SEMI S7-96
SAFETY GUIDELINES FOR ENVIRONMENTAL, SAFETY, AND HEALTH (ESH) EVALUATION OF SEMICONDUCTOR MANUFACTURING EQUIPMENT

NOTICE: This safety guideline does not purport to address all of the safety issues associated with its use. It is the responsibility of the user of this guideline to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

NOTE: This entire document was revised in 1995.

1 Purpose

1.1 The purpose of this document is to provide guidance to the equipment manufacturer or supplier, the evaluator, and the user to define responsibilities and to ensure the objective evaluation of designs and equipment.

1.2 Preservation of employee safety and conformance to environmental regulations are important criteria when selecting semiconductor manufacturing equipment. A basic expectation is that the equipment manufacturer will design and build inherently safe (to the operator, facility, and environment) equipment and will provide documentation that the equipment has been evaluated against a specific set of criteria, verifying conformance thereto.

1.3 A safety evaluation is important for a variety of reasons, including: operator safety, equipment reliability, conformance to regulatory (e.g., OSHA, EPA, local fire and building codes) and insurance requirements. These are intended to ensure a safe and environmentally responsible workplace.

2 Scope

2.1 This document defines the requirements for ESH evaluation of equipment design and operation.

2.2 These guidelines include:

- Purpose
- Scope
- Referenced Documents
- Terminology
- Codes, Regulations, and Standards
- Requirements for Third Party Evaluators
- Contracting with an Evaluator
- Documentation Provided to the Evaluator by the Supplier
- Evaluation Methods
- Contents of Reports
- Provision of Reports to Potential Users

2.3 The evaluation program is designed to be used in addressing the ESH aspects of new, refurbished, or resold process tools prior to the tool being delivered to the user.

2.4 The evaluator may be within the supplier's organization. As some equipment suppliers do not maintain a comprehensive ESH equipment evaluation program in-house, third party contractor(s) may be used. In either case, the evaluator should meet the requirements listed in Section 6.

3 Referenced Documents

NOTE: All documents cited shall be the latest published versions.

3.1 *SEMI Document*

SEMI S2 — Safety Guidelines for Semiconductor Manufacturing Equipment

3.2 *ANSI Document*[1]

Z34.1 — Third Party Certification Program

4 Terminology

4.1 *supplier* — The party providing the equipment to, and communicating directly with, the user. It may be the manufacturer or an equipment representative or distributor. The supplier has the responsibilities of obtaining the required information from the manufacturer or other sources and of providing it to the evaluator.

4.2 *user* — The purchaser of semiconductor manufacturing who will use the equipment.

5 Codes, Regulations, and Standards

5.1 Semiconductor equipment should conform to the applicable codes, regulations, and standards. The

[1] American National Standards Institute, 1430 Broadway, New York, NY 10018

evaluation should include accordance with the codes, guidelines, and the local regulations of potential users. To assist in this, the supplier should provide the evaluator with a list of jurisdictions in which the supplier intends to market the equipment.

6 Requirements for Third Party Evaluators

6.1 The evaluator should have at least five years' experience in the semiconductor equipment or fabrication or similar industry and:

a. be established in accordance with ANSI Z34.1, Third Party Certification Program; or

b. consist of individual(s) who are registered or certified professional(s) in the discipline(s) in which the evaluations were performed; or

c. consist of individual(s) with baccalaureate or higher degrees in related technical discipline(s) (engineering or science).

NOTE: In the United States, the United Kingdom, and several other countries, the “baccalaureate” or “bachelor of science” degree is awarded upon completion of a technical course of study, typically of four years, at a college or university. It is the degree prerequisite for professional registration in most U.S. states and for study towards a master's degree or doctorate.

7 Contracting with an Evaluator

7.1 The supplier initiates the evaluation by providing a “scope of work” to the evaluator. This scope should define the services to be provided, including the standards and guidelines that will be used to evaluate the equipment and the responsibilities of each party.

7.2 The evaluator is responsible only to the supplier.

7.3 Changes made to the equipment to bring it into accord with codes, regulations, and guidelines are the responsibility of the supplier.

