US>, European, Taiwan, Japan) couldn't satisfy above condition as each requirement is based on different assumptions and equations. While the highest calculated value of horizontal force is obtained by calculation based on one of those regional requirements, the highest vertical force may be obtained by calculation based on another of them.
Furthermore, while current S2 criteria don't give highest value for horizontal or vertical force, it is consistently high enough for both directions. Considering the fact that no equipment that was designed and anchored in accordance with current S2 seismic protection criteria was reported to be overturned or significantly moved relatively to the floor in recent three major earthquakes experienced in Japan (i.e., Great Hanshin-Awaji Earthquake, Niigata Chuetsu Earthquake and Great East Japan Earthquake), each of which significantly affected area including locations of volume production semiconductor fabs, the TF was convinced that S2 should be regarded as a field proven criteria.

[5556A result and this ballot]
As described in “History”, the TF decided to keep all of seismic force values of current S2 on the basis of “field proven”.
As the result of the Ballot responses, however, shown discontent on this TF decision for the vertical seismic force value and its deliberation, TF decided to update the vertical value and its base assumption in this Ballot,
Japan TF has reviewed all negatives, comments and incorporated their updated responses into this version 5556B.

The ballot results will be reviewed and adjudicated at the meetings indicated in the table below. Check www.semi.org/standards under Calendar of Events for the latest update.

Line Item 1 Revision to §19 “Seismic Protection”
Part A Revision to “§19 Seismic Protection”
Part B Revision to “Related Information 4 Seismic Protection”

Review and Adjudication Information

	Task Force Review	**Committee Adjudication**
Group:	Seismic protection Task Force	Japan TC Chapter of EH&S Global Technical Committee
Date:	Wednesday June.15, 2016	Tuesday June. 28, 2016
Time & Timezone:	13:30- JST	08:00- 18:00 JST
Location:	SEMI Japan, Tokyo Office	SEMI Japan, Tokyo Office
City, State/Country:	Kudan-Minami, Chiyoda-ku, Tokyo, Japan	Kudan-Minami, Chiyoda-ku, Tokyo, Japan
Leader(s):	Naokatsu Nishiguchi (SCREEN Business Support Solutions) SBT.nnishiguchi@screen.co.jp	Supika Mashiro (Tokyo Electron) Hidetoshi Sakura (Intel) Moray Crawford (Hatsuta)
Standards Staff:	Junko Collins jcollins@semi.org	Junko Collins jcollins@semi.org

Task Force Review meeting’s details are subject to change, and additional review sessions may be scheduled if necessary.
Contact the task force leader or Standards staff for confirmation.

If you will not be able to attend these meetings in person but would like to participate by telephone/web, please contact Standards staff.

Safety Checklist for SEMI Draft Document 5556B
Line Item Revision to SEMI S2-0715, Environmental, Health, and Safety Guideline for Semiconductor Manufacturing Equipment
Revisions to §19 "Seismic Protection"
(In Delayed Effective Date Format)

Developing/Revising Body

Name/Type: Seismic Protection Task Force
Technical Committee: Environment Health & Safety (EHS)
Region: Japan

Leadership

Position	*Last*	*First*	*Affiliation*
Leader	Nishiguchi	Naokatsu	SCREEN Business Support Solutions

Documents, Conflicts, and Consideration

Safety related codes, standards, and practices used in developing the safety guideline, and the manner in which each item was considered by the technical committee

# and Title	*Manner of Consideration*
ASCE 7-10- Minimum Design Load for Buildings and Other Structures	*Used as an example of RI of Seismic protection*
TBC- Taiwan Building Code	*Used as an example of RI of Seismic protection*
UBC-Uniform Building Code	*Used as an example of RI of Seismic protection*
Seismic Design and Construction Guideline for Building Equipment	*Used as an example of RI of Seismic protection*

Known inconsistencies between the safety guideline and any other safety related codes, standards, and practices cited in the safety guideline

# and Title	*Inconsistency with This Safety Guideline*

Other conflicts with known codes, standards, and practices or with commonly accepted safety and health principles to the extent practical

# and Title	*Nature of Conflict with This Safety Guideline*

Participants and Contributors

Last	First	Affiliation
Austin	Lindy	Salus Engineering
Aihara	Hisashi	Office Aihara
Barsky	Joseph	TUV Rheiniand
Choi	Joyce	Nordson
Choo	Choong Huat	Seagate
Costuros	Ted	Applied Materials
Crane	Lauren	KLA-Tencor
Crawford	Moray	Hatsuta
Crocket	Alan	KLA-Tencor
Derbyshire	Pauline	TUV SUD
Ergete	Nigusu	Intertek GS[3]
Evanston	Chris	Salus Engineering
Faust	Bruce	TUV SUD America
Fessler	Mark	TEL
Frankfurth	Mark	Cymer
Giles	Andrew	ESTEC
Greenberg	Cliff	Nikon Precision
Hamilton	Jeff	TEL
Hayford	James	AMAT
Hobbs	Duncan	Seagate
Holbrook	Glernn	TUV SUD
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Jumper	Steve	Applied Materials
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Kiley	Andrew	Applied Materials
Klug	Wolfgang	TUV Rheinland Germany
Krauss	Josh	EHS[2]
Krauss	Mark	EHS[2]
Larsen	Sean	Lam Research
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The content requirements of this checklist are documented in Section 14.2 of the *Regulations Governing SEMI Standards Committees.*

SEMI Draft Document #5556B
Line Item Revision to SEMI S2-0715, Environmental, Health, and Safety Guideline for Semiconductor Manufacturing Equipment Delayed Revision to §19 "Seismic Protection"

This Safety Guideline was technically approved by the global Environmental Health & Safety Technical Committee. This edition was approved for publication by the global Audits and Reviews Subcommittee on December 4, 2015. Available at www.semiviews.org and www.semi.org in January 2016; originally published in 1991; previously published July 2015.

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

NOTICE: This Document contains material that has been balloted and approved by the Environmental Health & Safety Global Technical Committee, but is not immediately effective. This material and the date on which it becomes effective are included in Delayed Revisions Sections 1 & 2. The provisions of this information are not an authoritative part of the Document until their effective dates. The main body of SEMI S2-0715 remains the authoritative version. Some or all of the provisions of revisions not yet in effect may optionally be applied prior to the effective date, providing they do not conflict with portions of the authoritative version other than those that are to be revised or replaced as part of the deferred change, and are labeled accordingly. Material that is to be replaced by revisions that are not yet in effect is preceded by a NOTICE indicating its status.

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.

2 Scope

2.1 *Applicability* — This Safety Guideline applies to equipment used to manufacture, measure, assemble, and test semiconductor products.

NOTE 1: The list of section numbers and their titles that were shown in ¶ 2.2 in previous revisions of SEMI S2 have been relocated to the front of the main part of the Document into the Table of Contents.

2.2 *Precedence of Sectional Requirements* — In the case of conflict between provisions in different sections of this Safety Guideline, the section or subsection specifically addressing the technical issue takes precedence over the more general section or subsection.

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

3 Limitations

3.1 This Safety Guideline is 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.

3.2 It is not the philosophy of this Safety Guideline to provide all of the detailed EHS design criteria that may be applied to semiconductor manufacturing equipment. This Safety 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.

3.3 This Safety Guideline is not intended to be applied retroactively.

3.3.1 Equipment models with redesigns that significantly affect the EHS aspects of the equipment should conform to the latest version of SEMI S2.

3.3.2 Models and subsystems that have been assessed to a previous version of SEMI S2 should continue to meet the previous version, or meet a more recently published version, and are not intended to be subject to the provisions of this version.

3.4 In many cases, references to standards have been incorporated into this Safety Guideline. These references do not imply applicability of the entire standards, but only of the sections referenced.

4 Referenced Standards and Documents

4.1 *SEMI Standards and Safety Guidelines*

SEMI E6 — Guide for Semiconductor Equipment Installation Documentation

SEMI F5 — Guide for Gaseous Effluent Handling

SEMI F14 — Guide for the Design of Gas Source Equipment Enclosures

SEMI F15 — Test Method for Enclosures Using Sulfur Hexafluoride Tracer Gas and Gas Chromatography – Has Been Moved to SEMI S6

SEMI S1 — Safety Guideline for Equipment Safety Labels

SEMI S3 — Safety Guideline for Process Liquid Heating Systems

SEMI S6 — EHS Guideline for Exhaust Ventilation of Semiconductor Manufacturing Equipment

SEMI S7 — Safety Guideline for Evaluating Personnel and Evaluating Company Qualifications

SEMI S8 — Safety Guidelines for Ergonomics Engineering of Semiconductor Manufacturing Equipment

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

SEMI S12 — Environmental, Health and Safety Guideline for Manufacturing Equipment Decontamination

SEMI S13 — Environmental, Health and Safety Guideline for Documents Provided to the Equipment User for Use with Manufacturing Equipment

SEMI S14 — Safety Guidelines for Fire Risk Assessment and Mitigation for Semiconductor Manufacturing Equipment

SEMI S22 — Safety Guideline for the Electrical Design of Semiconductor Manufacturing Equipment

4.2 *ANSI Standards*[1]

ANSI/RIA R15.06 — Industrial Robots and Robot Systems – Safety Requirements

ANSI/ISA 84.00.01 — Functional Safety: Safety Instrumented Systems for the Process Industry Sector

4.3 *CEN/CENELEC Standards*[2]

CEN EN 775 — Manipulating Industrial Robots – Safety

CEN EN 1050 — Safety of Machinery – Principles of Risk Assessment

CEN EN 1127-1 — Explosive Atmospheres – Explosion Prevention and Protection – Part 1: Basic Concepts and Methodology

4.4 *DIN Standards*[3]

DIN V VDE 0801 — Principles for Computers in Safety-Related Systems

4.5 *IEC Standards*[4]

[1] American National Standards Institute, 25 West 43rd Street, New York, NY 10036, USA; Telephone: 212.642.4900, Fax: 212.398.0023, http://www.ansi.org

[2] European Committee for Standardization, Avenue Marnix 17, B-1000 Brussels; Telephone: 32.2.550.08.11, Fax: 32.2.550.08.19, http://www.cen.eu

[3] Deutsches Institut für Normung e.V., Available from Beuth Verlag GmbH, Burggrafenstrasse 4-10, D-10787 Berlin, Germany; http://www.din.de

IEC 60825-1 — Safety of Laser Products – Part 1: Equipment Classification, Requirements

IEC 61010-1 — Safety Requirements for Electrical Equipment for Measurement, Control, and Laboratory Use – Part 1: General Requirements

IEC 61508 — Functional Safety of Electrical/Electronic/Programmable Electronic Safety-Related Systems

4.6 *IEEE Standards*[5]

IEEE C95.1 — Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 300 GHz

4.7 *ISO Standards*[6]

ISO 2415 — Forged Shackles for General Lifting Purposes Dee Shackles and Bow Shackles

ISO 10218-1 — Robots and Robotic Devices – Safety Requirements for Industrial Robots – Part 1: Robots

ISO 13849-1 — Safety of Machinery – Safety-Related Parts of Control Systems – Part 1: General Principles for Design

4.8 *NFPA Standards*[7]

NFPA 12 — Standard on Carbon Dioxide Extinguishing Systems

NFPA 13 — Standard for the Installation of Sprinkler Systems

NFPA 72 — National Fire Alarm and Signaling Code

NFPA 497 — Recommended Practice for the Classification of Flammable Liquids, Gases, or Vapors and of Hazardous (Classified) Locations for Electrical Installations in Chemical Process Areas

NFPA 704 — Standard System for the Identification of the Hazards of Materials for Emergency Response

NFPA 2001 — Standard on Clean Agent Fire Extinguishing Systems

4.9 *Underwriters Laboratories Standards*[8]

UL 508A — Standard for Industrial Control Panel

4.10 *US Code of Federal Regulations*[9]

21 CFR Parts 1000-1050 — Food and Drug Administration/Center for Devices and Radiological Health (FDA/CDRH), Performance Standards for Electronic Products, Title 21 Code of Federal Regulations, Parts 1000-1050

4.11 *Other Standards and Documents*

ACGIH, Industrial Ventilation Manual[10]

ASHRAE Standard 110 — Method of Testing Performance of Laboratory Fume Hoods[11]

Burton, D.J., Semiconductor Exhaust Ventilation Guidebook[12]

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[4] International Electrotechnical Commission, 3 rue de Varembé, Case Postale 131, CH-1211 Geneva 20, Switzerland; Telephone: 41.22.919.02.11, Fax: 41.22.919.03.00, http://www.iec.ch

[5] Institute of Electrical and Electronics Engineers, 3 Park Avenue, 17th Floor, New York, NY 10016-5997, USA; Telephone: 212.419.7900, Fax: 212.752.4929, http://www.ieee.org

[6] International Organization for Standardization, ISO Central Secretariat, 1, ch. de la Voie-Creuse, CP 56, CH-1211 Geneva 20, Switzerland; Telephone: 41.22.749.01.11, Fax: 41.22.733.34.30, http://www.iso.org

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

[8] Underwriters Laboratory, 2600 N.W. Lake Road, Camas, WA 98607-8542, USA; Telephone: 877.854.3577, Fax: 360.817.6278, http://www.ul.com

[9] United States Food and Drug Administration/ Center for Devices and Radiological Health (FDA/CDRH). Available from FDA/CDRH; http://www.accessdata.fda.gov/scripts/cdrh/cfdocs/cfcfr/cfrsearch.cfm

[10] ACGIH, 1330 Kemper Meadow Road, Cincinnati, OH 45240, USA. http://www.acgih.org

[11] ASHRAE, 1791 Tullie Circle, NE, Atlanta, GE 30329, USA. http://www.ashrae.org

Uniform Building Code™ (UBC)[13]

Uniform Fire Code™[14]

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

5 Terminology

NOTICE: § 5 will be revised upon the July 2018 publication as shown in Delayed Revisions Section 2. The Environmental Health & Safety Global Technical Committee has voted that the revision is OPTIONAL before the Effective Date.

5.1 *Abbreviations and Acronyms*

5.1.1 *ACGIH®* — American Conference of Governmental Industrial Hygienists (ACGIH is a registered trademark of the American Conference of Governmental Industrial Hygienists.)

5.1.2 *ASHRAE* — American Society of Heating, Refrigeration, and Air Conditioning Engineers

5.1.3 *MPE* — maximum permissible exposure

5.1.4 *NOHD* — nominal ocular hazard distance

5.2 *Definitions*

NOTE 2: Composite reports using portions of reports based upon earlier versions of SEMI S2 and SEMI S10 may require understanding of the SEMI S2-0703 or SEMI S10-1296 definitions for the terms hazard, likelihood, mishap, severity, and risk.

5.2.1 *abort switch* — a switch that, when activated, interrupts the activation sequence of a fire detection or fire suppression system.

5.2.2 *accredited testing laboratory* — an independent organization dedicated to the testing of components, devices, or systems that is recognized by a governmental or regulatory body as competent to perform evaluations based on established safety standards.

5.2.3 *baseline* — for the purposes of this Document, ‘baseline’ refers to operating conditions, including process chemistry, for which the equipment was designed and manufactured.

5.2.4 *breathing zone* — imaginary globe, of 600 mm (2 ft.) radius, surrounding the head.

5.2.5 *capture velocity* — the air velocity that at any point in front of the exhausted hood or at the exhausted hood opening is necessary to overcome opposing air currents and to capture the contaminated air at that point by causing it to flow into the exhausted hood.

5.2.6 *carcinogen* — confirmed or suspected human cancer-causing agent as defined by the International Agency for Research on Cancer (IARC) or other recognized entities.

5.2.7 *chemical distribution system* — the collection of subsystems and components used in a semiconductor manufacturing facility to control and deliver process chemicals from source to point of use for wafer manufacturing processes.

5.2.8 *cleanroom* — a room in which the concentration of airborne particles is controlled to specific limits.

5.2.9 *combustible material* — for the purpose of this Safety Guideline, a combustible material is any material that does propagate flame (beyond the ignition zone with or without the continued application of the ignition source) and does not meet the definition in this section for noncombustible material. See also the definition for *noncombustible material*.

5.2.10 *equipment* — a specific piece of machinery, apparatus, process module, or device used to execute an operation. The term ‘equipment’ does not apply to any product (e.g., substrates, semiconductors) that may be damaged as a result of equipment failure.

