SEMI S17-0311
SAFETY GUIDELINE FOR UNMANNED TRANSPORT VEHICLE (UTV) SYSTEM

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NOTICE: This Document was completely rewritten in 2011.

1 Purpose

1.1 This Safety Guideline is intended as a set of safety considerations for unmanned transport vehicle (UTV) system. UTV system is used to automate the movement of material within semiconductor or flat panel display (FPD) factories or laboratories. UTV system includes both floor traveling vehicle (FTV) system and overhead traveling vehicle (OTV) system.

2 Scope

2.1 This Safety Guideline applies to UTV and UTV system used in semiconductor or FPD manufacturing.

2.2 This Safety Guideline addresses both floor traveling and overhead traveling UTV and UTV system. FTV system includes automated guided vehicle (AGV) system and rail guided vehicle (RGV) system. OTV system includes overhead shuttle (OHS) system and overhead hoist transport (OHT) system.

2.3 Evaluations for conformance to this Document should be conducted on all UTV and UTV system including separate items such as rails, control panels, power panels, lifter of OHT or OHS from maintenance/service space, and any other type of equipment necessary for operation, maintenance or service of the UTVs.

2.4 This Document contains the following sections:

- Purpose
- Scope
- Limitations
- Referenced Standards and Documents
- Terminology
- General Provisions
- Manuals
- Building Interface
- Ergonomics and Human Factors
- Seismic Protection
- Design for Injury Prevention in UTV System Hazard Zone
- Collision Protection
- Emergency Operation
- Manual Operation
- Maintenance and Service
- Interface to Automated Material Handler of Semiconductor or FPD Manufacturing Equipment
- Protection from Load held by UTV

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- Hazard Indication
- Hazardous Materials
- Related Documents

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 may have limited application to UTV and UTV system without on-board power (direct or induced) such as primary-grounded linear-motor-driven OHS and OHS system. Determinations of applicability should be made by section when evaluating such UTV or UTV system.

3.2 This Safety Guideline does not address material transportation, handling mechanisms, or automated material handling system (AMHS) included as part of semiconductor manufacturing equipment (SME) or flat panel display manufacturing system (FPDMS). These types of mechanisms or AMHS should be evaluated as part of the manufacturing equipment or manufacturing system per SEMI S2 or SEMI S26.

3.3 Person guided vehicle (PGV) is not a UTV, therefore, PGV is not addressed by this Safety Guideline.

3.4 This Safety Guideline does not supersede international, national or local codes, regulations and laws, which may impose separate requirements for assessing the safety of installations.

4 Referenced Standards and Documents

4.1 *SEMI Standards and Safety Guidelines*

SEMI E15.1 — Specification for 300 mm Tool Load Port

SEMI E23 — Specification for Cassette Transfer Parallel I/O Interface

SEMI E84 — Specification for Enhanced Carrier Handoff Parallel I/O Interface

SEMI S1 — Safety Guideline for Equipment Safety Labels

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

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

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

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

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 Standards*[1]

ANSI/ISA SP84.01 — Application of Safety Instrumented Systems for the Process Industry

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

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

4.3 *IEC Standards*[2]

IEC 60204-1 — Safety of Machinery – Electrical Equipment of Machines – Part 1: General Requirements

[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] 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

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IEC 61310-1 — Indication, Marking and Actuation – Part 1: Requirements for Visual, Auditory and Tactile Signals

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

4.4 *ISO Standards*[3]

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

ISO 13857 — Safety of Machinery – Safety Distances to Prevent Hazard Zones Being Reached by Upper and Lower Limbs

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

ISO 14119 — Safety of Machinery – Interlocking Devices Associated with Guards – Principles for Design and Selection

ISO 14120 — Safety of Machinery – Guards – General Requirements for the Design and Construction of Fixed and Movable Guards

4.5 *Other Documents*

FEMA 450 — NEHRP Recommended Provisions and Commentary for Seismic Regulations for New Buildings and Other Structures, 2003 edition[4]

FEMA 451 — NEHRP Recommended Provisions: Design Examples[4]

5 Terminology

5.1 *Abbreviations and Acronyms*

5.1.1 *AGV* — automated guided vehicle

5.1.2 *AMHS* — automated material handling system

5.1.3 *EMO* — emergency off

5.1.4 *E-Stop* — emergency stop

5.1.5 *FPD* — flat panel display

5.1.6 *FECS* — fail-to-safe equipment control system

5.1.7 *FPDME* — FPD manufacturing equipment

5.1.8 *FPDMS* — FPD manufacturing system

5.1.9 *FTV* — floor traveling vehicle

5.1.10 *HEI* — hazardous energy isolation

5.1.11 *OHB* — overhead buffer

5.1.12 *OHS* — overhead shuttle

5.1.13 *OHT* — overhead hoist transport

5.1.14 *OTV* — overhead traveling vehicle

5.1.15 *PGV* — person guided vehicle

5.1.16 *RGV* — rail guided vehicle

5.1.17 *SME* — semiconductor manufacturing equipment

[3] 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

[4] Federal Emergency Management Agency, 8231 Stayton Drive, Jessup, Maryland, 20794-2012, USA. Telephone: +1.800.480.2520; Fax: +1.301.362.5335; http://www.fema.gov

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5.1.18 *UTV* — unmanned transport vehicle

5.2 *Definitions*

5.2.1 *automated operation* — system operation under full pre-programmed control of a computer controller.