8 Documentation Provided to the Evaluator by the Supplier

8.1 Any previous evaluations of equipment related to the included documents, with all appropriate documentation.

8.2 Material Safety Data Sheets (MSDS's) for all chemicals used in the maintenance of the equipment and for those used in baseline and known, user-intended processes.

8.3 When information is known for user intended or baseline process(s), the evaluator should be provided the estimated consumption of raw materials and the amount(s) of by-products generated as described in Section 20.2.1 of SEMI S2.

8.4 Copies of the equipment's installation, maintenance, and operation manuals.

8.5 Copies of any hazard analysis or safety reviews of the subject equipment.

8.6 A list of all assemblies and sub-assemblies.

8.7 Design drawings and schematics.

9 Evaluation Methods

9.1 The evaluator should ensure the review of the supplier's documents (listed above) and the outlining of deficiencies with corrective and/or improvement recommendations.

9.2 The ESH testing and evaluation may proceed concurrently with the document review by agreement of the parties.

9.3 After the supplier has addressed all deficiencies noted in the third party report, the supplier should review the actions taken with the evaluator. If appropriate, the evaluator may re-evaluate some or all of the areas addressed.

10 Contents of Reports

10.1 An interim report should be provided to the supplier after evaluator has performed the agreed services. It should include an overview of the services performed, the standards, guidelines, and codes against which the equipment was evaluated, and the evaluator's findings. Items found in conformance with the documents should be documented as well as those found to be deficient.

10.2 The evaluator's final report should be provided after the supplier and the evaluator have agreed that the changes made have brought the equipment into conformance with the applicable documents. This report should be attached to the supplier's bid to a potential user.

10.3 If the evaluator and the supplier differ in their interpretation of requirements of the applicable documents, the creator of the document in question should be consulted for an interpretation. If the difference remains unresolved, the evaluator should include this and any other unresolved issues in its final report.

10.4 The final report should be signed by the evaluator and should contain at least the following sections:

10.4.1 *Management Summary* — A brief description of the evaluation, recommendations, and results. A statement that the equipment does or does not conform (with noted exceptions) with the ESH specifications, guidelines, and codes that were used for the evaluation.

10.4.2 *System Description* — Type of equipment evaluated and its function.

10.4.3 *Analysis and Test Methods* — Specific tests used to determine the compliance with the criteria. This should include a point-by-point evaluation of requirements listed in the pertinent specifications.

10.4.4 *Environmental, Safety, and Health Assessment* — The detailed results of the evaluation, including the point-by-point results, using SEMI S2 as an outline. If a section is not applicable, so state.

10.4.5 *Body* — The body of the report should describe the type of ESH evaluations, methods, and test equipment used, and results achieved. The methods used may include: fault testing, fault tree analysis, task analysis, industrial hygiene analysis, chemical mass balance, and ergonomics assessment.

10.4.6 *Recommendations* — Listings of recommendations made by the evaluator and statements that the recommendations were implemented, rejected, or otherwise addressed.

10.4.7 *Detailed Analysis and Test Worksheets* — Copies of the laboratory and field test data.

10.4.8 *Additional Information/Remarks* — Any information that may clarify tests performed, exceptions not specifically defined in the documents, precautions for certain applications of the equipment, or conditions of operation.

11 Provision of Reports to Potential Users

11.1 Whenever possible, copies of the evaluator's final report should be made available to potential users. If the supplier considers some information in the evaluator's report proprietary, the supplier should write an overview report that includes all environmental, safety, and health information with all proprietary information deleted.

11.2 Deficiencies that have been remedied and now meet the appropriate standards do not need to be listed in the report available to users.

11.3 This modified report should be signed by the evaluator.

SEMI S8-0705
SAFETY GUIDELINES FOR ERGONOMICS ENGINEERING OF SEMICONDUCTOR MANUFACTURING EQUIPMENT

These safety guidelines were technically approved by the global EH&S Committee. This edition was approved for publication by the global Audits and Reviews Subcommittee on April 7, 2005. It was available at www.semi.org in June 2005 and on CD-ROM in July 2005. Originally published in 1995; previously published in 2003.