[12] IVE, Inc., 2974 South Oakwood, Bountiful, UT 84010, USA. http://www.eburton.com

[13] International Conference of Building Officials, 5360 Workman Mill Road, Whittier, CA 90601-2298, USA. http://www.icbo.org

[14] International Fire Code Institute, 5360 Workman Mill Road, Whittier, CA 90601-2298, USA. http://www.ifci.org

5.2.11 *face velocity* — velocity at the cross-sectional entrance to the exhausted hood.

5.2.12 *facilitization* — the provision of facilities or services.

5.2.13 *fail-safe* — designed so that a failure does not result in an increased risk.

NOTE 3: For example, a fail-safe temperature limiting device would indicate an out-of-control temperature if it were to fail. This might interrupt a process, but would be preferable to the device indicating that the temperature is within the control limits, regardless of the actual temperature, in case of a failure.

5.2.14 *fail-to-safe equipment control system (FECS)* — a safety-related programmable system of control circuits designed and implemented for safety functions in accordance with recognized standards such as ISO 13849-1 (EN 954-1) or IEC 61508, ANSI/ISA84.00.01. These systems (e.g., safety programmable logic controller (PLC), safety-related input and output (I/O) modules) diagnose internal and external faults and react upon detected faults in a controlled manner in order to bring the equipment to a safe state.

NOTE 4: A FECS is a subsystem to a programmable electronic system (PES) as defined in IEC 61508-4 Definitions.

NOTE 5: Related Information 13 provides additional information on applications of FECS design.

5.2.15 *failure* — the termination of the ability of an item to perform a required function. Failure is an event, as distinguished from ‘fault,’ which is a state.

5.2.16 *fault* — the state of an item characterized by inability to perform a required function, excluding the inability during preventive maintenance or other planned actions, or due to lack of external resources.

5.2.17 *fault-tolerant* — designed so that a reasonably foreseeable single point failure does not result in an unsafe condition.

5.2.18 *flammable gas* — any gas that forms an ignitable mixture in air at 20°C (68°F) and 101.3 kPa (14.7 psia).

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

5.2.20 *flash point* — the minimum temperature at which a liquid gives off sufficient vapor to form an ignitable mixture with air near the surface of the liquid, or within the test vessel used.

5.2.21 *gas cylinder cabinet* — cabinet used for housing gas cylinders, and connected to gas distribution piping or to equipment using the gas. Synonym: gas cabinet.

5.2.22 *gas panel* — an arrangement of fluid handling components (e.g., valves, filters, mass flow controllers) that regulates the flow of fluids into the process. Synonyms: gas jungle, jungle, gas control valves, valve manifold.

5.2.23 *gas panel enclosure* — an enclosure designed to contain leaks from gas panel(s) within itself. Synonyms: jungle enclosure, gas box, valve manifold box.

5.2.24 *harm* — physical injury or damage to health of people, or damage to equipment, buildings, or environments.

5.2.25 *hazard* — condition that has the potential to cause harm.

5.2.26 *hazardous electrical power* — power levels equal to or greater than 240 VA.

5.2.27 *hazardous production material (HPM)* — a solid, liquid, or gas that has a degree-of-hazard rating in health, flammability, or reactivity of class 3 or 4 as ranked by NFPA 704 and which is used directly in research, laboratory, or production processes that have as their end product materials that are not hazardous.

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

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

5.2.29 *hinged load* — a load supported by a hinge such that the hinge axis is not vertical.

5.2.30 *hood* — in the context of § 22of this Safety Guideline, ‘hood’ means a shaped inlet designed to capture contaminated air and conduct it into an exhaust duct system.

5.2.31 *incompatible* — as applied to chemicals: in the context of § 23 of this Safety Guideline, describes chemicals that, when combined unintentionally, may react violently or in an uncontrolled manner, releasing energy that may create a hazardous condition.

5.2.32 *intended reaction product* — chemicals that are produced intentionally as a functional part of the semiconductor manufacturing process.

5.2.33 *interlock* — a mechanical, electrical or other type of device or system, the purpose of which is to prevent or interrupt the operation of specified machine elements under specified conditions.

5.2.34 *ionizing radiation* — alpha particles, beta particles, gamma rays, X-rays, neutrons, high-speed electrons, high-speed protons, and other particles capable of producing ions in human tissue.

5.2.35 *laser* — any device that can be made to produce or amplify electromagnetic radiation in the wavelength range from 180 nm to 1 mm primarily by the process of controlled stimulated emission.

5.2.36 *laser product* — any product or assembly of components that constitutes, incorporates, or is intended to incorporate a laser or laser system (including laser diode), and that is not sold to another manufacturer for use as a component (or replacement for such component) of an electronic product.

5.2.37 *laser source* — any device intended for use in conjunction with a laser to supply energy for the excitation of electrons, ions, or molecules. General energy sources, such as electrical supply mains, should not be considered to be laser energy sources.

5.2.38 *laser system* — a laser in combination with an appropriate laser energy source, with or without additional incorporated components.

5.2.39 *lifting accessory* — a component (e.g., eyehook, shackle, hoist ring, wire rope, chain, or eyebolt) which is part of a lifting fixture or is attached directly between the lifting device and the load in order to lift it.

5.2.40 *lifting device* — a mechanical or electro-mechanical structure that *is* provided for the purpose of raising and lowering a load during maintenance or service tasks, and *may be* capable of moving the load in one or more horizontal directions.

5.2.41 *lifting equipment* — lifting devices, lifting fixtures and lifting accessories.

5.2.42 *lifting fixture* — a mechanical device or an assembly of lifting accessories (e.g., hoisting yoke, wire rope sling, webbing sling, or chain assembly) placed between the lifting device (but not permanently attached to it) and the load, in order to attach them to each other.

5.2.43 *likelihood* — the expected frequency with which harm will occur. Usually expressed as a rate (e.g., events per year, per product, or per substrate processed).

5.2.44 *local exhaust ventilation* — local exhaust ventilation systems operate on the principle of capturing a contaminant at or near its source and moving the contaminant to the external environment, usually through an air cleaning or a destructive device. It is not to be confused with laminar flow ventilation. Synonyms: LEV, local exhaust, main exhaust, extraction system, module exhaust, individual exhaust.

5.2.45 *lower explosive limit* — the minimum concentration of vapor in air at which propagation of flame will occur in the presence of an ignition source. Synonyms: LEL, lower flammability limit (LFL).

5.2.46 *maintenance* — planned or unplanned activities intended to keep equipment in good working order. See also the definition for *service.*

5.2.47 *mass balance* — a qualitative, and where possible, quantitative, specification of mass flow of input and output streams (including chemicals, gases, water, de-ionized water, compressed air, nitrogen, and by-products), in sufficient detail to determine the effluent characteristics and potential treatment options.

5.2.48 *material safety data sheet (MSDS)* — written or printed material concerning chemical elements and compounds, including hazardous materials, prepared in accordance with applicable standards.

5.2.49 *maximum permissible exposure (MPE)* — level of laser radiation to which, under normal circumstances, persons may be exposed without suffering adverse effects.

5.2.50 *nominal ocular hazard distance (NOHD)* — distance at which the beam irradiance or radiant exposure equals the appropriate corneal maximum permissible exposure (MPE).

NOTE 7: Examples of such standards are USA government regulation 29 CFR 1910.1200, and Canadian WHMIS (Workplace Hazardous Material Information System).

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

5.2.52 *non-ionizing radiation* — forms of electro-magnetic energy that do not possess sufficient energy to ionize human tissue by means of the interaction of a single photon of any given frequency with human tissue. Non-ionizing radiation is customarily identified by frequencies from zero hertz to 3×10^{15} hertz (wavelengths ranging from infinite to 100 nm). This includes: static fields (frequencies of 0 hertz and infinite wavelengths); extremely low frequency fields (ELF), which includes power frequencies; sub radio-frequencies; radiofrequency/microwave energy; and infrared, visible, and ultraviolet energies.

5.2.53 *non-recycling, deadman-type abort switch* — a type of abort switch that must be constantly held closed for the abort of the fire detection or suppression system. In addition, it does not restart or interrupt any time delay sequence for the detection or suppression system when it is activated.

5.2.54 *occupational exposure limits (OELs)* — for the purpose of this Document, OELs are generally established on the basis of an eight hour workday. Various terms are used to refer to OELs, such as permissible exposure levels, Threshold Limit Values®, maximum acceptable concentrations, maximum exposure limits, and occupational exposure standards. However, the criteria used in determining OELs can differ among the various countries that have established values. Refer to the national bodies responsible for the establishment of OELs. (Threshold Limit Value is a registered trademark of the American Conference of Governmental Industrial Hygienists.)

5.2.55 *operator* — a person who interacts with the equipment only to the degree necessary for the equipment to perform its intended function.

5.2.56 *parts-cleaning hood* — exhausted hood used for the purpose of cleaning parts or equipment. Synonym: equipment cleaning hood.

5.2.57 *placed on the market* — made physically available, regardless of the legal aspects of the act of transfer (loan, gift, sale, hire).

5.2.58 *positive-opening* — as applied to electromechanical control devices. The achievement of contact separation as a direct result of a specified movement of the switch actuator through non-resilient members (i.e., contact separation is not dependent upon springs).

5.2.59 *potentially hazardous non-ionizing radiation emissions* — for the purposes of this Safety Guideline, non-ionizing radiation emissions outside the limits shown in Appendix 4 are considered potentially hazardous.

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

5.2.61 *radio frequency (rf)* — electromagnetic energy with frequencies ranging from 3 kHz to 300 GHz. Microwaves are a portion of rf extending from 300 MHz to 300 GHz.

5.2.62 *readily accessible* — capable of being reached quickly for operation or inspection, without requiring climbing over or removing obstacles, or using portable ladders, chairs, etc.

5.2.63 *recognized* — as applied to standards; agreed to, accepted, and practiced by a substantial international consensus.

5.2.64 *rem* — unit of dose equivalent. Most instruments used to measure ionizing radiation read in dose equivalent (rems or sieverts). 1 rem = 0.01 sievert.

5.2.65 *reproductive toxicants* — chemicals that are confirmed or suspected to cause statistically significant increased risk for teratogenicity, developmental effects, or adverse effects on embryo viability or on male or female reproductive function at doses that are not considered otherwise maternally or paternally toxic.

5.2.66 *residual* — as applied to risks or hazards: that which remains after engineering, administrative, and work practice controls have been implemented.

5.2.67 *risk* — the expected magnitude of losses from a hazard, expressed in terms of severity and likelihood.

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

5.2.69 *safety critical part* — discrete device or component, such as used in a power or safety circuit, whose proper operation is necessary to the safe performance of the system or circuit.

5.2.70 *service* — unplanned activities intended to return equipment that has failed to good working order. See also the definition for *maintenance.*

5.2.71 *severity* — the extent of potential credible harm.

5.2.72 *short circuit current rating* — the maximum available current to which an equipment supply circuit is intended, by the equipment manufacturer, to be connected.

NOTE 8: Short circuit current rating for an electrical system is typically based on the analysis of short circuit current ratings of the components within the system. See UL 508A and Related Information 2 of SEMI S22 for methods of determining short circuit rating.

5.2.73 *sievert (Sv)* — unit of dose equivalent. Most instruments used to measure ionizing radiation read in dose equivalent (rems or sieverts). 1 Sv = 100 rems.

5.2.74 *standard temperature and pressure* — for ventilation measurements, either dry air at 21°C (70°F) and 760 mm (29.92 inches) Hg, or air at 50% relative humidity, 20°C (68°F), and 760 mm (29.92 inches) Hg.

5.2.75 *supervisory alarm* — as applied to fire detection or suppression systems; an alarm indicating a supervisory condition.

5.2.76 *supervisory condition* — as applied to fire detection or suppression systems; condition in which action or maintenance is needed to restore or continue proper function.

5.2.77 *supplemental exhaust* — local exhaust ventilation that is used intermittently for a specific task of finite duration.

5.2.78 *supplier* — party that provides equipment to, and directly communicates with, the user. A supplier may be a manufacturer, an equipment distributor, or an equipment representative. See also the definition for *user*.

5.2.79 *testing* — the term ‘testing’ is used to describe measurements or observations used to validate and document conformance to designated criteria.

5.2.80 *trouble alarm* — as applied to fire detection or suppression systems; an alarm indicating a trouble condition.

5.2.81 *trouble condition* — as applied to fire detection or suppression systems; a condition in which there is a fault in a system, subsystem, or component that may interfere with proper function.

5.2.82 *user* — party that acquires equipment for the purpose of using it to manufacture semiconductors. See also the definition for *supplier*.

5.2.83 *velocity pressure (VP)* — the pressure required to accelerate air from zero velocity to some velocity V. Velocity pressure is proportional to the kinetic energy of the air stream. Associated equation:

$$VP = (V/4.043)^2 \qquad (1)$$

where:

V = air velocity in m/s

VP = velocity pressure in mm water gauge (w.g.)

$$\text{U.S. units: } VP = (V/4005)^2 \qquad (2)$$

where:

V = velocity in feet per second

VP = velocity pressure in inches water gauge (w.g.)

5.2.84 *volumetric flow rate (Q)* — in the context of § 22 of this Safety Guideline, *Q* = the volume of air exhausted per unit time. Associated equation:

$$Q = VA \tag{3}$$

where:

V = air flow velocity

A = the cross-sectional area of the duct or opening through which the air is flowing at standard conditions.

5.2.85 *wet station* — open surface tanks, enclosed in a housing, containing chemical materials used in the manufacturing of semiconductor materials. Synonyms: wet sink, wet bench, wet deck.

5.2.86 *yield strength* — the stress at which a material exhibits a specified permanent deformation or set. This is the stress at which, the strain departs from the linear portion of the stress-strain curve by an offset unit strain of 0.002.[15]

6 Safety Philosophy

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).

6.2 The assumption is made that operators, maintenance personnel, and service personnel are trained in the tasks that they are intended to perform.

6.3 The following should be considered in the design and construction of equipment:

- regulatory requirements;
- industry standards;
- this Safety Guideline; and
- good engineering and manufacturing practices.

6.4 This Safety 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.

6.5 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 9: The intent is to control single fault conditions that result in significant risks (i.e., Very High, High, or Medium risks based on the example risk assessment matrix in SEMI S10).

NOTE 10: The risk category of 'Very High' corresponds identically to the risk category, used in previous SEMI Documents (e.g., SEMI S10-1296, SEMI S2, and SEMI S14) of 'Critical.' The term was changed to facilitate translation from English.

6.6 Equipment safety features should be fail-safe or of a fault-tolerant design and construction.

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.

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;

[15] *Roark's Formulas for Stress and Strain,* Seventh Edition, McGraw-Hill (2002): p. 826.

- the probability of occurrence and severity of harm;
- 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 11: CEN EN 1050 contains examples of hazard analysis methods.

NOTE 12: The term mishap was replaced with the results of harm in the SEMI S10-1103 revision.

NOTE 13: Related Information 15 provides some discussion of safety considerations related to equipment remote control.

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 *Design to Eliminate Hazards* — From the initial concept phase, the supplier should design to eliminate hazards.

NOTE 14: It is recommended that the supplier continue to work to eliminate identified hazards.

6.9.2 *Incorporate Safety Devices* — 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 15: It is recommended that provisions be made for periodic functional checks of safety devices, when applicable.

6.9.3 *Provide Warning Devices* — 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 *Provide Hazard Alert Labels* — Where it is impractical to eliminate hazards through design selection or adequately reduce the associated risk with safety or warning devices, hazard alert labels should be provided. See § 10 for label information.

6.9.5 *Develop Administrative Procedures and Training* — Where hazards are not eliminated through design selection or adequately controlled with safety or warning devices or hazard alert 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.

7 General Provisions

8 Evaluation Process

9 Documents Provided to User

10 Hazard Alert Labels

11 Safety Interlock Systems

12 Emergency Shutdown

13 Electrical Design

14 Fire Protection

15 Process Liquid Heating Systems

16 Ergonomics and Human Factors

17 Hazardous Energy Isolation

18 Mechanical Design

Line Item 1 Revision to §19 "Seismic Protection" (Effective July 2018) Part A Revision to "§19 Seismic Protection"

19 Seismic Protection

NOTE 117: 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.~~ The specific forces experienced by a piece of equipment during a seismic event will depend largely on building design, installation details, and specific local ground conditions.