5.2.2 *automated guided vehicle (AGV)* — a vehicle guided by something other than rail, but traveling on the floor.

5.2.3 *automated material handling system (AMHS)* — system that moves load automatically by means of a robot, a vehicle, or a conveyor, etc., without being touched by someone's hand.

5.2.4 *emergency off (EMO)* — function to place the UTV system into a safe shutdown condition without generating any additional hazard to personnel or the facility when an EMO actuator (e.g., button) is activated.

5.2.5 *emergency-stop (E-stop)* — function to place all moving parts of a UTV or the part of the UTV system on which the E-stop actuator located into a safe stop condition without generating any additional hazard to personnel or the facility when an E-stop actuator (e.g., button) is activated.

5.2.6 *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 or IEC 61508, ANSI/ISA SP 84.01. 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. [SEMI S2]

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

5.2.8 floor traveling vehicle (FTV) — AGV or RGV.

5.2.9 *FPD manufacturing system (FPDMS)* — system used to manufacture, assemble, or test FPD products. The FPDMS is constructed by integration of equipment that processes substrates (e.g., glass substrates, reticules), its component parts and its auxiliary, support, or peripheral equipment (e.g., chemical controllers, chemical distribution systems, vacuum pumps) and AMHS. Each piece of equipment or AMHS is the subsystem of the FPDMS. FPDMS also includes other items (e.g., structures, piping, ductwork, effluent/exhaust treatment systems, valve manifold boxes, filtration, and heaters) specific to the aforementioned system, but may not include such an item if the item is part of a facility and can support more than one piece of FPD manufacturing system. [SEMI S26]

5.2.10 *guard* — physical barrier designed to provide protection.

5.2.11 *hazard zone* — the space inside the UTV operating space where there is a risk of injury to personnel.

5.2.12 *hoist* — the assembly in an OHT that performs loading/unloading operation by transferring a load.

5.2.13 *lifting device* — a mechanical or electro-mechanical structure that is provided for the purpose of raising and lowering a UTV during maintenance or service tasks.

5.2.14 *load* — load is the object to be transported by a UTV system. Load includes a carrier (cassette, box, pod, etc.) and its contents.

5.2.15 *loading/unloading operation* — the action necessary to move a load to and from a UTV system. This operation may involve hoisting, manual, or robotic manipulation to transfer loads between a UTV system and SME or between a UTV system and FPD manufacturing equipment (FPDME) (such as process equipment or stockers).

5.2.16 *manual operation* — any control outside of automated operation.

5.2.17 *manufacturing equipment* — machinery, associated electrical equipment, apparatus, process modules or devices used to manufacture, measure, assemble and test semiconductor or FPD products but not including any product (e.g., substrates, semiconductors) or UTV system.

5.2.18 *overhead buffer (OHB)* — hanging shelf for placing FOUP temporarily under or on same height of OTV hanging from the ceiling

5.2.19 *overhead hoist transport (OHT)* — a vehicle that travels overhead on a rail (or rails) and does have a hoist.

5.2.20 *overhead shuttle (OHS)* — a vehicle that travels overhead on a rail (or rails) and does not have a hoist.

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5.2.21 *overhead traveling vehicle (OTV)* — OHS or OHT, a vehicle that travels overhead, and may or may not have a hoist.

5.2.22 *rail guided vehicle (RGV)* — a vehicle guided by a rail (or rails) on the floor.

5.2.23 *station* — the destination point where a UTV is programmed to stop for loading/unloading operation (also known as a control point).

5.2.24 *travel* — the automated motion of a UTV along a rail or programmed path from one station to another station. Travel does not include loading/unloading operation.

5.2.25 *unmanned transport vehicle (UTV)* — a vehicle used to automate the movement of production material within semiconductor or FPD factories. There are two types of UTVs; FTV and OTV.

5.2.26 *user* — party that acquires UTV system for the purpose of using it to manufacture semiconductors or FPDs.

5.2.27 *UTV system* — consists of UTV, and equipment and fixtures for driving and controlling UTV such as controller, guided rail, guards, etc.

6 General Provisions

6.1 This Safety Guideline provides the minimum safety considerations for design, construction and evaluation specific to UTV systems.

NOTE 1: It is recommended to refer to other SEMI Safety Guidelines for safety considerations on design and construction that are not covered in this guideline.

6.2 The UTV system supplier should reduce the risk to an acceptable level.

6.2.1 Risk assessment should be performed to identify and evaluate hazards, and appropriate protective measures should be applied to reduce the risk. Risk assessment should be initiated early in the design phase, and updated as the design matures.

NOTE 2: Refer to SEMI S2 Safety Philosophy section for information on protective measures.

NOTE 3: Refer to SEMI S10 for risk assessment.