NOTICE: The official values in this guideline are expressed in The International System of Units (SI). Values that:

— are expressed in inch-pound (also known as "US Customary" or "English") units,

— are enclosed in parentheses, and

— directly follow values expressed in SI units

are not official, are provided for reference only, and might not be exact conversions of the SI values.

1 Purpose

1.1 These guidelines provide ergonomics design principles and considerations for semiconductor manufacturing equipment.

1.2 The purpose of these guidelines is to promote compatibility between the user and the equipment in the manufacturing environment. The following general principles are integral to the ergonomics design and evaluation of equipment:

1.2.1 The equipment should be designed to optimize safety by distributing tasks. Tasks should be distributed among hardware, software, and users to make the best use of their respective capabilities and to minimize limitations and hazards. Appropriate distribution of tasks will also optimize performance.

1.2.2 Equipment should be designed to minimize potential for errors and mishaps, by conforming to users' expectations.

1.2.3 The equipment design should reduce fatigue and injury by fitting the equipment to the expected body size, strength, and range of motion characteristics of the user population. Such design will also facilitate task performance.

2 Scope

2.1 The guidelines address safety aspects of ergonomics engineering in the design of semiconductor manufacturing equipment. It should be noted that in order to ensure comprehensive coverage of potential safety hazards, some guidelines also address general design goals for effective human-machine performance. The guidelines apply to the design, operation, maintenance, and service of semiconductor manufacturing equipment, as well as, to a limited extent, equipment installation (see ¶7.3).

NOTICE: This safety guideline does not purport to address all of the safety issues associated with its use. It is the responsibility of the users of this safety guideline to establish appropriate safety and health practices and determine the applicability of regulatory or other limitations prior to use.

3 Limitations

3.1 International, national, and local standards, codes, and regulations must be consulted to ensure that equipment meets regulatory requirements**.**

3.2 Human factors data compiled in references and specifications are influenced by the population from which they were drawn and the reason they were collected. Human factors design criteria are sometimes based on studies using few subjects or are context-specific. Ergonomics experts should be consulted where data development or interpretation is required.

3.3 The equipment design should incorporate reasonable accommodations for users with special needs, such as left-handedness and color blindness. Where feasible the design should also accommodate users with hearing or vision impairments and/or physical disabilities. It should be understood that although designing for the target user population will accommodate some users with special needs, these guidelines cannot anticipate and fully accommodate all such users.

3.4 Existing models and subsystems that meet previous versions of SEMI S8 should continue to meet the guidelines of SEMI S8 in force at the time of design. Models with redesigns that significantly affect the ergonomic design of the equipment should include conformance to the latest version of SEMI S8 for the redesign.

NOTE 1: Conformance with this document is believed to be a suitable substitute for conformance with its predecessors.

3.5 Conformance with the guidelines in Appendix 1 (SESC) constitutes conformance with SEMI S8.

4 Referenced Standards and Documents

4.1 *SEMI Standards*

SEMI E95 — Specification for Human Interface for Semiconductor Manufacturing Equipment

SEMI S1 — Safety Guideline for Equipment Safety Labels

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

4.2 *CEN/CENELEC Standards*[1]

4.2.1 European Norm (EN) standards are listed herein for application to semiconductor manufacturing equipment to be used in the European Union (EU). As EN standards are intended for use with a broad range of industrial and consumer products, conflicts with SEMI safety guidelines are likely. Additionally, provisional EN (prEN) standards are subject to revision prior to adoption.