NOTE XXX: Preventing all damage to equipment during a particular seismic event is generally considered impractical. Nonetheless, it is useful if the design of the equipment limits the failure of parts that might result in unacceptable risk to personnel and the environment. These criteria are intended to accomplish two things:

1. Guide equipment suppliers to identify and correctly design the internal frame and components critical to controlling risk if the equipment is subject to anticipated seismic forces; and
2. Identify the equipment information needed by users to appropriately secure the equipment within their facility.

NOTE XXX: The user might require more stringent design criteria than what are given here because of increased site vulnerability (e.g., local soil conditions and building design may produce significantly higher accelerations), alternate installation scenarios, or local regulatory requirements.

19.1 *General* — The equipment should be designed ~~to control~~ so that if it is anchored as specified in the documentation provided to the equipment user, and it experiences anticipated seismic forces, it will not overturn, and no parts will fail or yield such that there would be a ~~the~~ risk of injury to personnel, or adverse environmental impact of Medium or higher per SEMI S10.~~, equipment and facility damage due to movement, overturning, or leakage of chemicals (including liquid splashing), during a seismic event. The design should also control equipment damage due to failure of fragile parts (e.g., quartzware, ceramics) during a seismic event.~~

NOTE XXX: Section 19.2 contains criteria for anticipated forces.

~~NOTE 118: These criteria are intended to accomplish two things:~~

~~1. allow equipment suppliers to correctly design the internal frame and components to withstand seismic forces; and~~
~~2. allow equipment designers to provide end-users with the information needed to appropriately secure the equipment within their facility.~~

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).~~ The determination of such parts should include consideration of potential equipment movement and overturning, leakage of chemicals (including fluid lines breaking and liquids splashing), failure of fragile parts (e.g., quartzware, ceramics) or cantilevered parts, hazardous materials release, fire, and projectiles.

~~NOTE 119: It is recommended that the hazard analysis described in § 6.8 be used to evaluate both the risk of part failure and the effectiveness of control measures.~~

19.1.1.1 Such ~~These~~ parts should be accessible for visual evaluation of damage.

NOTE 120: SEMI S8 contains guidelines for maintainability and serviceability; these may be used to ~~determine~~ estimate sufficient accessibility.

19.1.2 Structurally independent modules are modules which react to seismic forces independently and do not transfer the forces to adjacent modules. They should be assessed independently.

19.1.3 Structurally dependent modules are modules which transfer the forces to each other. They should be assessed together.

NOTE XXX: Because the modules of cluster tools tend to have a complicated support structure, it is recommended that they be assessed for seismic protection and anchoring measures by qualified engineers.

NOTE XXX: SEMI S7 §8 highlights qualifications of personnel capable of reviewing and validating calculations or test results. A person may be qualified to perform such calculations by: education in mechanical, structural, civil, seismic, or architectural engineering; being licensed or certified as PE (USA), Chartered (UK), or Eur Ing (EU) or equivalent; or experience in design, construction, and analysis of such structures.

19.1.4 The equipment should be considered in the condition it is anticipated to be in during normal operation and with all facilities operating normally, when and after the seismic forces are experienced.

19.1.5 The equipment supplier should indicate in the documents provided to the equipment user which facilities are necessary to limit risk to the level stated in ¶19.1.

19.1.6 The seismic forces should be considered acting on the equipment's center of gravity.

19.2 *Anticipated Seismic Forces Design Loads* — The seismic forces anticipated to be experienced by the equipment (see ¶19.1) should be at least the following: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 force equal to 94% of the weight of the equipment, acting at the equipment's center of mass.

19.2.2 For equipment not containing HPMs, the equipment should be designed to withstand a horizontal loading of force equal to 63% of the weight of the equipment, acting at the equipment's center of mass.

NOTE 121: 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 67% of the weight of the equipment for equipment containing HPMs and 74% of the weight of the equipment for equipment not containing HPMs should be used to resist the overturning moment. When calculating for overturning, a maximum value of 85% of the weight of the equipment should be used to resist the overturning moment.

NOTE XXX: See Related Information 4 for a discussion of how the values were selected. The lighter effective weight is the worst case when calculating the overturning moment.

NOTE 122: 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. It is recommended that interested parties consult a qualified mechanical, civil, or structural engineer to determine building code requirements for a particular location. RI 4 contains examples of seismic force criteria in various world regions.

NOTE XXX: The above minimum anticipated seismic forces are based on requirements for rigid manufacturing or process equipment constructed of high-deformability materials and installed mid height in the fab, and are intended to be sufficient for the basic safety goals of SEMI S2.

NOTE 123: 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 §§ 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 § 9.

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

- Acceptable locations on the equipment frame for anchorage.

NOTE 124: 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 intended by the supplier to limit equipment motion during a seismic event should be clearly identified by direct labelling on the equipment..

NOTE 125: It is not the intent of SEMI S2 that the supplier provide the seismic attachment point hardware. Such hardware may be provided as agreed upon between supplier and user.

NOTE 126: It is the responsibility of the user to verify that the vibration isolation, leveling, seismic reinforcing, and load distribution is adequate.

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

APPENDIX 1
DESIGN GUIDELINES FOR EQUIPMENT USING LIQUID CHEMICALS — Design and Test Method Supplement Intended for Internal and Third Party Evaluation Use

APPENDIX 2
IONIZING RADIATION TEST VALIDATION — Design and Test Method Supplement Intended for Internal and Third Party Evaluation Use

APPENDIX 3
EXPOSURE CRITERIA AND TEST METHODS FOR NON-IONIZING RADIATION (OTHER THAN LASER) AND ELECTROMAGNETIC FIELDS

APPENDIX 4
FIRE PROTECTION: FLOWCHART FOR SELECTING MATERIALS OF CONSTRUCTION

APPENDIX 5
LASER DATA SHEET — SEMI S2

RELATED INFORMATION 1
EQUIPMENT/PRODUCT SAFETY PROGRAM
RELATED INFORMATION 2
ADDITIONAL STANDARDS THAT MAY BE HELPFUL
RELATED INFORMATION 3
EMO REACH CONSIDERATIONS

RELATED INFORMATION 4
SEISMIC PROTECTION

NOTICE: This Related Information is not an official part of SEMI S2 and was derived from the work of the global Environmental Health & Safety Technical Committee. This Related Information was approved for publication by full letter ballot procedures on October 21, 1999.

R4-1 Seismic Protection Checklist

Supporting Review Criteria for Seismic Protection of Related Components

If the answer to Questions A.1 or A.2 is 'No,' or the answer to any other of these questions in the checklist is 'Yes,' then a detailed analysis may need to be performed by a structural or mechanical engineer.

A. Equipment Anchorage

1. Have lateral force and overturning calculations been performed (see example)?
   ❑ Yes ❑ No Comments:

2. Are all modules fastened at a minimum of four points and can the fasteners support the forces identified in question 1 above?
   ❑ Yes ❑ No Comments:

3. Is it possible that there could be excessive seismic anchor movements that could result in relative displacements between points of support or attachment of the components (e.g., between vessels, pipe supports, main headers, etc.)?
   ❑ Yes ❑ No Comments:

4. Is there inadequate horizontal support?
   ❑ Yes ❑ No Comments:

5. Is there inadequate vertical supports and/or insufficient lateral restraints?
   ❑ Yes ❑ No Comments:

6. Are support fasteners inappropriately secured?
   ❑ Yes ❑ No Comments:

7. Is there inadequate anchorage of attached equipment?
   ❑ Yes ❑ No Comments:

NOTE 176: One way of judging whether supports, fasteners, or anchorages are 'inadequate' or 'inappropriately secured' is to determine whether their stress levels under seismic loading stay below the allowable stress levels set by building code. Such allowable stress levels are typically a fraction <1 of the yield strength.

B. Equipment Assembly, Installation and Operation

1. Are the materials of construction of the components susceptible to seismic damage?
   ❑ Yes ❑ No Comments:

2. Are there significant cyclic operational loading conditions that may substantially reduce system fatigue life?
   ❑ Yes ❑ No Comments:

3. Are there any threaded connections, flange joints, or special fittings?
❑ Yes ❑ No Comments:

4. If answer to Question 4 is 'Yes,' are these connections, joints, or special fittings in high stress locations?
❑ Yes ❑ No Comments:

5. Are there short or rigid spans that cannot accommodate the relative displacement of the supports (e.g., piping spanning between two structural systems)? Is hazardous gas piping provided with a 'pigtail' (i.e., spiral) or bent 3 times (z, y, and z direction) to absorb 3-dimensional displacements?
❑ Yes ❑ No Comments:

6. Are there large, unsupported masses (e.g., valves) attached to components?
❑ Yes ❑ No Comments:

7. Are there any welded attachments to thin wall components?
❑ Yes ❑ No Comments:

8. Could any sensitive equipment (e.g., control valves) be affected?
❑ Yes ❑ No Comments:

C. Seismic Interactions

1. Are there any points where seismically induced interaction with other elements, structures, systems, or components could damage the components (e.g., impact, falling objects, etc.)?
❑ Yes ❑ No Comments:

2. Could there be displacements from inertial effects?
❑ Yes ❑ No Comments:

LETTER BALLOT

Line Item 1 Revision to §19 "Seismic Protection" (Effective July 2018) Part B Revision to "Related Information 4 Seismic Protection"

R4-2 Derivation of § 19, Seismic Load Guidelines

R4-2.1 The horizontal loadings(F_p) of 94% and 63% of the equipment weight (W_p), found in § 19.2.1 and § 19.2.2, were based on following assumptions for factors in the design lateral force formula 32-2 in § 1632.2 of the 1997 Uniform Building Code (UBC):

- a_p = 1.0 (i.e., treat the equipment as a rigid structure)
- C_a = 0.44(1.2) 0.53 (i.e., seismic zone 4, soil profile type S_D, and site 5 km from a seismic source type A)
- I_p = 1.0 and 1.5 for non-HPM and HPM equipment, respectively (see Table 16-K)
- h_x/h_r = 0.5 (i.e., equipment attached at point halfway between grade elevation and roof elevation)
- R_p = 1.5 (i.e., shallow anchor bolts). , not from Table 16-K but §1632.2 explanation of R_p

$$F_P = \frac{a_p C_a I_p}{R_p}\left(1 + 3\left(\frac{h_x}{h_r}\right)\right) W_p \qquad \text{(R4-1)}$$

~~Starting with equation 32-2, letting I_p = 1.5, and substituting the above values:~~

- ~~$F_{p\,(ultimate)}$ = [(1.0 × 0.44(1.2) × 1.5)/1.5] [1 + 3(0.5)] W_p~~

~~= [0.44(1.2)] [1 + 1.5] W_p~~
~~= [0.528] [2.5] W_p~~
~~= [1.32] W_p~~

~~NOTE 177: This number is now adjusted from ultimate strength loading to yield strength loading by dividing by 1.4:~~

- ~~$F_{p\,(yield)}$ = $F_{p\,(ultimate)}$/1.4~~

~~= [1.32]/1.4 W_p~~
~~= [0.94] W_p~~

~~And for I_p = 1.0,~~

- ~~$F_{p\,(yield)}$ = [.94] [1.0/1.5] W_p~~

~~= [.63] W_p~~

~~Notes re-selection of a_p value of 1.0:~~

- ~~Table 16-O of 1997 UBC, line 3.C., was interpreted to read: 'Any *flexible* equipment...'~~
- ~~in structural terms, the structure of typical semiconductor equipment is considered 'rigid.'~~

R4-2.2 *Assumptions Used for Above Derivation*

R4-2.2.1 Regarding the selection of 1.0 as the value for a_p – Table 16-O of the 1997 UBC assigns values of a_p depending on the type of building component under consideration. Line 3-B is for electrical, mechanical and plumbing equipment which generally describes semiconductor manufacturing equipment, as is assigned an a_p value of 1.0. Line 3-C is the only line in the equipment group (3) that is assigned an a_p value greater than 1.0. Since this 3-C line is applicable to "Any flexible equipment..." and in structural terms, typical semiconductor equipment was considered to be rigid rather than flexible in structural terms. Per 1997 UBC §1634.3, rigid structures have a period less than 0.06 seconds (i.e. a natural frequency greater than 16.67 Hz).

R4-2.2.2 Regarding the selection of 0.53 as the value for C_a – Table 16-Q of the 1997 UBC gives values for C_a based on Soil Profile Type (selected as S_D, Stiff Soil Profile, see Table 16-J), and Seismic Zone Factor (selected as 0.4 - determined from Seismic Zone 4 per the map in Figure 16-2 and Table 16-I). From those values, Table 16-Q indicates the value of C_a to be $0.44N_a$, where N_a, the Near Source Factor, is 1.2, per Table 16-S based on a Seismic Source Type selected as A ("Faults that are capable of producing large magnitude events and that have a high rate of seismic activity" from Table 16-U) and a distance to the seismic source, selected as 5 km. Thus C_a = 0.44 x 1.2 = 0.53.

R4-2.2.3 Because typical semiconductor equipment is considered rigid, a frequency response analysis was not considered to be necessary.

R4-2.2.4 Assuming when the ground and building is accelerating downward, the lessened equipment weight load is symmetrical to the additional weight load when the ground is accelerating upward, the worst case (i.e. the least) amount of equipment weight available to oppose an overturning force would, be 67% of W and 74% of W for HPM and non-HPM equipment, respectively. ~~Seismic waves typically have vertical as well as horizontal components associated with them; however, these components typically arrive out of phase (i.e., they do not reach maximum values simultaneously). The vertical component serves to, in effect, reduce the amount of equipment mass that is available to resist overturning or toppling. The task force chose to take this into account by limiting the calculated weight available to resist overturning to 85% of the weight of the equipment. An alternate method, not chosen by the task force, could have been to simultaneously apply a vertical (Z) force.~~

NOTE XXX: In 2016 the S2 Seismic task force reviewed the worst case conditions for opposing the overturning force on equipment and decided to assume, that the vertical and horizontal seismic waves will be at their maximum, worst case values at the same time, and to provide values for the HPM and non-HPM cases separately.

~~R4-3 Source for Examples of Seismic Anchorage Details~~

~~R4-3.1 Detailed illustrations of examples of seismic anchorage details were developed by Working Group #9 of the Japan 300 mm ('J300') effort, and were printed in their Report No. 9 in the *2nd Lecture, ICs Factory Design for 300 mm Wafer Line Standardizing Study, December, 1996.*~~

~~R4-3.2 *Design Example (refer to Figure R4-1 for illustration of example)*~~

~~R4-3.2.1 Disclaimer: the calculations below are not a complete seismic analysis. A complete analysis might also include such things as: stress distribution through a multiple fastener connection; prying action; bearing stress; simultaneous combined stresses on the fasteners; and a review of weld geometry. A complete seismic analysis should be done by a qualified engineer.~~

R4-3 Examples of Seismic Design Loads Based on Standards and Codes Applicable for Some of the Known Semiconductor Manufacturing Locations

NOTE XXX: The examples in R4-3.1, R4-3.2, and R4-3.3 are only rough approximation of the calculations and analysis required. Refer to the specific standards and codes for a complete understanding of how to apply them.

NOTE XXX: It was the intention of the Japan Seismic Protection TF to include values of seismic protection design loads and supporting formula applicable in Europe, but they were unable to identify adequate references for this revision.

R4-3.1 United States using American Society of Civil Engineers (ASCE) 7-10

R4-3.1.1 The horizontal seismic design force, F_p, is derived from the following equations and variables (see ASCE 7-10 equations 13.3-1, 13.3-2, and 13.3-3). The semiconductor manufacturing equipment is considered a nonstructural building component:

$$F_P = \frac{0.4\, a_P\, S_{DS}\, W_P}{\left(\frac{R_P}{I_P}\right)}\left(1 + 2\frac{z}{h}\right) \qquad \text{(R4-2)}$$

F_p is not required to be taken as greater than:

$$F_P = 1.6 \cdot S_{DS} \cdot I_P \cdot W_P \qquad \text{(R4-3)}$$

and F_p should not be taken as less than:

$$F_P = 0.3 \cdot S_{DS} \cdot I_P \cdot W_P \qquad \text{(R4-4)}$$

where:
S_{DS} = design, 5 percent damped, spectral response acceleration parameter at short periods (see ASCE7-10 §11.4.4)
S_{DS} is given by (see ASCE 7-10 equations 11.4-1 and 11.4-3)
$S_{DS}=2/3*F_a*S_S$
S_s shall be in accordance with Section 11.4.1, but need not be taken larger than 1.5, according to ASCE 7-10 Section12.14.8.1.
Therefore, the maximum value of S_{DS} becomes "S_{DS}=2/3*1*1.5=1" from ASCE 7-10 Table11.4-1.
"S_{DS}=1" is considered to be the most conservative value to be applied for equipment installed in the U.S.

a_p = component amplification factor. Manufacturing and process equipment is assigned a value of 1.0 (see ASCE7-10 Table 13.6-1)
R_P= component response modification factor. Manufacturing and process equipment is assigned a value of 2.5 (see ASCE7-10 Table 13.6-1)
I_P = component importance factor. Generally speaking, equipment that contains toxic or explosive substances is assigned a value of 1.5, and a value of 1.0 otherwise (see ASCE 7-10 §13.1.3)
W_P = operating weight of the component
z = Height in structure at point of attachment of component with respect to the base
h = Average roof height of structure with respect to the base

R4-3.1.1.1 Generally process equipment is considered rigid. For flexible equipment a_p would be assigned a value of 2.5 see ASCE7-10 Table 13.6-1). According to ASCE 7-10 §11.2, a flexible component is a nonstructural component having a fundamental period greater than 0.06 s, and a rigid component is a nonstructural component having a fundamental period less than or equal to 0.06 s.

