

SEMI S28-1011

SAFETY GUIDELINE FOR ROBOTS AND LOAD PORTS INTENDED FOR USE IN SEMICONDUCTOR MANUFACTURING EQUIPMENT

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NOTICE: This Standard or Safety Guideline has an Inactive Status because the conditions to maintain Current Status have not been met. Inactive Standards or Safety Guidelines are available from SEMI and continue to be valid for use.

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

NOTICE: Conformance to the “should” provisions of this guideline is necessary to declare conformance to this document. Conformance to “may”, “suggested”, “preferred”, “recommended”, “NOTE”, or “Related Information” provisions is not necessary to declare conformance.

1 Purpose

1.1 This Safety Guideline provides a set of performance and design based safety considerations for load ports and wafer handling robots that are intended to be integrated into semiconductor manufacturing equipment (SME).

1.2 This Safety Guideline provides additional guidance to manufacturers of load ports and wafer handling robots beyond the general coverage of SEMI S2.

1.3 This Safety Guideline covers essential safety issues for load ports and wafer handling robots, intended for integration into SME, that might not be covered in other applicable safety guidelines and standards for industrial robots.

1.4 This Safety Guideline provides guidance for the safety evaluation of load ports and wafer handling robots before integration.

1.5 This Safety Guideline aids the designers of load ports and wafer handling robots in anticipating safety considerations that will arise during integration into SME.

1.6 This Safety Guideline guides suppliers of load ports and wafer handling robots concerning the document contents needed by integrators for safety evaluations of their completed SME systems.

2 Scope

2.1 This Safety Guideline applies to atmospheric and vacuum wafer-handling robots that are manufactured with their supplier’s intention that they be integrated into semiconductor manufacturing equipment.

2.2 This Safety Guideline applies to load ports that interface with front-opening unified pods (FOUP), standard mechanical interface (SMIF) pods, and cassettes and that are manufactured for integration into semiconductor manufacturing equipment.

2.3 This Safety Guideline includes safety considerations in addition to those of safety standards for industrial robots.

2.4 This Safety Guideline applies to wafer handling robots and load ports that are being evaluated independently of SME.

2.5 The documentation provisions of § 8 are to be applied to load ports and wafer handling robots sold after this safety guideline is published, regardless of design or development date.

2.6 This Document contains the following sections:

1. Purpose
2. Scope
3. Limitations

4. Referenced Standards and Documents
5. Terminology
6. General Considerations
7. Safety Features for WHRs and Load Ports
8. Information to be Provided to the Integrator

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 does not apply to unmanned transport vehicle (UTV) systems (floor-traveling vehicle systems and space-traveling vehicle systems), which move carriers between areas of the factory.

NOTE 1: UTV systems are the subject of SEMI S17, Safety Guidelines for Unmanned Transport Vehicle (UTV) Systems.

3.2 This Safety Guideline does not address design and manufacture of multipurpose industrial robots of any type (e.g., as defined by ANSI/RIA R15.06, ANSI/RIA/ISO 10218-1, EN ISO 10218-1, and UL 1740) used for moving structural, construction, or building maintenance loads around a factory.

3.2.1 This Safety Guideline does not replace regulatory requirements for industrial robots (e.g., multipurpose industrial robots used to transport wafers).

3.3 This Safety Guideline does not apply to mechanisms that support and move wafers only while they are being processed, measured or inspected by the SME (e.g., x-y stages).

3.4 This Safety Guideline does not apply to flat panel substrate handling robots.

NOTE 2: Safety for flat panel display equipment is the subject of SEMI S26, Environmental, Health, and Safety Guideline for FPD Manufacturing System.

3.5 This Safety Guideline does not apply to equipment that handles reticle SMIF pods (see SEMI E100 and SEMI E117).

3.6 This Safety Guideline is not intended to be used for evaluating SME that has integrated wafer handling robots or load ports.

NOTE 3: Once wafer handling robots and load ports are integrated into SME or EFEMs, SEMI S2 may be used for evaluation.

3.7 This Safety Guideline is not intended to be used to verify compliance with ISO, IEC and other standards, nor is it intended that other standards would be alternate means of satisfying the criteria of this Safety Guideline.

NOTE 4: Certain IEC, ISO and other standards are referenced in this Safety Guideline because they can be helpful for the design of safety circuits.

3.8 This Safety Guideline is not intended to be applied to load port and wafer handling robot designs retroactively. The considerations contained in § 7 are not intended to be applied to load ports and wafer handling robots developed before this Safety Guideline is published.