6.3 *Evaluation* — Conformance to SEMI S17 of all UTV and UTV system should be technically evaluated in accordance with the criteria of § 7 through § 19 of this Safety Guideline.

7 Manuals

7.1 The UTV system supplier should provide the user with manuals based on the originally intended use of the UTV and UTV system. The manuals should describe the scope and normal use of the UTV and UTV system, and provide information to enable safe operation, maintenance, and service of the UTV and UTV system.

7.2 The manuals should conform to SEMI S13.

8 Building Interface

8.1 *UTV System Interface to the Building Component* — When a UTV system is required to interface with building components (e.g., doors, elevators, fire walls), the UTV supplier should provide the user with written specifications for the interface.

8.2 The FTV operating space should not overlap an evacuation route.

9 Ergonomics and Human Factors

9.1 *General* — Ergonomics and human factors design principles should be incorporated into the development of UTV system to identify and eliminate or mitigate ergonomic hazards and human factors-related hazards.

9.2 *Provisions for Conformance* — The UTV system should be assessed to the guidelines set forth in SEMI S8. The supplier ergonomic success criteria (SESC; see SEMI S8), or the equivalent, should be used to document the assessment.

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10 Seismic Protection

NOTE 4: Users have facilities in regions that are susceptible to seismic activity. The user may require more stringent design criteria because of increased site vulnerability (e.g., local soil conditions, building design and installation floor level such as in multi-fabrication-floor facility may produce significantly higher accelerations) and local regulatory requirements. Certified drawings and calculations may be required in some jurisdictions.

10.1 *General* — The UTV system should be designed to control the risk of personnel injury, damaging adjacent manufacturing equipment, damaging components of the UTV system, and facility damage due to movement, overturning, or fall of components of the UTV system during a seismic event. The criteria of this section are intended to accomplish two things:

1. allow UTV system suppliers to design the internal frame and components to withstand seismic forces properly at the development and/or design stage of their products and systems even when the site and facility where they are installed are not yet specified; and
2. allow UTV system designers to provide users with the information needed to appropriately secure the UTV system within their facility.

10.1.1 Because preventing all damage to the UTV system may be impractical, the design should be made to control the failure and displacement of components that may result in incident that can cause any harm that is ranked catastrophic or severe in the severity group of SEMI S10.

10.2 *Design Seismic Loads* — The components of UTV system and all devices used for anchoring the UTV system should be designed as described by ¶ 10.2.1 or ¶ 10.2.2. If ¶ 10.2.1 and ¶ 10.2.2 are not applicable due to the actual installation or structural configuration of the UTV system, ¶ 10.2.3 should be followed.

10.2.1 For the UTV system supported by the structure of the floor halfway between grade elevation and roof elevation, each component of the system should be designed to withstand a horizontal seismic load of 100% of the weight of the component and a vertical seismic load of ±50% of the weight of the component, both acting at the component's center of mass. The seismic design should be done to include both cases when the UTV is empty and when the UTV is fully loaded.

10.2.2 For the UTV system supported directly by the roof structure or indirectly through secondary frames, each component of the system should be designed to withstand a horizontal seismic load of 150% of the weight of the component and a vertical seismic load of ±75% of the weight of the component, both acting at the component's center of mass. The seismic design should be done to include both cases when the UTV is empty and when the UTV is fully loaded.

10.2.3 UTV system suppliers should follow Appendix 1 and determine proper seismic loads. The factors of Equation A1-1 in Appendix 1 can be changed based on the actual structural configuration of the UTV system.

10.2.4 UTV system suppliers should design structurally the components of UTV system and all devices by seismic force analysis and determine seismic measures.

NOTE 5: Horizontal seismic loads should be calculated independently on each of the X-axis and Y-axis, or on the axis that produces the largest loads on the anchorage points.

NOTE 6: It is not the intent of this Document to show a complete guide of the seismic protection design or calculations. The seismic protection systems and methods vary from country to country: USA, Taiwan and Japan, etc. As practical guidebooks, there are FEMA 451 — Seismic Design and Construction Guideline for Building Equipment published by the Building Center of Japan (available in Japanese language only) and FM Global Property Loss Prevention Data Sheets 1-2 Earthquakes.

NOTE 7: Because the UTV system may be placed into service anywhere in the world, it is recommended that the seismic protection design of the UTV system be based upon requirements that allow the UTV system, as designed, to be installed in most sites worldwide. The above horizontal seismic loads are based on requirements for General Manufacturing and Process Machinery in Seismic Zone (Ss=200%, Fa=1.0) in FEMA 450 — NEHRP Recommended Provisions and Commentary for Seismic Regulations for New Buildings and Other Structures. The building structure is assumed to be single-fabrication-floor facility as major and typical. The vertical seismic loads conform to the seismic design code for buildings in Taiwan for general sites and Taipei Basin and also to the Seismic Design and Construction Guideline for Building Equipment of Japan. They are assumed to satisfy most design situations worldwide.

NOTE 8: It is recommended that the user engage a professional mechanical, civil, or structural engineer to make sure the conditions above are appropriate for the planning site and facility.

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