R4-3.1.1.2 The vertical seismic design force is given in the text of ASCE7-10 § 13.3.1 and should be considered a concurrent force = ±0.2 S_{DS} W_P.

R4-3.2 Taiwan using the Taiwan Building Code (TBC)

R4-3.2.1 The horizontal seismic design force, F_{ph} is derived from the following equations and variables (see equations 4-1a, 4-1b, and 4-1c). The semiconductor manufacturing equipment is considered a nonstructural building component:

$$F_{ph} = 0.4\, S_{DS}\, I_p\, \frac{a_p}{R_{pa}} \cdot (1 + 2\, h_x/h_n) \cdot W_p \qquad \text{(R4-5)}$$

where F_{ph} is not required to be taken as greater than:

$$F_{ph} = 1.6 \cdot S_{DS} \cdot I_P \cdot W_P \qquad \text{(R4-6)}$$

and F_{ph} should not be taken as less than:

$$F_{ph} = 0.3 \cdot S_{DS} \cdot I_P \cdot W_P \qquad \text{(R4-7)}$$

and where
S_{DS} = design, 5 percent damped, spectral response acceleration parameter at short periods
a_p = component amplification factor. General process equipment is assigned a value of 1.0 (see TBC Table 4-2)
R_{pa} = allowable seismic response reduction factor
I_p = component importance factor (1.5 for life safety related equipment or equipment with toxic or flammable materials; 1.0 for others)
W_P = component operating weight
h_x = distance between the foundation and the floor on which the component is located
h_n = distance between the foundation and the roof

R4-3.2.2 S_{DS} is given by:

$$S_{DS} = F_a\, S_S^D \qquad \text{(R4-8)}$$

where
S_S^D = design horizontal response acceleration coefficients for site with short natural period from TBC Table 2-1. Values include: Hsinchu generally 0.6 to 0.8; Hsinchu science park 0.7 to 0.8; Taichung 0.7 to 0.8; Tainan 0.7 to 0.8
F_a = amplification factor of site response acceleration spectrum from TBC Table 2-2(a). Values range from 1.0 to 1.2.depending on the site soil profile category (firm, normal, or soft) and the value of S_S^D

R4-3.2.3 R_{pa} is given by:

$$R_{pa} = 1 + \frac{R_p - 1}{1.5}$$

$$= 1 + (2.5 - 1)/1.5 = 2 \qquad \text{(R4-9)}$$

where R_p for general process equipment is assigned a value of 2.5 (see TBC Table 4-2)

R4-3.2.4 The vertical seismic load, F_{pv} is given by:

$$F_{pv} = \frac{1}{2} F_{ph} \quad \text{(R4-10)}$$

for general sites or the Taipei Basin, or

$$F_{pv} = \frac{2}{3} F_{ph} \quad \text{(R4-11)}$$

for sites near fault zones (e.g. 2 km or less).

R4-3.3 Japan using "Seismic Design and Construction Guideline for Building Equipment" — In Japan, there are several guidelines for non-structural elements of buildings (also called as 'building equipment'). One of the more commonly used guidelines is the "Seismic Design and Construction Guideline for Building Equipment" published by Building Center of Japan (BCJ). It conforms to the Building Standard Law of Japan and has been adopted as a jurisdictional requirement for building construction. The sufficiency of the criteria in the Guideline has been field-proven in several large earthquakes in Japan of greater than '6-Lower' intensity per the Japan Meteorological Agency (JMA) seismic intensity scale. This example uses the so-called "Local Earthquake Intensity Method" from the Guideline. The guideline is titled "建築設備耐震設計・施工指針" in Japanese. There is no official English translation available. The translation "Seismic Design and Construction Guideline for Building Equipment" and other translation of terms and descriptions were provided by the Japan Seismic Protection TF. They are intended to be reasonably understandable and adequate.

R4-3.3.1 The design horizontal seismic force F_H (acting on the equipment center of gravity) is given by:

$$F_H = K_H \cdot W \quad \text{(R4-12)}$$

where

K_H = Design horizontal seismic intensity
W = Equipment Operational Weight (in kilonewton – kN)

When the design vertical seismic force F_v need to be considered:

$$F_V = K_V \cdot W \quad \text{(R4-13)}$$

$$K_V = \frac{1}{2} K_H \quad \text{(R4-14)}$$

where
K_V =the design vertical seismic intensity

As general building structure other than seismically isolated structure is required of dynamic analysis, Design horizontal seismic intensity (K_H) is given by:

$$K_H = Z \cdot K_S \quad \text{(R4-15)}$$

where
K_S =Standard design seismic intensity
Z = Regional coefficient (see Figure R4-1). For most of semiconductor manufacturing locations in Japan this value is 1.0.

R4-3.3.2 K_S is selected based on the location of the equipment in the building, and the desired Class of seismic resistance (see Table R4-1). Generally speaking, users ask semiconductor manufacturing equipment to be Class A. There are also particular values applied when the equipment is a water tank in the basement or on the first floor.

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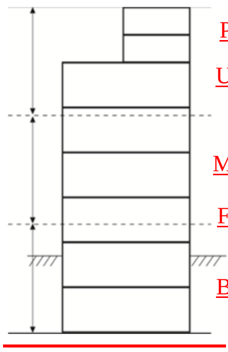
Table R4-1 Standard Design Seismic Intensity (KS)

Floor location#1	Seismic Resistance Class S#2	Seismic Resistance Class A#2	Seismic Resistance Class B#2	Illustration of floor locations#1
Upper Floors、Roof or Penthouse	2.0	1.5	1.0	
Middle Floors	1.5	1.0	0.6	
First Floor or Basement	1.0 (1.5)#3	0.6 (1.0)#3	0.4 (0.6)#3	



#1 Floor Locations
'Upper Floors' means:
・The top floor of a two to six story building,
・The top floor and the next to the top floor of a seven to nine story building.
'Middle Floors' means:
・All the floors except for the Basement, First Floor and Upper Floors.
#2 Seismic Resistance Class (See Table R4-2 for the meaning of each class) is selected based on the followings:
・The Seismic Resistance Class is to be selected for equipment considering its function during or after severe earthquakes.
・The Seismic Resistance Class for equipment on vibration isolation devices is to be selected as Class A or Class S.
#3 The values within parentheses apply to water tanks

Table R4-2 Meaning of Seismic Resistance Class

Seismic Resistance Class	Meaning
S	Human safety is assured and secondary damage prevented after a major earthquake. All functions are maintained securely without major repairs.
A	Human safety is assured and secondary damage prevented after a major earthquake. Important functions are maintained securely without major repairs.
B	Human safety is assured and secondary damage prevented after a major Earthquake.

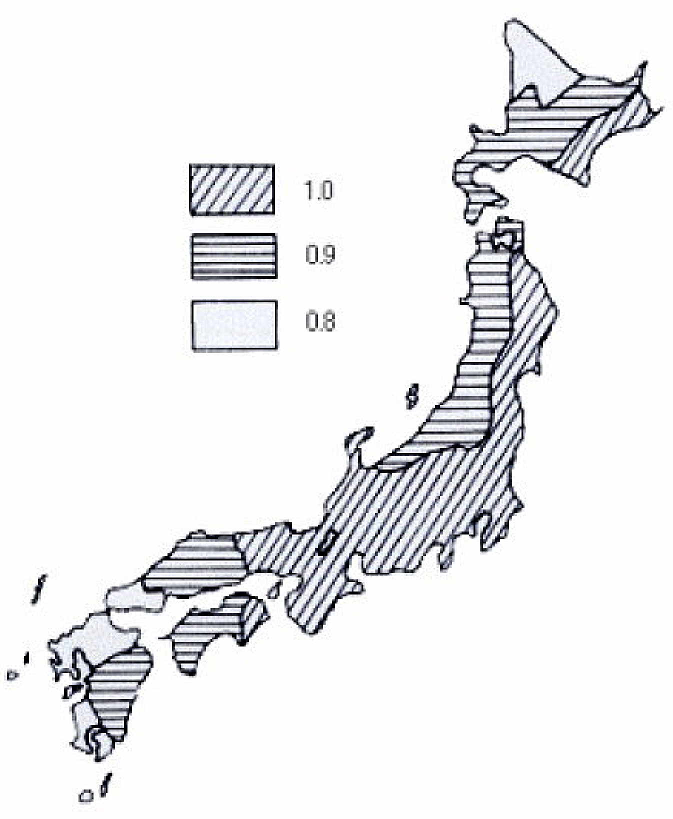
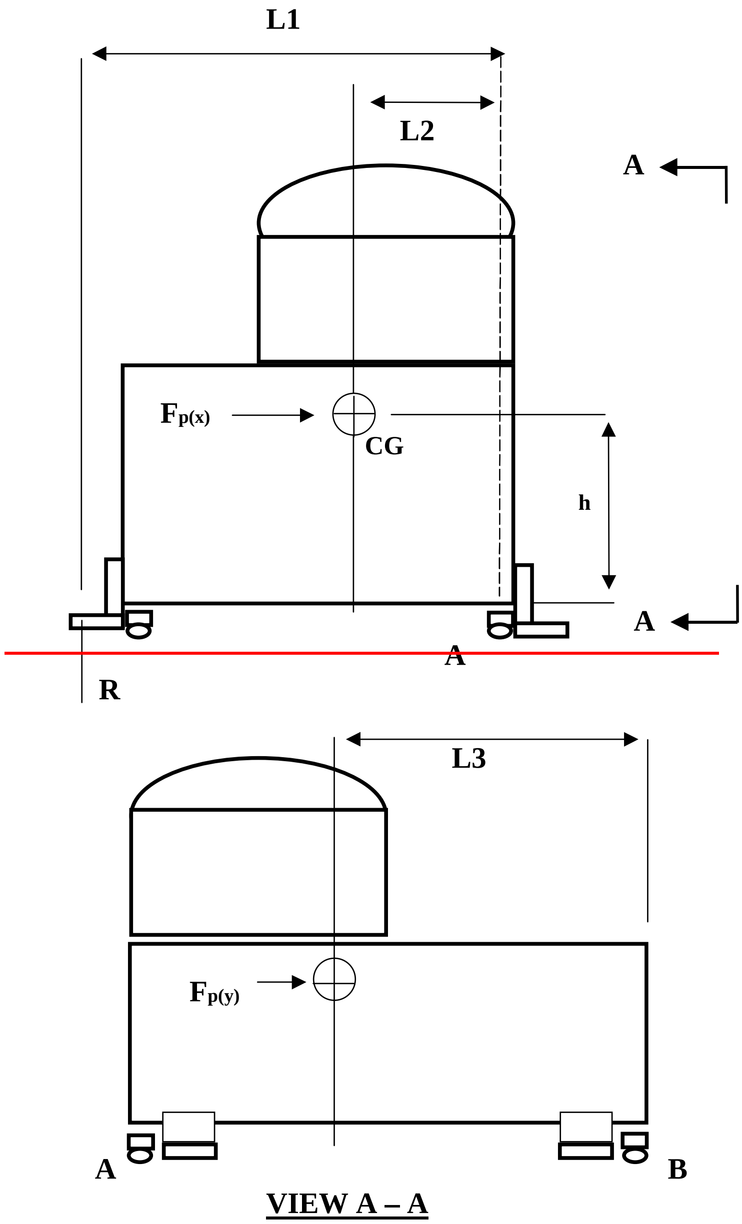


Figure R4-1 Map of Regional Coefficients, Z, in Japan

~~R4-4 Calculation of Lateral Force~~

~~R4-4.1 Lateral force on each leg is equal to F_p/# of legs = F_p/4~~

~~R4-4.2 The lateral force acts as shear on the floor anchor fasteners and shear or tensile loading on the equipment anchor fasteners depending upon orientation. The actual reactions of the fasteners should be calculated by a qualified engineer.~~



~~Figure R4-1~~
~~Design Example~~

R4-4 Example Calculation of Lateral Force and Vertical Force on Equipment Anchor Bolts

R4-4.1 The following calculations are not a complete seismic analysis. A complete analysis include such things as: stress distribution through a multiple-fastener connection; prying action; bearing stress; simultaneous combined stresses on the fasteners; and a review of weld geometry. A complete seismic analysis should be done by a qualified engineer.

R4-4.2 This is a generic example. It assumes a box shaped piece of equipment anchored by N bolts distributed evenly on two opposite sides of the box, n bolts on each side.

LETTER BALLOT

R4-4.3 The maximum anticipated horizontal force (F_H) and vertical force (F_V) acting simultaneously on the center of gravity of the equipment will come from the selected regional requirement or the minimum values given in §19.2.

NOTE XXX: The force values used in the following calculation are the minimum values for equipment containing HPMs given in §19.2.

R4-4.4 Figures R4-2 and R4-3 illustrate the key factors of the calculation. Table R4-3 explains the key variables and provides example values for the calculation.

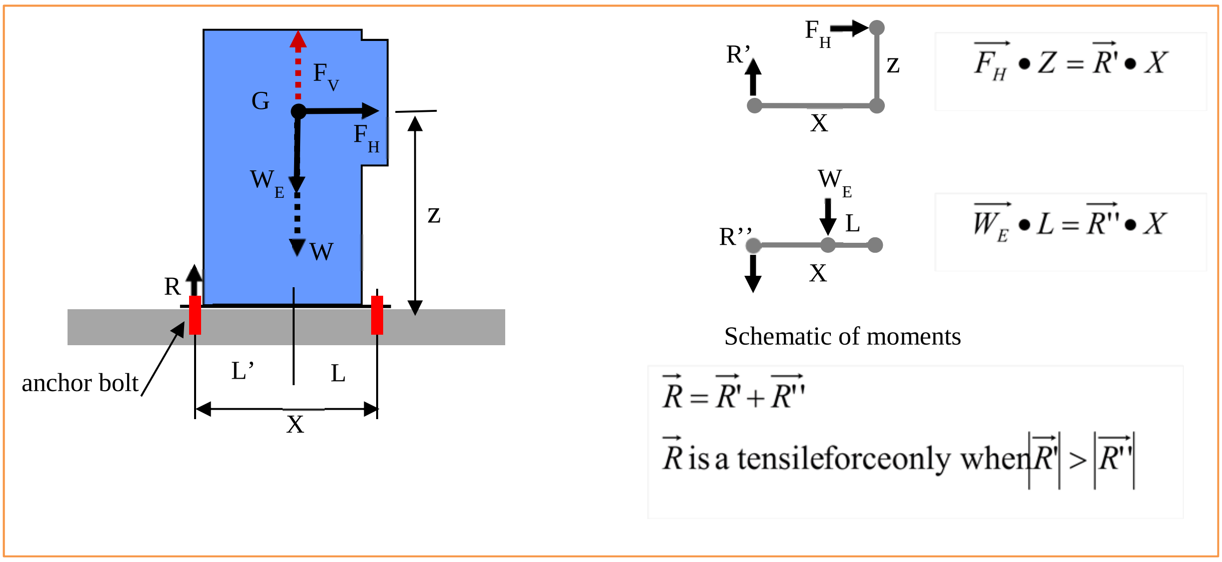
NOTE XXX: A similar calculation is provided in the 1991 American Society of Heating, Refrigeration and Air-Conditioning Engineers (ASHRAE) handbook, Chapter 49 "Seismic Restraint Design".