4 Referenced Standards and Documents

4.1 SEMI Standards and Safety Guidelines

SEMI E1.9 — Mechanical Specification for Cassettes Used to Transport and Store 300 mm Wafers

SEMI E19.4 — 200 mm Standard Mechanical Interface (SMIF)

SEMI E62 — Specification for 300 mm Front-Opening Interface Mechanical Standard (FIMS)

SEMI E63 — Mechanical Specification for 300 mm Box Opener/Loader to Tool Standard (BOLTS-M) Interface

SEMI E92 — Specification for 300 mm Light Weight and Compact Box Opener/Loader to Tool-Interoperability Standard (BOLTS/Light)

SEMI E100 — Specification for a Reticle SMIF Pod (RSP) Used to Transport and Store 6 inch or 230 mm Reticles

SEMI E117 — Specification for Reticle Load Port

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

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

SEMI S17 — Safety Guideline for Unmanned Transport Vehicle (UTV) Systems

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

SEMI S26 — Environmental, Health, and Safety Guideline for FPD Manufacturing System

4.2 ANSI Standards¹

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

ANSI/RIA/ISO 10218-1 — Robots for Industrial Environment – Safety Requirements – Part 1: Robot

4.3 Council of the European Union Directives²

Directive 2006/42/EC of the European Parliament and of the Council on 17 May 2006 on machinery, and amending Directive 95/16/EC (commonly known as the Machinery Directive)

Council Directive 2006/95/EC of 20 November 2006 on the harmonization of the laws of Member States relating to electrical equipment designed for use within certain limits (commonly known as the Low Voltage Directive)

4.4 IEC Standards³

IEC 60204-1 — Safety of Machinery – Electrical Equipment of Machines

IEC 60204-33 — Safety of Machinery – Electrical Equipment of Machines – Part 33: Requirements for Semiconductor Fabrication Equipment

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

4.5 ISO Standards⁴

EN ISO 10218-1 — Robots for Industrial Environments – Safety Requirements – Part 1: Robot

NOTE 5: “EN” standards have been adopted as law by EU member countries.

NOTE 6: EN Standard⁵ EN 775 (Manipulating Industrial Robots – Safety) has been withdrawn. It has been replaced by ISO 10218-1.

ISO 12100-1 — Safety of Machinery – Basic Concepts, General Principles for Design, Part 1: Basic Terminology, Methodology

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

ISO 13849-2 — Safety of Machinery – Safety-Related Parts of Control Systems – Part 2: Validation

¹ American National Standards Institute, 25 West 43rd Street, New York, NY 10036, USA; Telephone: +1.212.642.4900, Fax: +1.212.398.0023, <http://www.ansi.org>

² Council of the European Union, Rue de la Loi / Wetstraat, 175, B-1048 Brussels, Belgium; <http://europa.eu.int/comm/>

³ International Electrotechnical Commission, 3 rue de Varembe, Case Postale 131, CH-1211 Geneva 20, Switzerland; Telephone: +41.22.919.02.11, Fax: +41.22.919.03.00, <http://www.iec.ch>

⁴ International Organization for Standardization, ISO Central Secretariat, BIBC II, Chemin de Blandonnet 8, CP 401, 1214 Vernier, Geneva, Switzerland; Telephone: +41.22.749.01.11, <http://www.iso.org>

⁵ 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>

4.6 NFPA Standards⁶

NFPA79 — Electrical Safety of Industrial Machinery

4.7 UL Standard⁷

UL 1740 — Standard for Robots and Robotic Equipment

4.8 SEMATECH Document⁸

99033693A-ENG — Integrated Minienvironment Design Best Practices

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

5 Terminology

5.1 Abbreviations and Acronyms

5.1.1 *EFEM* — equipment front end module

5.1.2 *EMO* — emergency off

5.1.3 *FIMS* — front-opening interface mechanical standard

5.1.4 *FOUP* — front-opening unified pod

5.1.5 *FPD* — flat panel display

5.1.6 *IEC* — International Electrotechnical Commission

5.1.7 *ISO* — International Organization for Standardization

5.1.8 *SMIF* — standard mechanical interface

5.1.9 *SME* — semiconductor manufacturing equipment

5.1.10 *UL* — Underwriters Laboratories

5.1.11 *UTV* — unmanned transport vehicle

5.1.12 *WHR* — wafer handling robot

5.2 Definitions

5.2.1 *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. [SEMI S2, S22]

5.2.2 Definitions Related to Carriers

5.2.2.1 *carrier* — a device for holding wafers, dice, packaged integrated circuits, or reticles for various processing steps in semiconductor manufacturing. [SEMI E78, SEMI E129]