EN 894-2 — Safety/Ergonomics for Displays

EN 894-3 — Safety/Ergonomics for Control Actuators

EN 60204-1 — Safety of Machinery — Electrical Equipment of Machines, Part 1. Specification for General Requirements

4.3 *Military Standard* [2]

MIL-STD-1472 — Human Engineering Design Criteria for Military Systems, Equipment, and Facilities

4.4 *NFPA Standard*[3]

NFPA 79 — Electrical Standard for Industrial Machinery

4.5 *ISO Standard*[4]

ISO 9241 — Ergonomic Requirements for Office Work with Visual Display Terminals

4.6 *Other Standards and Documents*

Humanscale, The MIT Press, Massachusetts Institute of Technology, Cambridge, MA 02142, 1974

ANSI/IES RP7[5] — Practice for industrial lighting

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1 European committee for standardization (CEN)/European Committee for Electrotechnical Standardization (CENELEC), Central Secretariat: rue de Stassart 35, B-1050 Brussels, Belgium, Website: www.cenelac.org

2 United States Military Standards, Available through the Naval Publications and Forms Center, 5801 Tabor Avenue, Philadelphia, PA 19120-5099, USA. Telephone: 215.697.3321

3 National Fire Protection Association, 1 Batterymarch Park, Quincy, MA 02269, Website: www.nfpa.org

4 International Organization for Standardization, ISO Central Secretariat, 1, rue de Varembé, Case postale 56, CH-1211 Geneva 20, Switzerland. Telephone: 41.22.749.01.11; Fax: 41.22.733.34.30, Website: www.iso.ch

5 American National Standards Institute, Headquarters: 1819 L Street, NW, Washington, DC 20036, USA. Telephone: 202.293.8020; Fax: 202.293.9287, New York Office: 11 West 42nd Street, New York, NY 10036, USA. Telephone: 212.642.4900; Fax: 212.398.0023, Website: www.ansi.org

Waters, Thomas, et. al., *Application Manual for the Revised NIOSH Lifting Equation,* U.S. Department of Health and Human Services (NIOSH), Cincinnati, OH, 1994.

A. Mital, A.S. Nicholson, M.M. Ayoub: *A Guide to Manual Materials Handling,* Taylor and Francis, London, 1993.

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

5 Terminology

5.1 *Abbreviations and Acronyms*

5.1.1 *MAWL* — Maximum Acceptable Weight of Lift

5.1.2 *MMH* — Manual Material Handling

5.1.3 *SESC* — Supplier Ergonomics Success Criteria (See Appendix 1.)

5.2 *Definitions*

5.2.1 *administrative controls* — administrative controls modify the way in which a job is performed without involving equipment design. They are non-engineering controls which include: job rotation, job enlargement, work-rest scheduling, micro-breaks, and stretching exercises. Engineering controls are preferred over administrative controls.

5.2.2 *anthropometric considerations* — design considerations based upon anthropometric (e.g., size and strength) limitations of user personnel.

5.2.3 *anthropometry* — description of the physical measurement of humans (e.g., size, strength).

5.2.4 *cognitive* — relating to human information processing, perception, and attention.

5.2.5 *critical controls and displays* — controls and displays which prevent the equipment from entering, or indicate that equipment is entering an unsafe condition in which hazards to personnel or damage to equipment may occur. Emergency Off (EMO) switches, interlock defeat indicators, and malfunction alarms are examples of critical controls and displays.

5.2.6 *cumulative trauma disorder* — a disorder which results from the accumulation of stresses (e.g., forces, repetitive movements, etc.) to a body part over a period of time.

5.2.7 *duration* — the length of time of a cycle or the entire task, which represents the time of exposure to single or multiple risk factors.

5.2.8 *emergency off (EMO)* — a control circuit which, when activated, places the equipment into a safe shutdown condition.

5.2.9 *engineering control* — a method to eliminate or mitigate a hazard through equipment design.

5.2.10 *ergonomic-related hazard* — an equipment or workplace condition that creates stress to the user that contributes to the risk of developing either an acute injury or a cumulative trauma disorder.

5.2.11 *ergonomic issues* — those issues dealing with the user’s physical and cognitive needs, capabilities, and human performance limitations in relation to the design of machines, tasks, and other features of the human’s working environment.

5.2.12 *ergonomics* — the study of human mental and physical capability in relation to the working environment and the equipment operated by the worker.

5.2.13 *excessive reach* — a reach which may result in biomechanical or other stress to the user.