NOTE XXX: An explanation of why the effective weight of the equipment can be less than the weight when the equipment is in motion during a seismic event can be found by researching, for example, 'elevator physics'.

Table R4-3 The key variables and examples

Variable	Notes	Value for this example
W	The maximum normal operating weight of the equipment	49,000 Newtons[#1] (5000 kg force)
F_H	The maximum anticipated seismic horizontal force acting on the equipment	0.94W (HPM)
F_V	The vertical seismic force by which the weight is reduced to determine effective weight used for overturning calculations.	0.33W (HPM)
W_E	The effective weight of the equipment accounting for the vertical seismic force ($W – F_v$)	0.67W (HPM)
G	The center of gravity of the equipment	As indicated
Z	The height of the center of gravity	2 meters
R	The tensile force on an anchor bolt	to be calculated
r	The lateral force on an anchor bolt	to be calculated
N	The total number of anchor bolts	6
n	The total number of anchor bolts on one side of the equipment.	3
X	The distance between the two rows of n anchor bolts (= L + L')	1 meter
L	The shortest distance from a row of anchor bolts to the horizontal position of G	0.4 meters

#1 Earth's surface gravity exerts a force of 9.8 Newton on 1 kilogram of mass.



#1 Dashed lines show the forces which are summed to give W_E.

Figure R4-2 Illustration of the Key Factors and The Seismic Motions

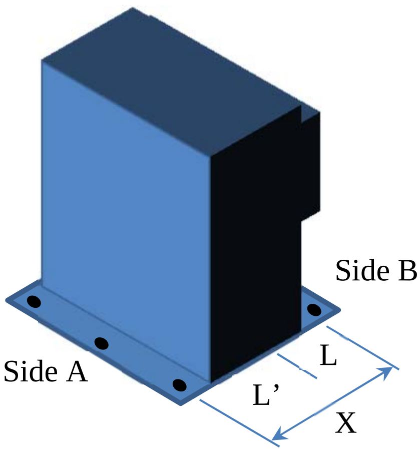


Figure R4-3 Illustration of the Key Factors

R4-4.5 F_H may vary depending on whether the equipment contains HPMs or not, and is usually expressed as a portion of the equipment weight. For this example it is taken as .94W (The minimum anticipated value from §19.2 for equipment containing HPMs).

R4-4.6 F_V is not necessarily the maximum vertical force that could act on the equipment because of the assumption in R4-2.2.4. This value is also usually expressed as a portion of the equipment weight. For this example it is taken as 0.33W.

R4-4.7 This example uses the length L rather than L' to calculate the moment due to the effect weight of the equipment (which opposes the overturning moment), because it results in the worst case (smaller) value for the moment.

R4-5 Calculation of Overturning Force

R4-5.1 For the equipment not to begin overturning, the sum of the angular moments (torques) around the line through the bolts on Side B must be zero. (taking clockwise as the positive direction):

$$\sum M = (F_H \cdot Z)\text{-}(R \cdot X \cdot n)\text{-}(W_E \cdot L) = 0 \qquad \text{(R4-16)}$$

R4-5.2 For the example configuration, the worst case tensile force (R) on a single bolt (on side A) is given by:

$$R = \frac{(F_H \cdot Z) - (W_E \cdot L)}{X \cdot n} \qquad \text{(R4-17)}$$

Using the example values gives:

$$R = \frac{(0.94 \cdot 49{,}000N \cdot 2m) - (0.67 \cdot 49{,}000N \cdot 0.4m)}{1m \cdot 3} = 0.54 \cdot 49000N = 26{,}460 \text{ Newtons} \qquad \text{(R4-18)}$$

R4-5.3 If the worst case tensile stress on the anchor bolts exceeds the tensile strength of the bolts or the strength of the bolt-to-floor bond, then the equipment might overturn.

R4-5.4 If there are no anchor bolts installed, the equipment will begin to overturn if :

$$(F_H \cdot Z) > (W_E \cdot L) \qquad \text{(R4-19)}$$

but whether the equipment completely overturns or not will depend on the duration and simultaneity of the worst case vertical force and the worst case horizontal force.

R4-6 Calculation of Lateral Force

R4-6.1 The lateral force on one bolt (r) is derived from the maximum anticipated horizontal force acting on the equipment's center of gravity as follows:

$$r = F_H / N \qquad \text{(R4-20)}$$

Using the example values gives:

$$r = 0.94W/6 = 7{,}677 \text{ Newtons} \qquad \text{(R4-21)}$$

R4-6.2 The lateral force acts as shear on the floor anchor fasteners and shear or tensile loading on the equipment anchor fasteners depending upon their orientation.

~~R4-5.1 Sum the moments of the reactions on the system about line through the legs A and B:~~

$$\text{(CW = +)} \sum M_{AB} = 0 = F_P(h) - 0.85W_P(L_2) - 2R(L_1) = 0 \qquad \text{(R4-1)}$$

$$R = \frac{F_P(h) - 0.85W_P(L_2)}{2L_1} \qquad \text{(R4-2)}$$

$$F_P = 0.94W_P$$

$$R = \frac{W_P(0.94h - 0.85L_2)}{2L_1} \qquad \text{(R4-3)}$$

~~If $0.94h \geq 0.85L_2$, then there is a tension reaction, R, at the two anchors, to resist overturning of system.~~

~~Example:~~

~~L1 = 50 inch~~

~~L2 = 20 inch~~

~~h = 36~~

~~W = 5000 lbs~~

~~Lateral force = Fp/4 = 0.94(5000)/4 = 1175~~

~~Overturning force = R =~~ $$\frac{W_P\,(0.94h - 0.85L_2)}{2L_1}$$ ~~(R4-4)~~

$$= \frac{5000\,(0.94(36) - 0.85(20))}{2(50)}$$ ~~(R4-5)~~

~~R = 842 lbs~~

DELAYED REVISIONS 1(Effective July 2018)
FAIL-TO-SAFE EQUIPMENT CONTROL SYSTEMS REVISION

NOTICE: This Delayed Revisions Section contains material that has been balloted and approved by the Environmental Health & Safety Global Technical Committee, but is not immediately effective. The provisions of this material are not an authoritative part of the Document until their effective date. The main body of SEMI S2-0715 remains the authoritative version. Some or all of the provisions of revisions not yet in effect may optionally be applied prior to the effective date, providing they do not conflict with portions of the authoritative version other than those that are to be revised or replaced as part of the deferred revision, and are labeled accordingly.

NOTICE: Unless otherwise noted, all material to be added shall be underlined, and all material to be deleted shall be ~~struck through~~.

D1-1 Revision to §11 (Safety Interlock Systems) (OPTIONAL Before Effective Date)

D1-1.1 Revision to ¶ 11.6.1 as shown below.

11.6.1 ~~FECS may be used in conjunction with electromechanical or solid state devices and components provided the programmable safety control system conforms to an appropriate standard for electronic safety systems. Components of the FECS should be tested and certified according to the requirements of the standard used. Examples of recognized electronic safety systems standards include IEC 61508, ISO 13849-1, ANSI/ISA SP84.00.01, DIN V VDE 0801.~~ If a programmable safety controller or FECS is used, the design should conform to the Safety Interlock Design criteria in SEMI S22.

NOTE 39: ¶ 13.4.3 states additional assessment criteria for safety-related components and assemblies.

NOTE 40: A FECS is a subsystem of a (PES) Programmable Electronic System. IEC 61508 is the preferred standard for complex PES.

NOTE 41: Related Information 13 provides additional information on applications of FECS design.

NOTE XX: The Safety Interlock Design criteria are in § 13.7.3 of the 0715 version of S22.

D1-2 Revision to § 12 (Emergency Shutdown) (OPTIONAL Before Effective Date)

D1-2.1 Revision to ¶ 12.2.2 as shown below.

12.2.2 The EMO circuit should consist of electromechanical components.

EXCEPTION 1: Solid-state devices and components may be used, provided the system or relevant parts of the system are evaluated and found suitable for use. The components should be evaluated and found suitable considering abnormal conditions such as over voltage, under voltage, power supply interruption, transient over voltage, ramp voltage, electromagnetic susceptibility, electrostatic discharge, thermal cycling, humidity, dust, vibration and jarring. The final removal of power should be accomplished by means of electromechanical components.

EXCEPTION 2: FECS may be used in conjunction with electromechanical or solid state devices and components provided the FECS meets the Safety Interlock Design criteria in SEMI S22. ~~conforms to an appropriate standard for electronic safety systems.~~ ~~Components of the FECS should be tested and certified according to the requirements of the standard used.~~ ~~IEC 61508 and ISO 13849-1 are examples of internationally recognized electronic safety systems standards.~~ The final removal of power should be accomplished by means of electromechanical components.

NOTE 44: ¶ 13.4.3 states additional assessment criteria for safety-related components and assemblies.

NOTE 45: A FECS is a subsystem of a (PES) Programmable Electronic System. IEC 61508 is the preferred standard for complex PES.

DELAYED REVISIONS 2(Effective July 2018) ADDITIONS RELATED TO PLATFORMS, STAIRS, LADDERS AND ELEVATED LOCATIONS

NOTICE: This Delayed Revisions Section contains material that has been balloted and approved by the Environmental Health & Safety Global Technical Committee, but is not immediately effective. The provisions of this material are not an authoritative part of the Document until their effective date. The main body of SEMI S2-0715 remains the authoritative version. Some or all of the provisions of revisions not yet in effect may optionally be applied prior to the effective date, providing they do not conflict with portions of the authoritative version other than those that are to be revised or replaced as part of the deferred revision, and are labeled accordingly.

NOTICE: All the material is to be added. For clarity, it *has* not been underlined. The paragraph numbering will be adjusted as necessary when the material is incorporated into the Document. To avoid confusion with the published Document:

- Proposed Terminology has been numbered starting with 5.2.701. Terms will be inserted into § 5.2 in alphabetical order and the paragraphs in the section will be renumbered upon the effective date.
- Proposed NOTEs have been numbered starting with 701. NOTEs that are added to SEMI S2 will appear in the locations, relative to the numbered paragraphs, shown below. The added NOTEs will be numbered sequentially within SEMI S2 and the present NOTESs in SEMI S2 will be renumbered as necessary upon the effective date.

D2-1 Addition (in alphabetical order) to § 5 (Terminology) (OPTIONAL Before Effective Date)

5.2.701 *anchor point* — a location or device which receives the load in a fall arrest or restraint system and to which the other components of that system are connected.

5.2.702 *certified anchor point* — an anchor point that a qualified person certifies to be capable of supporting the forces foreseen to be applied to it by fall arrest or fall restraint system.

5.2.703 *elevated location* — a walking or working surface occupancy of which results in the feet being at 500 mm (19.7 in.) or more above an adjacent surface.

5.2.704 *fall arrest* — stopping a person in free fall.

5.2.705 *fall protection* — engineered or administrative controls that reduce the risk of a fall.

5.2.706 *fall restraint* — preventing a person's center of gravity reaching a fall hazard by use of a harness, lanyard, and connectors.

5.2.707 *guardrail system* — a physical barrier positioned at a prescribed height to prevent a fall from an elevated location. It consists of posts (vertical supports), a toprail, a midrail, and, in some cases, a toeboard.

5.2.708 *handrail* — a horizontal or inclined member designed to be grasped by the hand for support.

NOTE 701: Unlike a guardrail system, a handrail is not intended to keep personnel from falling from an elevated location.

5.2.709 *ladder* — a fixed or portable means of access with a pitch more than 75° but not more than 90°, whose horizontal elements are steps or rungs.

5.2.710 *landing* — a horizontal elevated location, not intend by the supplier as a location of work, at the end of a series of steps.

5.2.711 *midrail* — the linear element of a guardrail system that is approximately midway between the toprail and the walking or working surface.

5.2.712 *platform* — a horizontal elevated location intended by the supplier to support the weight of personnel, their tools, and equipment while working.

5.2.713 *platform stand* — a fixed-height, self-supporting, movable unit consisting of one or more platforms on a rigid base (with or without wheels or casters) and a means of ascending or descending between levels.

5.2.714 *qualified person (fall arrest and restraint systems)* — individual having extensive knowledge, training, and experience designing, analyzing, evaluating and specifying fall arrest and restraint systems.

5.2.715 *rung* — a horizontal crosspiece of a ladder, intended by the supplier to be used both to support feet and to be gripped by hands.

5.2.716 *stairs* — fixed or portable means of access with a pitch not more than 45°, whose horizontal elements are steps.

5.2.717 *stair ladder* — fixed or portable means of access with a pitch more than 45° but not more than 75°, whose horizontal elements are steps or rungs.

5.2.718 *step* — a horizontal surface, other than a rung, landing, or platform, intended by the supplier to support ascent or descent of people.

5.2.719 *task* — a group of related job elements directed toward a specific objective.

5.2.720 *task analysis* — determining the specific actions required of the user when operating, maintaining, or servicing equipment. Within each task, steps are described in terms of the perception, decision-making, memory, posture, and biomechanical requirements as well as the expected errors.

5.2.721 *toeboard* — a vertical barrier erected along an edge of a walking or working surface to reduce falls of materials.

5.2.722 *toprail* — the linear element of a guardrail system that is farthest from the walking or working surface.

5.2.723 *walking or working surface* — a surface on which the supplier intends personnel to walk, stand, squat, kneel, sit, or lie for work.

D2-2 Addition of a New § 18.8 (Material Currently Designated 18.8 and Thereafter will be Renumbered) (OPTIONAL Before Effective Date)

18.8 *Provisions for Work at Elevated Locations*

NOTE 702: The performance goal of § 18.8 and Related Information X is to ensure risks associated with performing work at elevated locations are either Low or Very Low, as assessed in accordance with SEMI S10.

18.8.1 Where operation, service or maintenance is required at elevated locations, a task analysis should be performed with risk assessment of the means of gaining access and of the performance of the work from the intended walking or working surface.

18.8.2 If the risk assessment determines a risk greater than Low, as assessed in accordance with SEMI S10, then an appropriate means of fall protection to mitigate the risk to Low or Very Low should be provided or specified.

18.8.3 Fall protection, including walking or working surfaces, and means of gaining access, such as ladders, stair ladders, platform stands, platforms, stairs, guardrail systems and handrails that are provided as standalone pieces or integral to the equipment should be designed in accordance with good engineering practices.

NOTE 703: Examples of good engineering practices can be found in Related Information X, as well as in various international standards. Good engineering practices also include consideration of intended use (e.g., energized electrical work).

NOTE 704: There are many regional and international codes, as well as various international standards, and regulations with different requirements for the devices covered in Related Information X. The selection of criteria for incorporation into Related Information X was based on meeting the majority of the different requirements, using the most conservative of the different requirements or using the most appropriate of the different requirements for the semiconductor industry.

18.8.4 Documents provided to the equipment user should include information (including, at a minimum, height of tasks, number of people required, and rated load) about the means of access that are to be used to perform tasks described in the supplier's instructions but that are not provided by the supplier.

18.8.5 *Fall Protection*

18.8.5.1 If fall protection is needed to mitigate the risk of work required at elevated locations, as assessed in accordance with SEMI S10, to Low or Very Low, fall protection should be specified or provided.

18.8.5.2 Fall protection may be accomplished with guardrail systems, fall arrest systems, fall restraint systems, or other equally effective means (see the definition of fall protection in ¶ 5.2.705).

NOTE 705: Local or regional requirements may differ as to the height at which guarding is required to be provided.

- California Code of Regulations, Title 8, Section 3210(b) calls for guarding to be used at heights of 1.2 m (4 ft.) or greater.
- 29CFR 1910.23(c)(1) requires "every open-sided floor or platform 4 feet or more above adjacent floor or ground level shall be guarded by a standard railing."
- ISO 14122-3, section 7.1.2 calls for guarding if there is a fall hazard above 500 mm (19.7 in.).
- IBC 2009, section 1013.1 calls for guarding to be employed at heights of 762 mm (30 in.) or greater.

18.8.5.3 If fall arrest or fall restraint systems are recommended by the equipment supplier, anchor points should be provided as part of the equipment or specified as part of the facility. Each anchor point should be designed or specified to support a static load of at least 22.24 kN (5,000 lbf.).

EXCEPTION: Fall arrest or fall restraint systems that meet the criteria for 'certified' (those designed and evaluated by a qualified person) may use two (2) times the arresting force or a static load of at least 8 kN (1,800 lbf.).