5.2.2.2 *cassette* — an open structure that holds one or more wafers. [SEMI E1.9]

5.2.2.3 *front opening unified pod (FOUP)* — a box (that complies with SEMI E47.1) with a non-removable cassette (so that its interior complies with SEMI E1.9) and with a front-opening interface (that mates with a FIMS port that complies with E62). [SEMI E47.1]

5.2.2.4 *pod* — a box having a standardized mechanical interface. [SEMI E19]

⁶ National Fire Protection Association, 1 Batterymarch Park, Quincy, MA 02269, USA; Telephone: +1.617.770.3000, Fax: +1.617.770.0700, <http://www.nfpa.org>

⁷ Underwriters Laboratory, 2600 N.W. Lake Road, Camas, WA 98607-8542, USA; Telephone: +1.877.854.3577, Fax: +1.360.817.6278, <http://www.ul.com>

⁸ SEMATECH, 257 Fuller Road, Suite 2200, Albany, NY 12203, USA; Telephone: +1.518.649.1000, <http://www.semitech.org>

5.2.3 *reticle SMIF pod (RSP)* — a minienvironment compatible carrier capable of holding one 6 inch or one 230 mm reticle in a horizontal orientation during transport and storage and is compatible with a Standard Mechanical Interface (SMIF) per SEMI E19.4. [SEMI E100]

5.2.4 *SMIF pod* — a pod for controlling the transport environment of wafer cassettes for sizes up to 200 mm as specified by SEMI E19.

NOTE 7: Pods include SMIF Pods (see SEMI E19.4), FOUPs, and reticle SMIF pods. Pods and cassettes are carriers.

NOTE 8: Pods are normally clamped in place while they are open, while cassettes are normally not clamped in place.

5.2.5 *confined space* — a space that: (1) is large enough and so configured that an employee can bodily enter and perform assigned work, and (2) has limited or restricted means for entry or exit, and (3) is not designed for continuous employee occupancy.

5.2.6 *controller* — a system that performs required operations when certain conditions occur or when interpreting and acting upon instructions and that communicates with a higher level manager.

NOTE 9: Controllers exist at all levels within a factory.

5.2.7 *defeat* — in the context of safety circuits or safety interlocks, to modify or block a control circuit or actuator so it cannot perform its safety function. Defeating might be authorized or unauthorized.

NOTE 10: SEMI S2 and SEMI S22 use the terms “defeat,” “bypass” and “override” apparently interchangeably but do not provide definitions.

5.2.8 *emergency stop* — a safety circuit that, when activated, provides a Category 0 or Category 1 Stop for hazardous moving parts but does not necessarily isolate or control all energy sources.

5.2.8.1 *Category 0 Stop* — the stopping of moving parts by immediately removing drive power to the drive actuators and activating all brakes and mechanical stopping devices.

5.2.8.2 *Category 1 Stop* — a controlled stop with drive power available to achieve the stop, followed by removing the drive power.

NOTE 11: A Category 1 Stop is not the same as a Category 1 control circuit. See RI-1 for information about Category 1 control circuits.

5.2.9 *emergency off* — a safety circuit that, when activated, places the equipment in a safe shutdown condition without generating any increased risk to personnel or the facility.

NOTE 12: Activation of the EMO circuit will cause a Category 0 or 1 stop, and will shutdown other parts of the equipment besides moving parts. SEMI S2 and SEMI S22 describe exceptions and conformance criteria.

5.2.10 *equipment front end module (EFEM)* — consists of the carrier handler that receives carriers from the factory material handling system on one or more load ports (as specified in SEMI E15.1), opens the carriers (if needed) and may include a substrate handler for unloading and loading wafers from the carrier to the process part of the equipment. [SEMI E63]

5.2.11 *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. [SEMI S2]

5.2.12 *fault* — the state of an item characterized by the inability to perform a required function, excluding the inability during preventive maintenance or other planned actions, or due to lack of external resources. [SEMI S2]

5.2.13 *fault-tolerant* — designed so that a reasonably foreseeable single-point failure does not result in an unsafe condition. [SEMI S2]

5.2.14 *floor-traveling vehicle* — a vehicle that automatically travels on the factory floor to a specified station where a load/unload operation is performed automatically or manually. Floor-traveling vehicles include automatic guided vehicles (AGV) and rail guided vehicles (RGV). [SEMI S17]

5.2.15 *hazardous electrical power* — power levels equal to or greater than 240 VA. [SEMI S22]

5.2.16 *hazardous voltage* — voltages greater than 30 volts RMS, 42.4 volts peak, or 60 volts DC. [SEMI S22]