5.2.14 *extended reach* — a reach which requires either stretching, stooping, crouching, bending forward at the waist greater than 20 degrees, or shoulder flexion or abduction greater than 45 degrees.

5.2.15 *force* — the mechanical effort to accomplish a specific movement or exertion. These include: static exertions, which produce no motion but have significant duration; dynamic exertions, which are motions including lifting, pushing, pulling; and contact stress, which is localized pressure exerted against the skin by an external force.

5.2.16 *frequency* — how often a task is performed over time.

5.2.17 *frequently used* — used in processing or job cycle at least once every hour. Multiple tool operation by a single operator should be considered.

5.2.18 *human error* — errors which include: failure to perform a required function; performing a function that has an undesirable consequence; failure to recognize and correct a hazardous condition; or inadequate or incorrect response to a contingency.

5.2.19 *inadvertent actuation* — accidental or unintentional activation or deactivation of a control.

5.2.20 *infrequently used* — used in processing or job cycle less frequently than once every hour. Multiple tool operation by a single operator should be considered.

5.2.21 *installation* — the activities performed after the equipment is received at a user site through preparation for initial service, including transportation, lifting, uncrating, placement, leveling, and facilities fit up.

5.2.22 *lateral pinch* — grip in which the object is held between the thumb and the side of the index finger (often referred to as key grip).

5.2.23 *maintenance* — planned or unplanned activities intended to keep equipment in good working order.

5.2.24 *mock up* — a full size physical model of the equipment, generally made of relatively inexpensive materials, used for human factors evaluation.

5.2.25 *neutral posture* — the position of the human body in which the joints are least stressed. Generally, the body in its neutral position is standing erect with the eyes looking forward, and the arms hanging by the sides.

5.2.26 *non-neutral (awkward) postures* — The position of a joint(s) away from its neutral, or least stressed, posture.

5.2.27 *normal line of sight* — the line extending from the eyes, perpendicular to the interoccular line and 15 degrees below the horizontal position of the eye.

5.2.28 *operation* — consists of functions by which the operator causes the equipment to perform its intended purpose; these may include loading product and setting or manipulating external controls.

5.2.29 *operator* — a user that interacts with the equipment only to the degree necessary for the equipment to perform its intended function.

5.2.30 *override* — to take precedence over the current control system state.

5.2.31 *palmar pinch* — grip where the fingers press against the palm of the hand, with the object held between the fingers and the palm. Thumb is not used (e.g., picking up a sheet of plywood).

5.2.32 *personal protective equipment (PPE)* — equipment and clothing worn to reduce potential for personal injury from hazards associated with the task to be performed (e.g., chemical gloves, respirators, safety glasses, etc.). In the context of this document, cleanroom attire (e.g., gloves, smocks, booties, hoods) is not considered personal protective equipment.

5.2.33 *power grip* — a grip in which the fingers and thumb wrap entirely around the handle such that the thumb contacts or overlaps the index finger.

5.2.34 *postural stress* — stress occurring when a body position places undue load on the muscles, tendons, nerves, and blood vessels, or produces pressure on a joint.

5.2.35 *primary viewing area* — the 30 degree cone around the normal line of site (15 degrees above, below, and to either side of the line of sight).

5.2.36 *problem tasks* — tasks which have been defined as presenting ergonomically incorrect conditions that are likely to cause biomechanical stresses or injury to personnel, misoperation, or damage to equipment or the product.

5.2.37 *risk factors* — those elements of the design which allow an increased potential for injury/illness to personnel, or for damage to equipment, environment, or product.

5.2.38 *semiconductor manufacturing equipment* — equipment used in the design, development, manufacture, assembly, measurement and test of semiconductors, and associated semiconductor support processes.

5.2.39 *service* — unplanned activities intended to return equipment, which has failed, to good working order.

5.2.40 *static posture* — a fixed position, with minimal movement of the particular body parts.

5.2.41 *stooping* — bending the head and shoulders, or the general body, forward and downward from an erect position.