D2-3 Addition of a New Related Information Section (OPTIONAL Before Effective Date)

RELATED INFORMATION X
DESIGN CRITERIA FOR PLATFORMS, STEPS, AND LADDERS

NOTICE: This Related Information is not an official part of SEMI S2 and was derived from the work of the Environmental Health & Safety Global Technical Committee. This Related Information was approved for publication by full letter ballot procedures on December 4, 2015.

R1-1 RX-1 Purpose

R1-1.1 RX-1.1 This Related Information provides good engineering practices for the design of ladders, stair ladders, platform stands, platforms, stairs, guardrail systems and handrails.

R1-2 RX-2 Scope

R1-2.1 RX-2.1 The scope of this Related Information is ladders, stair ladders, platform stands, platforms, stairs, guardrail systems and handrails that are provided, by the supplier, as standalone pieces or integral to the equipment.

R1-3 RX-3 Terminology

NOTE 706: These terms and their definitions are in addition to those in § 5 of SEMI S2.

R1-3.1 RX-3.1 *alternating tread stair ladder* — stair ladder on which the treads are approximately one-half the width of the stair ladder and alternate in right and left alignment for the length of the stair ladder. (See Figure RX-1.)

Figure RX-1
Example of Alternating Tread Stair Ladder

R1-3.2 RX-3.2 *dead load* — the static force exerted on a structure or object.

R1-3.3 RX-3.3 *horizontal guardrail system* — a guardrail system, such as those erected along the exposed sides and ends of platforms, in which the toprail, midrail, and toeboard are approximately horizontal.

R1-3.4 RX-3.4 *inclined guardrail system* — a guardrail system, such as those erected along the exposed sides of stairs, in which the toprail, midrail, and toeboard are approximately parallel to the direction of travel, rather than being horizontal.

R1-3.5 RX-3.5 *live load* — the force exerted on a structure or object as a consequence of its anticipated environment and normal use (e.g., load from personnel and transient materials such as tool boxes).

NOTE 707: 'Live load' can be contrasted with 'dead load', which is essentially the non-variable load, exerted by materials and installation conditions of the structure.

R1-3.6 RX-3.6 *pitch* — the angle between the plane passing through the front edges of consecutive steps or rungs and the horizontal surface. Pitch is defined mathematically by:

$$\text{pitch} = \text{arctangent (rise/run)} \qquad \text{(RX-1)}$$

R1-3.7 RX-3.7 *rise* — vertical distance between the treads of successive steps or rungs.

R1-3.8 RX-3.8 *run* — horizontal distance between the front edges of successive steps or rungs.

R1-3.9 RX-3.9 *span* — the usable width (right to left) of a step or rung perpendicular to the direction of travel.

R1-3.10 RX-3.10 *step or platform depth* — the dimension of a step or platform, measured in the direction of travel (e.g., from front to back).

R1-3.11 RX-3.11 *test load* — a load applied to demonstrate compliance with criteria.

R1-3.12 RX-3.12 *tread* — the walking surface of a step.

R1-4 RX-4 Materials of Construction

R1-4.1 RX-4.1 Selection of materials of construction should consider their intended use, such as during energized electrical work or with extreme temperatures.

R1-5 RX-5 Walking or Working Surfaces, Including Platforms but Excluding Rungs and Steps

R1-5.1 RX-5.1 The design of walking or working surfaces should take into account the area required for, and loads presented by, personnel, tools and parts for tasks intended by the supplier.

NOTE 708: There are two types of loading criteria specified in this Related Information; a distributed stress load such as ¶ RX-5.4 which increases with an increasing surface area, and point stress load such as ¶ RX-5.5, which remains constant regardless of the overall walking or working surface area. The distributed load minimum addresses the general structural support for the walking or working surface; the point load minimum addresses the ability of the walking or working surface to support the foreseen localized loads.

R1-5.2 RX-5.2 The tests outlined in this Related Information are to be performed by trained and qualified personnel who have knowledge of the techniques and the test apparatus described herein.

R1-5.3 RX-5.3 Walking or working surfaces should be made of material either solid or with openings such that a 10 mm (0.38 in.) sphere cannot pass through for surfaces at a height of 3 meters or greater above another walking or working surface, and such that a 25 mm (1 in.) sphere cannot pass through regardless of height.

R1-5.4 RX-5.4 Walking or working surfaces should be able to support at least 3.6 kN/m^2 (75 lbf/ft^2) evenly distributed over the entire surface.

R1-5.5 RX-5.5 At locations where a person can stand or walk, the platform or walking or working surface should be able to support at least 1.3 kN (300 lbf.) concentrated load placed in each position that would cause maximum stress to one or more structural members. The concentrated load should be assumed to be on a 90 mm (3.5 in.) by 90 mm (3.5 in.) square.

R1-5.6 RX-5.6 The height difference between the loaded and an adjoining, unloaded walking or working surface should not exceed 4 mm (0.16 in.).

R1-5.7 RX-5.7 Conformance with ¶¶ RX-5.4 and RX-5.5 should be verified either by calculations performed by a qualified engineer or by testing. If testing is used to verify conformance with ¶ RX-5.5, the following test method should be used.

NOTE 709: SEMI S7 § 8 highlights qualifications of personnel capable of reviewing and validating calculations or test results. A person may be qualified to perform such calculations by:

- education in mechanical, structural, civil or architectural engineering;
- being licensed or certified as PE (USA), Chartered (UK), or Eur Ing (EU) or equivalent; or
- experience in design, construction, and analysis of such structures.

RX-5.7.1 Preload walking or working surface for one minute with a 200 N (45 lbf.) load placed in each location described in ¶ RX-5.7.2. After removal of the preload, the position of the walking or working surface should be used as the origin for measurement in the next part of the test.

RX-5.7.2 Walking or working surface should withstand a test load of at least 1.3 kN (300 lbf.) concentrated load placed at each of:

- center of walking or working surface,
- midpoint of the longest unsupported edge,
- in a corner of a cantilevered surface, and
- locations that would cause maximum stress

for one minute without failure or permanent deformation in excess of 1/200 of its span or 3 mm (0.12 in.) (whichever is larger) once the test load has been removed. The test load includes the rigid plate specified in ¶ RX-5.7.3. ‘Unsupported edge’ and the deformation criteria pertain to both individual plates and other components comprising the walking surface and the span of the continuous walking surface.

RX-5.7.3 Tests should be conducted using a rigid plate at least 12 mm (0.5 in.) thick by not more than 90 mm (3.5 in.) by 90 mm (3.5 in.) square. An elastomeric pad (rubber or polyurethane, with a Shore hardness of 80 ± 10 Durometer ‘A’) at least 12 mm (0.5 in.) thick, the same size as the rigid plate should be adhered to the plate’s underside.

R1-5.8 RX-5.8 *Means of Ascent and Descent* — Walking or working surfaces should be specified or provided with a fixed or portable means of ascent and descent (e.g., steps, stairs, ladders).

EXCEPTION 1: Walking or working surface height is less than or equal to 230 mm (9 in.) above the adjacent walking or working surface;

EXCEPTION 2: Walking or working surface height is greater than 230 mm (9 in.) and not greater than 380 mm (15 in.) above the adjacent walking or working surface and the walking or working surface is intended by the supplier to be accessed (regardless of duration of use) by the same individual less than an average of once an hour, and no more than an average of 4 times, per 12 hours; or

EXCEPTION 3: Walking or working surface height is greater than 380 mm (15 in.) and not greater than 715 mm (28 in.) above the adjacent walking or working surface and the walking or working surface is intended by the supplier to be accessed (regardless of duration of use) by the same individual less than an average of 4 times per 12 hours, and hand coupling points are present to assist in ascending and descending.

NOTE 710: The 380 mm (15 in.) height limit for walking or working surfaces without a means of ascent and descent are based upon biomechanical modeling using the 50th percentile male and not relying on any hand coupling. The height limit will accommodate the strength of the 25th percentile female.

NOTE 711: The 715 mm (28 in.) limit is based upon the hip height of the 5th percentile Hong Kong female (bare footed).

NOTE 712: There are generally two movements (up/down) each time a walking or working surface is accessed. The 4 times corresponds to 4 round trip movements within 12 hours.

R1-6 RX-6 Guardrail Systems

R1-6.1 RX-6.1 *All Guardrail Systems*

RX-6.1.1 Posts should be spaced not more than 2.4 m (8 ft.) center to center.

RX-6.1.2 Posts, toprails and midrails should be 38 mm (1.5 in.) in its minimum outside dimension.

NOTE 713: There are no requirements for posts, toprails, and midrails to be round.

RX-6.1.3 The toprails of guardrail systems should also meet the criteria in § RX-7.1 for handrails.

RX-6.1.4 Stairs ascending more than 500 mm (19.7 in.) above the adjacent floor or standing level, should have inclined guardrail systems on open sides where there is a lateral space exceeding 50 mm (2 in.). (Figure RX-2 illustrates the gap.)

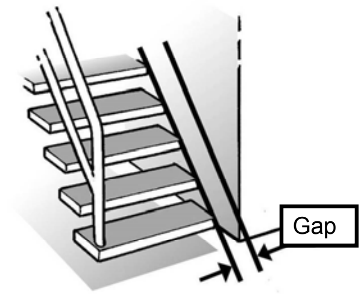


Figure RX-2
Lateral space between Stair and Wall

NOTE 714: The 500 mm criterion is based upon ISO 14122-3 as to when guarding is required, but IBC section 1009.12 requires railings on all stairs. The 50 mm lateral spacing is based on the 5th percentile Chinese female foot breadth being 81 mm (3.2 in.).

R1-6.2 RX-6.2 *Toeboards*

RX-6.2.1 Toeboards should be at least 100 mm (4 in.) high and should be placed not more than 6.35 mm (0.25 in.) above the platform, walking, or working surface.

NOTE 715: ISO 14122-3 notes 10 mm (0.38 in.) as the gap between toeboard and walking surface.

RX-6.2.2 Inclined and horizontal guardrail systems should have toeboards if they would reduce the risk of falling objects striking personnel to Low or Very Low Risk (according to the risk assessment method of SEMI S10) in the area expected (during work tasks intended by the supplier) to be occupied.

NOTE 716: ISO 14122-3 requires toeboards to be used if the gap is greater than 30mm (1.2 in.) from the adjacent structure.

RX-6.2.3 Toeboards should be made of material either solid or with openings such that a 10 mm (0.38 in.) sphere cannot pass through.

R1-6.3 RX-6.3 *Strength*

RX-6.3.1 Guardrail systems should support, without permanent deformation exceeding 3 mm (0.12 in.), a load equal to 890 N (200 lbf.), applied in any direction at the least favorable points along the toprail. Conformance may be verified by applying loads upward, downward, and horizontally (perpendicular to the toprail, toward and away from the walking or working surface). The maximum loaded deflection should not exceed 30 mm (1.2 in.).

RX-6.3.2 Midrails or functionally equivalent structural members should be capable of withstanding, without permanent deformation exceeding 3 mm (0.12 in.), a force of 667 N (150 lbf.) applied in any downward or outward direction at any point along the midrail or functionally equivalent structural member. The maximum loaded deflection should not exceed 30 mm (1.2 in.).

RX-6.3.3 Conformance with strength criteria should be verified either by calculations performed by a qualified engineer or by testing.

NOTE 717: SEMI S7 § 8 highlights qualifications of personnel capable of reviewing and validating calculations or test results. A person may be qualified to perform such calculations by:

- education in mechanical, structural, civil or architectural engineering;
- being licensed or certified as PE (USA), Chartered (UK), or Eur Ing (EU) or equivalent; or
- experience in design, construction, and analysis of such structures.

R1-6.4 RX-6.4 *Horizontal Guardrail Systems*

RX-6.4.1 *Toprails* — the height of the top edge of toprail should be no less than 1.09 m (43 in.) and no more than 1.15 m (45 in.) above the walking or working surface. (See Figure RX-3.)

RX-6.4.2 *Midrails* — midrails or functionally equivalent structural members should be provided such that there is not a vertical gap more than 500 mm (19.7 in.) between elements of the guardrail system. (See Figure RX-3.)

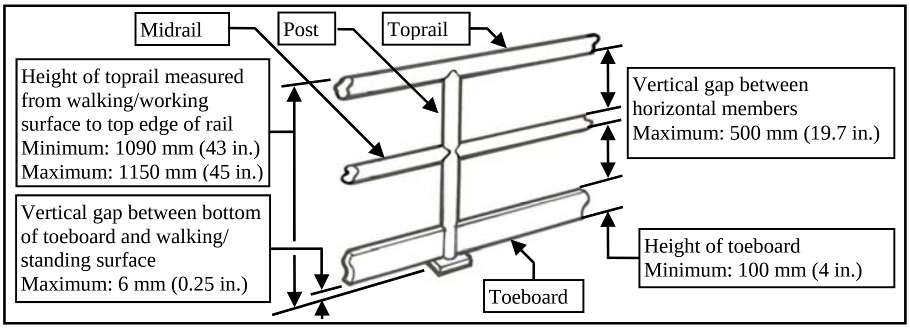


Figure RX-3
Horizontal Guardrail System

RX-6.4.3 *Access Through Horizontal Guardrail Systems*

RX-6.4.3.1 Where access through the guardrail system is required, the passage through it should either be provided with a self-closing gate or be offset so that a person cannot walk directly through the opening. A gate should have its toprail and midrail positioned at the same levels as those of the guardrail system.

RX-6.4.3.2 All gates should close against a firm stop to prevent users from pushing against them and falling through the opening. Gates are subject to the same strength criteria, when closed, as guardrail systems.

RX-6.4.3.3 Gates should be sized to provide a passage width not less than 610 mm (24 in.) when open. (See Figure RX-4.)

RX-6.4.3.4 Operating forces of gates should not exceed 44.5 N (10 lbf.) as measured at the end of the gate farther away from the hinge.

RX-6.4.3.5 Operating forces of sliding gates should not exceed 31 N (7 lbf.).

RX-6.4.3.6 If swinging, gates should be designed to open onto the platform or floor. Obstruction of the area behind the gate, when the gate is opened, is acceptable as long as there is sufficient space available to allow personnel to pass through and to allow the gate to close. (See Figure RX-4, including dimensions.)

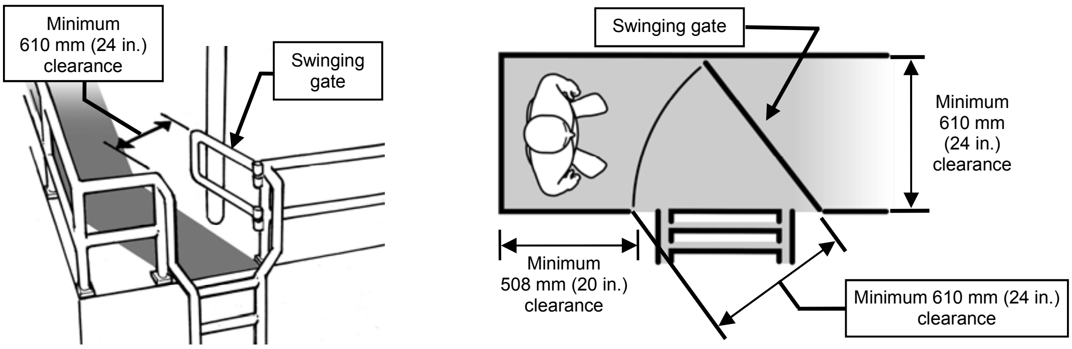


Figure RX-4
Gates in Horizontal Guardrail Systems

R1-6.5 RX-6.5 *Inclined Guardrail Systems*

RX-6.5.1 It is preferred that an inclined guardrail system be continuous for the full length of the incline. In the case of an interrupted inclined guardrail, the clear space between the two segments should not be less than 75 mm (3 in.) (to prevent hand traps), and not greater than 120 mm (4.7 in.).

RX-6.5.2 The height of an inclined guardrail should be 900 mm (35.5 in.) to 1m (39.4 in.) from the upper surface of the toprail to the surface of the tread in line with the leading edge of the tread. (See figure RX-5.)

NOTE 718: ISO 14122-3 requires 900 to 1000 mm (35.5 to 39.4 in.) and OSHA regulations require 762 mm to 864 mm (30 to 34 in.) however, a review of letters of interpretation within OSHA's website indicates that OSHA will accept compliance to published standards.

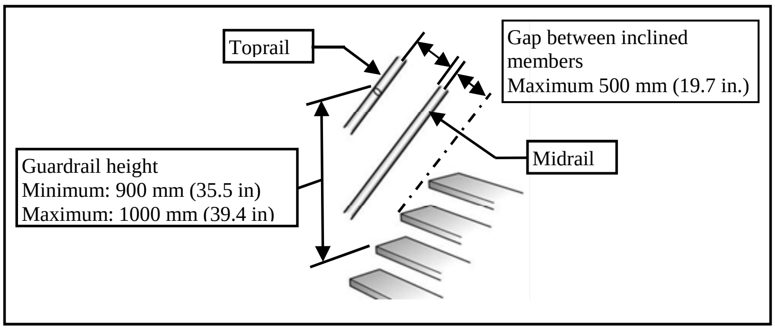


Figure RX-5
Inclined Guardrail System

R1-7 RX-7 Handrails

R1-7.1 RX-7.1 *Size and Shape*

RX-7.1.1 Each handrail should be mounted so as to offer no obstruction to a smooth surface along the top and both sides.

RX-7.1.2 The handrail should be of rounded or other section that will furnish an adequate handhold for anyone grasping it to avoid falling.

RX-7.1.3 The portions of handrails that are intended to be grasped should have a horizontal and vertical cross-sectional dimensions of not less than 33 mm (1.3 in.) or more than 56 mm (2.2 in.) each.

RX-7.1.4 Handrail ends should be arranged (e.g., turned toward a wall or downward) to reduce risks due to bodily impact to the end of the handrail.

R1-7.2 RX-7.2 The length of the handrail should be clear of obstacles within a distance of 100 mm (3.9 in.), except on the underside of the handrail at its support points.

R1-7.3 RX-7.3 The height should be 900 mm (35.5 in.) to 1 m (39.4 in.) from the upper surface to the surface of the tread in line with the leading edge of the tread.

R1-7.4 RX-7.4 *Strength*

RX-7.4.1 Handrails should support, without permanent deformation exceeding 3 mm (0.12 in.), a load equal to 890 N (200 lbf.), applied in each direction at the least favorable point(s) along the rail. Conformance may be verified by applying loads upward, downward, and horizontally (perpendicular to the rail, toward and away from the walking or working surface). The maximum loaded deflection should not exceed 30 mm (1.2 in.).

RX-7.4.2 Conformance with strength criteria should be verified either by calculations performed by a qualified engineer or by testing.

NOTE 719: SEMI S7 § 8 highlights qualifications of personnel capable of reviewing and validating calculations or test results. A person may be qualified to perform such calculations by:

- education in mechanical, structural, civil or architectural engineering;
- being licensed or certified as PE (USA), Chartered (UK), or Eur Ing (EU) or equivalent; or
- experience in design, construction, and analysis of such structures.

R1-8 RX-8 Stairs

NOTE 720: Stairs are defined as having a pitch of not more than 45 degrees. Means of ascent having a pitch of more than 45 degrees but not more than 75 degrees are stair ladders. Means of ascent having a pitch of more than 75 degrees but not more than 90 degrees are ladders.

R1-8.1 RX-8.1 The span of each step should be at least 559 mm (22 in.).

R1-8.2 RX-8.2 Tread surfaces should not have a slope greater than 6 mm in 300 mm (0.25 in. in 1 ft.) from horizontal.

R1-8.3 RX-8.3 The uppermost step nearest to a landing should be level with the landing, or meet the criteria in ¶ RX-8.8.

RX-8.3.1 If the uppermost step aligns level with the landing, its vertical misalignment to the top surface of the landing should not exceed 12 mm (0.5 in.).

R1-8.4 RX-8.4 If the upper step is part of a landing, that portion of the landing that serves the function of the upper step should meet the step criteria with regard to structure and dimensions.

R1-8.5 RX-8.5 The walking or working surfaces of all treads should be slip-resistant.

R1-8.6 RX-8.6 The horizontal overlap of steps to steps and steps to landings should be at least 10 mm (0.38 in.). (See Figure RX-6).

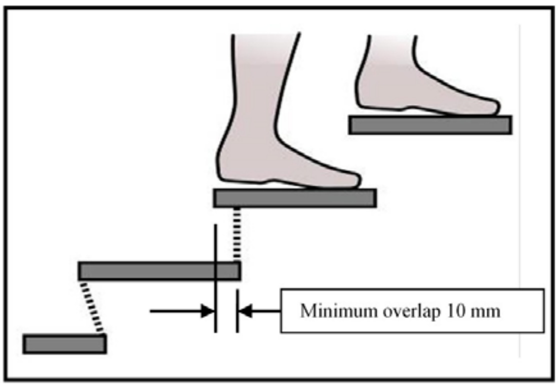


Figure RX-6
Stairs

R1-8.7 RX-8.7 Vertical clearance above each stair tread to an overhead obstruction should be at least 2134 mm (7 ft.) measured from the leading edge of the tread.

R1-8.8 RX-8.8 Rise and run should be uniform throughout any set of consecutive steps. The variation of the rise or of the run should not exceed 6 mm (0.25 in.).

R1-8.9 RX-8.9 The rise should be a maximum of 229 mm (9.0 in.) and the run should be a minimum 229 mm (9.0 in.).

R1-8.10 RX-8.10 Landings that are between sets of steps should be at least as wide as the narrower set of steps and have a minimum depth (dimension in the direction of travel) of 559 mm (22 in.).

NOTE 721: OSHA 29 CFR 1910.20(g) requires 762 mm (30 in.) in the direction of travel.

R1-8.11 RX-8.11 Stairs should have a handrail on each side enclosed by a wall.

EXCEPTION: If each side is enclosed by a wall and the stairs are less than 1118 mm (44 in.) wide, one handrail is sufficient.

NOTE 722: Stairs allow the user to descend while facing in the direction of travel.

R1-8.12 RX-8.12 *Strength*

RX-8.12.1 The minimum rated live load of stairs should be the greater of 1.3 kN (300 lbf.) and the load intended by the supplier.

NOTE 723: The load of 1.3 kN (300 lbf.) is based on the mass of a person being 113.4 kg (250 lb.) plus an additional 23 kg (50 lb.) for equipment.

RX-8.12.2 Stairs should be designed to support a minimum of 4 times the rated live load.

NOTE 724: 29 CFR 1910.24 specifies stairs are to be constructed to carry a load five times the normal live load anticipated.

RX-8.12.3 The deflection of a step under the anticipated live load should not exceed 1/300 of the span or 6 mm (0.25 in.), whichever is less.

RX-8.12.4 Conformance with strength criteria should be verified either by calculations performed by a qualified engineer or by testing. If testing is used to verify conformance with § RX-8.12, the following test method should be used.

NOTE 725: SEMI S7 § 8 highlights qualifications of personnel capable of reviewing and validating calculations or test results. A person may be qualified to perform such calculations by:

- education in mechanical, structural, civil or architectural engineering;
- being licensed or certified as PE (USA), Chartered (UK), or Eur Ing (EU) or equivalent; or
- experience in design, construction, and analysis of such structures.

RX-8.12.14.1 Preload step with a 200 N (45 lbf.) load placed on the center of the step for one minute. After removal of the preload, the position of the step should be used as the origin for measurement in the next part of the test.

RX-8.12.14.2 Stairs should withstand a test load of four times the rated load placed on the center of each step for one minute without failure or permanent deformation in excess of 1/200 of its span once the test load has been removed. The test load includes the rigid plate specified in ¶ RX-8.12.4.3.

EXCEPTION: All steps within a series do not need to be tested if engineering rationale can show that worst case(s) have been tested. The engineering rationale should be documented in the test report.

RX-8.12.14.3 Test should be conducted using a rigid plate at least 12 mm (0.5 in.) thick by not more than 90 mm (3.5 in.) by the step depth plus 25 mm (1 in.). An elastomeric pad (rubber or polyurethane, with a Shore hardness of

80 ± 10 Durometer 'A') at least 12 mm (0.5 in.) thick, the same size as the rigid plate should be adhered to the plate's underside. (See Figure RX-7.)

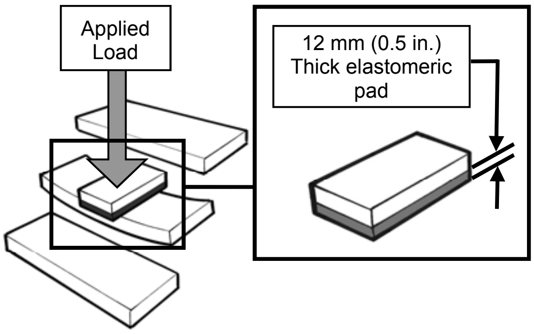


Figure RX-7
Stairs Load Testing

NOTE 726: The rigid plate is based on the standard loading block as defined in Figure 6 of ANSI A14.2-2000.

RX-8.12.14.4 Any damage or visible weakening of other components (siderails, legs, bracing, etc.) as a result of a test should constitute a failed test.

R1-9 RX-9 Stair ladders

NOTE 727: Stairs are defined as having a pitch of not more than 45 degrees. Means of ascent having a pitch of more than 45 degrees but not more than 75 degrees are stair ladders. Means of ascent having a pitch of more than 75 degrees but not more than 90 degrees are ladders.

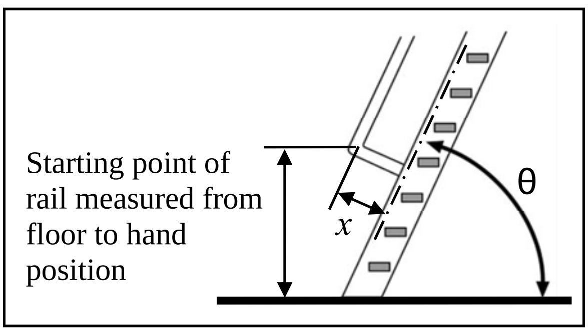
R1-9.1 RX-9.1 Stair ladders should have a run of not less than 76 mm (3 in.) nor more than 190 mm (7.5 in.) and a rise of not less than 190 mm (7.5 in.) nor more than 279 mm (11 in.).

NOTE 728: Steps are preferred at pitches between 45 degrees and 60 degrees.

R1-9.2 RX-9.2 Steps or rungs should be slip-resistant. It is recommended that steps or rungs be constructed of corrugated, serrated, knurled, textured or dimpled materials.

NOTE 729: Surface treatments such as abrasion strips, (e.g., adhesive-backed sandpaper) are less desirable, as they tend to wear or become damaged more easily than integral means.

R1-9.3 RX-9.3 Stair ladders reaching 500 mm (19.7 in.) or more above the floor should have handrails positioned where the distance from the line through the front edge of the steps on a stair ladder to the bottom of the handrail are as shown in Table RX-1, with the handrail beginning at a vertical distance of no more than 1 m (39.4 in.) from the floor or walking surface. Interpolate between stated values for intermediate pitches. (See Figure RX-8.)



R1-9.4

LETTER BALLOT

Figure RX-8
Stair Ladder

Table RX-1 Distances from the Pitch-Line on a Stair Ladder to the Bottom of the Handrail

θ (degrees)	*X (linear dimension perpendicular to the pitch-line) (mm)*
46°	625 ± 10
50°	500 ± 10
55°	375 ± 10
60°	250 ± 10
65°	200 ± 10
70°	150 ± 10
75°	100 ± 10

R1-9.5 RX-9.4 Each end of the stair ladder handrail should connect to the horizontal guardrail system (if present) at the top or bottom of the handrail. In the case of a gap, the clear space between the two segments should not be less than 75 mm (3 in.) (to prevent hand traps), and not greater than 120 mm (4.7 in.).

R1-9.6 RX-9.5 For handrail size, shape, and strength use the criteria in § RX-7.

R1-9.7 RX-9.6 The documentation provided to the user should instruct personnel to face stair ladders (except alternating tread stair ladders, see Figure RX-9) while ascending and descending.

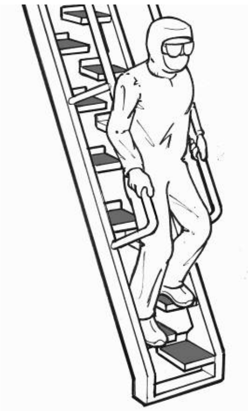


Figure RX-9
Descending an Alternating Tread Stair Ladder While Facing the Direction of Travel

R1-9.8 RX-9.7 *Strength*

RX-9.7.1 The minimum rated live load of a stair ladder should be the greater of 1.3 kN (300 lbf.) and the intended load.

RX-9.7.2 Stair ladders should be designed to support a minimum of 4 times the rated live load.

RX-9.7.3 Live loads imposed on a stair ladder should be considered to be concentrated at such point or points as will cause maximum stress in the structural member being considered.

RX-9.7.4 Conformance with strength criteria should be verified either by calculations performed by a qualified engineer or by testing. If testing is used to verify conformance with § RX-9.7, the following test method should be used.

NOTE 730: SEMI S7 § 8 highlights qualifications of personnel capable of reviewing and validating calculations or test results. A person may be qualified to perform such calculations by:

- education in mechanical, structural, civil or architectural engineering;
- being licensed or certified as PE (USA), Chartered (UK), or Eur Ing (EU) or equivalent; or
- experience in design, construction, and analysis of such structures.

RX-9.7.4.1 Preload step with a 200 N (45 lbf.) load placed on the center of the step for one minute. After removal of the preload, the position of the step should be used as the origin for measurement in the next part of the test.

RX-9.7.4.2 Stair ladders should withstand a test load of four times the rated load placed on the center of each step for one minute without failure or permanent deformation in excess of 1/200 of its span once the test load has been removed. The test load includes the rigid plate specified in ¶ RX-9.7.4.3.

EXCEPTION: Not all steps within a series need to be tested if engineering rationale can show that worst case(s) have been tested. The engineering rationale should be documented in the test report.

RX-9.7.4.3 Test should be conducted using a rigid plate at least 12 mm (0.5 inches) thick by not more than 90 mm (3.5 in.) by the step depth plus 25 mm (1 in.). An elastomeric pad (rubber or polyurethane, with a Shore hardness of 80 ± 10 Durometer ‘A’) at least 12 mm (0.5 in.) thick, the same size as the rigid plate should be adhered to the plate’s underside. (See Figure RX-7.)

RX-9.7.4.4 Any damage or visible weakening of other components (siderails, legs, bracing, etc.) as a result of the test should constitute a failed test.

R1-10 RX-10 Platform Stands

R1-10.1 RX-10.1 The steps or rungs of platform stands should be slip-resistant. It is recommended that steps or rungs be constructed of corrugated, serrated, knurled, textured or dimpled materials.

R1-10.2 RX-10.2 Steps or rungs should be uniformly spaced with differences between the largest and smallest rise and between the largest and smallest run to be no greater than 6 mm (0.25 in.).

R1-10.3 RX-10.3 It is preferred that the pitch not exceed 75°.

R1-10.4 RX-10.4 Where the pitch of steps for platform stands is no more than 45°, the steps should conform to the criteria for stairs.

R1-10.5 RX-10.5 Where the pitch of steps or rungs for platform stands is greater than 45° and not more than 75°, the steps or rungs should conform to the criteria for stair ladders.

R1-10.6 RX-10.6 Where the pitch of steps or rungs for platform stands is greater than 75 degrees, the steps or rungs should conform to the criteria for ladders.

R1-10.7 RX-10.7 Protection against overturning of the unit during use intended by the supplier should be provided.

NOTE 731: This criterion is not intended to replace criteria in ¶ 18.3.

R1-10.8 RX-10.8 Platform stands where the walking or working surface extends beyond the stand’s supporting structure (is cantilevered) should be designed so that a 2× rated load can be applied downward no farther than 50 mm (2 in.) from each edge of the platform or step without overturning.

NOTE 732: The general stability criteria (i.e., those that apply whether or not there is a cantilever) are contained in ¶ RX-10.1.15.

R1-10.9 RX-10.9 Joints comprised of threaded fasteners should be designed to be vibration tolerant (e.g., using a lock-nut or thread locking compound).

R1-10.10 RX-10.10 Platform stands with wheels or casters should be equipped with a system to stop horizontal movement while occupied.

R1-10.11 RX-10.11 Each wheel or caster should be able to support four times its anticipated load.

R1-10.12 RX-10.12 Each unit should be marked with:

- Supplier's or manufacturer's name or logo,
- Month and year of manufacture, and
- Maximum rated live load

R1-10.13 RX-10.13 Product documentation should include instructions regarding:

- Visual inspection,
- Proper use, and
- Maintenance

R1-10.14 RX-10.14 *Strength*

RX-10.14.1 The minimum rated live load of a platform stand should be the greater of 1.3 kN (300 lbf.) times the number of persons and the load intended by the supplier.