5.2.42 *task* — a group of related job elements performed within the work cycle and directed toward a specific objective.

5.2.43 *task analysis* — an analytical process employed to determine the specific actions required of the user when operating, maintaining, or servicing equipment, or doing work on single or multiple tools. Within each task, steps are described in terms of the perception, decision-making, memory storage, posture, and biomechanical requirements, as well as the expected errors.

5.2.44 *tip pinch* — grip in which the object is held between the tips of the thumb and index finger.

5.2.45 *user* — person interacting with the equipment. Users may include operators, maintainers, service personnel, and others.

5.2.46 *user population* — a specific cross section of persons that may reasonably be expected to interact with the equipment to perform operation, maintenance, or service tasks.

5.2.47 *validation testing* — testing to confirm effectiveness of design. An item's "effectiveness" is viewed in terms of its functional design, specific to SEMI S8.

5.2.48 *WIP nest* — a storage structure for Work in Process (WIP).

5.2.49 *work environment* — the location where semiconductor devices and associated support processes are designed, developed, manufactured, assembled, measured, and tested.

5.2.50 *workplace layout* — the physical arrangement of equipment in the facility.

5.2.51 *workspace* — the available area where the user is expected to operate, maintain, and service the equipment.

5.2.52 *workstation* — the location where equipment controls and displays are found or the location of loading/unloading of material.

6 General Guidelines

6.1 *Ergonomics-Related Safety Issues* — Ergonomics-related safety issues may exist whenever equipment design, installation, operation, service, or maintenance factors result in task demands that exceed the information processing or physical capabilities of properly trained users. For example, ergonomics-related safety issues may result from:

6.1.1 Static or awkward postures,

6.1.2 Repetitive motion,

6.1.3 Poor access, inadequate clearance, and excessive reach,

6.1.4 Lifting of heavy or bulky components,

6.1.5 Displays that are difficult to read or understand,

6.1.6 Controls that are confusing to operate or require too much force, and

6.1.7 Use of non-specific warnings or faults to communicate machine problems.

6.2 Safety-related issues should be designed out or otherwise reduced to an acceptable level prior to production. Ergonomics-related safety issues are reduced by implementing sound ergonomics engineering principles in design, and structuring job requirements around human performance capabilities and limitations.

6.3 Equipment should be designed to reduce or eliminate the potential types of error caused by human-machine or human-task mismatch (e.g., inadvertent actuation, errors of omission or commission).

6.4 Engineering controls are the preferred means to reduce hazards. Where an engineering approach to ergonomic hazard control is not feasible, the user should implement administrative controls to mitigate hazards by reducing the duration, frequency, or severity of exposure.

6.5 Highest priority should be placed on issues which have the potential of resulting in injury to personnel. Secondary priority should be placed on issues which have the potential of resulting in significant damage to equipment.

6.6 Information exchange between equipment suppliers and users regarding human-machine interface issues is encouraged during the development stage, as part of beta site testing, after equipment is in full production, and throughout the life cycle of the equipment.

6.7 Ergonomics evaluation should be performed throughout the conception, design, build, and install phases to determine whether ergonomics guidelines have been met. The examination should yield a completed SESC document (see Appendix 1).

6.7.1 Equipment evaluation should identify risk factors associated with equipment design that affect operation, training, installation, maintenance, or service tasks.

6.7.2 Use of mock-ups and simulations are beneficial to identify and resolve ergonomic issues before the design is finalized. Testing should be performed with individuals who are representative of the user population under anticipated working conditions.

6.7.3 The evaluation should include consideration of multiple pieces of equipment under the control of one individual, resulting in an operation being repeated several times sequentially. The supplier should state the criteria for this scenario and include it in the report.

6.8 The overall objective is to provide for equipment effectiveness and for worker safety, convenience, and comfort when operating and maintaining the equipment.

6.9 Damage or undue deterioration of required garments or PPE should not occur as a result of equipment operation. Controls, such as knobs and switches, should be designed to be compatible with gloves worn by users for contamination control or personal protection. For example, cleanroom gloves typically reduce grip strength by 15%. Equipment displays should consider the potential for impaired vision and hearing that may occur with the use of cleanroom hoods, chemical goggles, or face shields.