RX-10.14.2 All platform stands should be designed to support a minimum of 4 times the rated live load.

RX-10.14.3 Conformance with strength criteria should be verified either by calculations performed by a qualified engineer or by testing. If testing is used to verify conformance with § RX-10.14, the following test method should be used.

NOTE 733: SEMI S7 § 8 highlights qualifications of personnel capable of reviewing and validating calculations or test results. A person may be qualified to perform such calculations by:

- education in mechanical, structural, civil or architectural engineering;
- being licensed or certified as PE (USA), Chartered (UK), or Eur Ing (EU) or equivalent; or
- experience in design, construction, and analysis of such structures.

RX-10.14.3.1 Preload step or rung with a 200 N (45 lbf.) load placed on the center of the step or rung for one minute. After removal of the preload, the position of the step or rung should be used as the origin for measurement in the next part of the test.

RX-10.14.3.2 Treads should withstand a test load of four times the rated load placed on the center of each step or rung for one minute without failure or permanent deformation in excess of 1/200 of its span once the test load has been removed. The test load includes the rigid plate specified in ¶ RX-10.14.3.3.

EXCEPTION: Not all steps or rungs within a series need to be tested if engineering rationale can show that worst case(s) have been tested. The engineering rationale should be documented in the test report.

RX-10.14.3.3 Test should be conducted using a rigid plate at least 12 mm (0.5 in.) thick by not more than 90 mm (3.5 in.) by the step depth plus 25 mm (1 in.). An elastomeric pad (rubber or polyurethane, with a Shore hardness of 80 ± 10 Durometer 'A') at least 12 mm (0.5 in.) thick, the same size as the rigid plate should be adhered to the plate's underside. (See Figure RX-7.)

NOTE 734: The rigid plate is based on the standard loading block as defined in Figure 6 of ANSI A14.2-2000.

RX-10.14.3.4 Any damage or visible weakening of other components (siderails, legs, bracing, etc.) as a result of the test should constitute a failed test.

R1-10.15 RX-10.15 *Stability* — Platform stands should be stable under all anticipated load conditions with their rated live load uniformly distributed on the top step or platform.

RX-10.15.1 *Side stability* — With a load of 890 N (200 lbf.) evenly distributed on the top step or platform, platform stands should withstand a sideward horizontal force of not less than 98 N (22 lbf.) applied perpendicular to the side of the unit at the handrail or guardrail above the center of the top step or platform without the unit tipping over. For units without handrails or guardrails, the force should be applied to the top step or platform at its center.

RX-10.15.2 *ear stability* — This criterion is the same as for the side stability criterion except that a rearward horizontal force of 98 N (22 lbf.) applied perpendicular to the rear handrail or guardrail. For units without handrails or guardrail, the force should be applied to the top step or platform at its center.

RX-10.15.3 Conformance with stability criteria should be verified either by calculations performed by a qualified engineer or by testing. If testing is used to verify conformance with ¶ RX-10.15, the following test method should be used.

NOTE 735: SEMI S7 Related Information 2 highlights qualifications of personnel capable of reviewing and validating calculations or test results. A person may be qualified to review or validate such calculations by:

- education in mechanical, structural, civil or architectural engineering;
- being licensed or certified as PE (USA), Chartered (UK), or Eur Ing (EU) or equivalent; or
- experience in design, construction, and analysis of such structures.

RX-10.15.3.1 The test unit should be placed on a level surface with the movement prevention system engaged. Units with wheels or casters should be blocked to prevent movement.

RX-10.15.3.2 A load of 890 N (200 lbf.) should be evenly distributed on the top step or platform.

RX-10.15.3.3 The unit under test should be subjected to a sideward horizontal force of 98N (22 lbf.) applied perpendicular to the handrail, guardrail, top step or platform as shown in Figure A7-7.

RX-10.15.3.4 The unit under test should be subjected to a rearward horizontal force of 98N (22 lbf.) applied perpendicular to the handrail, guardrail, top step or platform as shown in Figure A7-7.

RX-10.15.3.5 The platform stand tipping over with a force of 98 N (22 lbf.) or less should constitute a failed test.

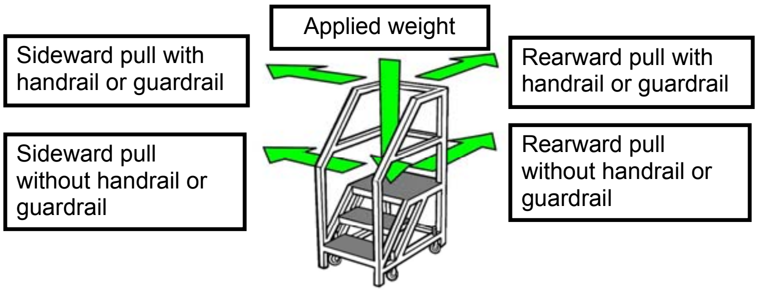


Figure RX-10
Stability Test Locations

R1-10.16 RX-10.16 *Dimensions*

RX-10.16.1 The minimum width of the base of platform stands should be 508 mm (20 in.), or the width of the top step or platform, whichever is greater.

RX-10.16.2 The maximum work level height of a platform stand should not exceed four (4) times its minimum base dimension. The minimum base dimension may be considered to include outriggers or other structural members.

RX-10.16.3 *The Platform of Platform Stands*

RX-10.16.3.1 The uppermost flat surface of a platform should have a depth of not less than 241 mm (9.5 in.).

RX-10.16.3.2 The minimum width should be 508mm (20 in.).

RX-10.16.3.3 Platforms intended by the supplier for use by more than one person at a time should have a depth of more than 813 mm (32 in.) or a surface area of more than 0.62 m^2 (6.7 ft^2).

RX-10.16.3.4 Platforms should allow work to be performed in orientations as intended by the supplier and meet the appropriate dimensional criteria within Appendix 1 of SEMI S8.

R1-11 RX-11 Ladders

NOTE 736: Stairs are defined as having a pitch of not more than 45 degrees. Means of ascent having a pitch of more than 45 degrees but not more than 75 degrees are stair ladders. Means of ascent having a pitch of more than 75 degrees but not more than 90 degrees are ladders.

R1-11.1 RX-11.1 *All Ladders*

RX-11.1.1 Rungs and steps of ladders should be spaced not less than 178 mm (7 in.) apart, nor more than 304.8 mm (12 in.) apart, as measured between consecutive treads of the rungs or steps and the spacing should be uniform throughout the length of the ladder. The variation of the spacing should not exceed 6 mm (0.25 in.).

R1-11.2 RX-11.2 Rungs should have a horizontal cross-sectional dimension between 19 mm (0.75 in.) and 40 mm (1.5 in.).

R1-11.3 RX-11.3 Steps of ladders should have a depth of not less than 76 mm (3 in.) nor more than 190 mm (7.5 in.).

NOTE 737: Rungs are preferred.

RX-11.3.1 The steps or rungs of ladders should be slip-resistant. It is recommended that steps or rungs be constructed using corrugated, serrated, knurled, textured or dimpled materials

RX-11.3.2 Each ladder should be marked with its maximum rated live load.

RX-11.3.3 The documents provided to the equipment user should include instructions for the ladder regarding:

- Visual inspection
- Proper use
- Maintenance

RX-11.3.4 *Strength*

RX-11.3.4.1 The minimum rated live load of a ladder should be the greater of 1.3 kN (300 lbf.) and the load intended by the supplier.

RX-11.3.4.2 Ladders should be designed to support a minimum of 4 times the rated live load.

RX-11.3.4.3 Live loads imposed by persons occupying a ladder should be considered to be concentrated at such point or points as will cause maximum stress in the structural member being considered.

RX-11.3.5 Conformance with strength criteria should be verified either by calculations performed by a qualified engineer or by testing. If testing is used to verify conformance with § RX-11.3.4, the following test method should be used.

NOTE 738: SEMI S7 § 8 highlights qualifications of personnel capable of reviewing and validating calculations or test results. A person may be qualified to perform such calculations by:

- education in mechanical, structural, civil or architectural engineering;
- being licensed or certified as PE (USA), Chartered (UK), or Eur Ing (EU) or equivalent; or
- experience in design, construction, and analysis of such structures.

RX-11.3.5.1 Preload step or rung with a 200 N (45 lbf.) load placed on the center of the step or rung for one minute. After removal of the preload, the position of the step or rung should be used as the origin for measurement in the next part of the test.

EXCEPTION: Not all steps or rungs within a series need to be tested if engineering rationale can show that worst case(s) have been tested. The engineering rationale should be documented in the test report.

RX-11.3.5.2 Ladders should withstand a test load of four times the rated load placed on the center of the each rung or step for one minute without failure or permanent deformation in excess of 1/200 of its span once the test load has been removed. The test load includes the rigid plate specified in ¶ RX-11.3.5.3.

RX-11.3.5.3 Test should be conducted using a rigid plate at least 12 mm (0.5 in.) thick by not more than 90 mm (3.5 in.) by 25 mm (1 in.) plus the contact depth of the step or rung. An elastomeric pad (rubber or polyurethane, with a Shore hardness of 80 ± 10 Durometer 'A') at least 12 mm (0.5 in.) thick, the same size as the rigid plate should be adhered to the plate's underside. (See Figure RX-7.)

RX-11.3.5.4 Any damage or visible weakening of other components (siderails, legs, bracing, etc.) as a result of the test should constitute a failed test.

R1-11.4 RX-11.4 *Additional Criteria for Fixed Ladders*

RX-11.4.1 The minimum span for fixed ladders should be 406.4 mm (16 in.).

RX-11.4.2 The minimum perpendicular distance from the center line of the rungs to the nearest permanent object on the climbing side of the ladder should be 915 mm (36 in.) for a pitch of 76 degrees, and 762 mm (30 in.) for a pitch of 90 degrees, with minimum clearances for intermediate pitches varying between these two limits in proportion to the slope. (See Figure RX-11.)

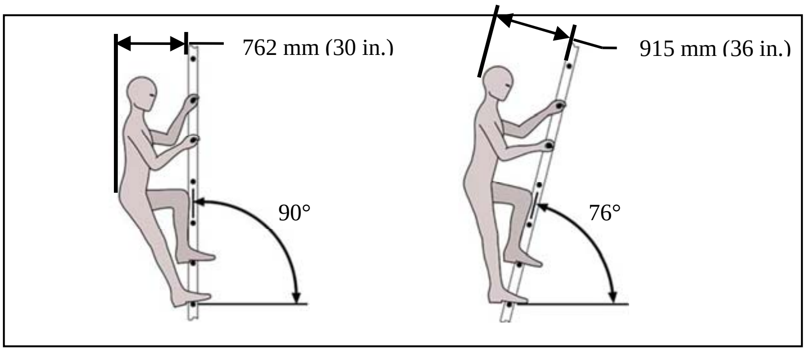


Figure RX-11
Ladder Climbing Side Clearance

RX-11.4.3 A clear width of at least 381 mm (15 in.) should be provided each way from the center line of the ladder in the climbing space. (See Figure RX-12.)

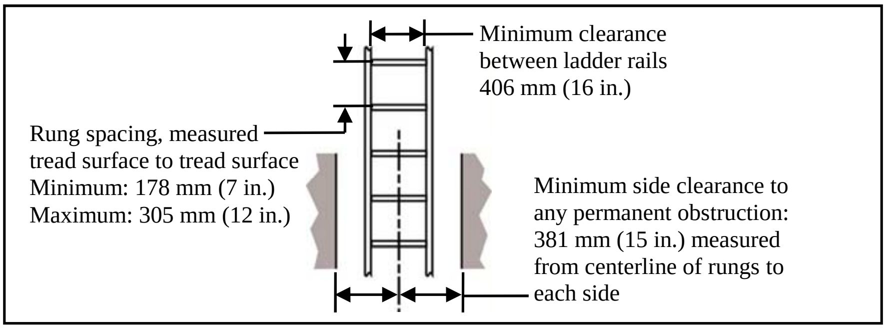


Figure RX-12
Ladder Clearances and Dimensions

RX-11.4.4 The distance from the center line of rungs or steps, to the nearest fixed obstruction in back of the ladder should be as shown in Figure RX-13. Only the indicated clearances above, below or away from the obstruction are normative in this illustration. Other aspects of the illustration such as the obstruction type, rung cross-section, and ladder angle are only demonstrative and are not intended to limit the application of this paragraph.

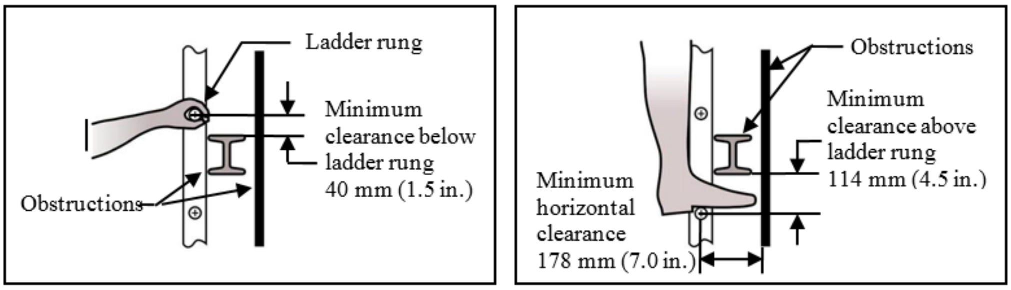


Figure RX-13
Ladder Clearances Opposite to Climbing Side

NOTE 739: This criterion is related only to distances to objects that are in back of the ladder and not distances within the ladder unit.

RX-11.4.5 The step-across distance from the nearest edge of ladder to the nearest edge of equipment or structure should be not more than 305 mm (12 in.).

RX-11.4.6 If the platform is being accessed from a ladder, one rung of the ladder should be located at the level of the platform. (See figure RX-13.)

RX-11.4.7 The side rails of step-through or side-step ladder extensions should extend 1.1 m (3.5 ft.) above obstructions and platforms. For step-through ladder extensions, the rungs should be omitted from the extension and the ladder should have not less than 610 mm (24 in.), nor more than 762 mm (30 in.) clearance between rails. (See Figure RX-14.)

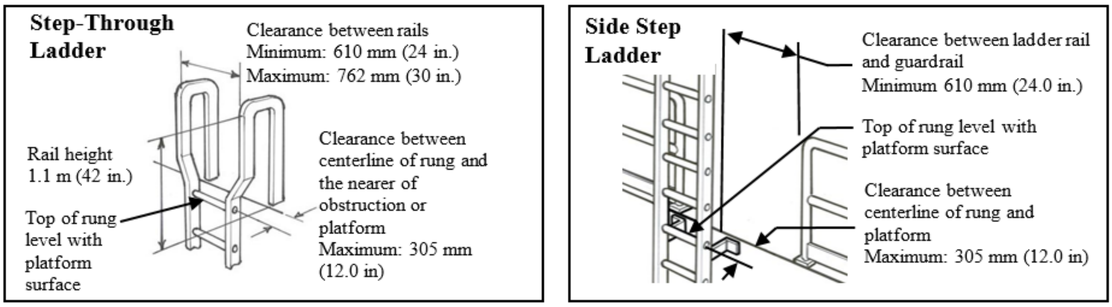


Figure RX-14
Step-Through and Side Step Ladders

RX-11.4.8 *Grab Bars*

RX-11.4.9 The distance from the center line of the grab bars (individual handholds placed adjacent to or as an extension above ladders for the purpose of providing access beyond the limits of the ladder) to the nearest permanent object in back of the grab bars should be not less than 102 mm (4 in.). Grab bars should not protrude on the climbing side beyond the rails of the ladder which they serve.

RX-11.4.9.1 Horizontal grab bars should be spaced by a continuation of the rung spacing.

RX-11.4.9.2 Vertical grab bars should have the same spacing as the ladder side rails.

RX-11.4.9.3 Grab bar diameters should be 19 to 40 mm (0.75 to 1.5 in.).

R1-11.5 RX-11.5 *Additional Considerations for Portable Ladders*

RX-11.5.1 The minimum span for portable ladders should be 304.8 mm (12 in.).

RX-11.5.2 Each portable ladder should also be marked with:

- Supplier's or manufacturer's name or logo
- Month and year of manufacture