6.10 Technical documentation (e.g., manuals) and on-equipment instructions (e.g., labels, indicators and screen menus) should be consistent in action, terminology, symbols, and format.

6.11 Equipment customized to meet specific customer requirements should not increase the level of ergonomic risk.

6.12 For recommendations on human interface design, see SEMI E95.

NOTE 2: SEMI E95 provides information on human computer interface. It is not the intent of SEMI S8 to incorporate the requirements of SEMI E95 by reference.

7 Documentation

7.1 The supplier should provide an evaluation of the equipment to SEMI S8 using Appendix 1, “Supplier Ergonomic Success Criteria” for measurable criteria. The evaluation should include a determination of the level of risk associated with non-conformance items. Evaluation of risk should be compatible with the SEMI S10 severity categories; catastrophic, severe, moderate, and minor.

7.1.1 For each item in Appendix 1 which does not meet the criteria, the evaluation report should include the measured actual dimensions, and state any supporting rationale for non-compliance. Supporting rationale may include test data or documented engineering judgment. EXCEPTION: For Section 1, the manual material handling analysis, the evaluation report should provide documented calculations regardless of the outcome of the analysis.

7.1.2 The evaluation report should also include the following information: manufacturer’s model number, serial number of unit evaluated, date the equipment was evaluated, a list of all tasks which were evaluated as part of the analysis and the name of the person performing the evaluation.

7.2 Supplier provided documentation should include administrative controls intended by the supplier to mitigate ergonomic risks.

7.3 Supplier provided documentation should illustrate any installation requirement necessary to meet SEMI S8 guidelines (e.g., Diagram should show clearance area required for opening hinged panels, operator working area, allowable range of vertical foot adjustment to keep ergonomic measurements within SESC acceptable limits, etc.).

7.4 The evaluation should specify an installation reference point for each independently adjustable section of the equipment for vertical measures. If there is a supplier recommended installation height, the reference for the evaluation should be the same. This installation height should be included in the supplier's installation documentation.

NOTE 3: Installation documentation may include installation manuals and other information provided by supplier addressing installation concerns.

8 Related Documents

8.1 *SEMI Standard*

SEMI S13 — Safety Guidelines for Operation and Maintenance Manuals Used with Semiconductor Manufacturing Equipment

8.2 *ANSI Documents*

ANSI Z535.4 — Product Safety Signs and Labels

8.3 *CEN/CENELEC Standards*[6]

EN 614-1 — Safety of Machinery — Ergonomic Design Principles, Part 1. Terminology and General Principles

EN 894-1 — Safety/Ergonomics for Operator Interaction

EN 50099-2 — Safety/Marking Principles

8.4 *NIOSH Documents*[7]

NIOSH Publication No. 81-122 — *Work Practices Guide for Manual Lifting*, National Institute for Occupational Safety and Health, 1981.

Revised NIOSH Equation, *Ergonomics*, Vol. 36, No. 7, 1993.

8.5 *SAE Document*[8]

SAE J833 — Human Physical Dimensions

8.6 *SEMATECH Documents*[9]

Preventing User-Hostile Interfaces in IC-Fab Equipment — Ergonomic Approaches for Preventing Ten Frequent Interface Problems, Miller, Dwight P. and Whitehurst, Hugh, SEMATECH Technology Transfer #92091299NA-ENG, Nov. 1992.

SEMATECH SCC User interface Style Guide, 1.0. 92061179A-ENG, August 21, 1992.

8.7 *Other Documents*

Bailey, Robert W., *Human Performance Engineering*, Prentice Hall, 1989.

Eastman Kodak Company, *Ergonomic Design for People at Work, Vols. 1 and 2,* Van Nostrand-Reinhold, 1983.

EN ISO 7250 — *Basic human body measurements for technological design*

EN ISO 14738 — *Safety of Machinery, Anthropometric requirements for the design of workstations at machinery*

Grandjean, E., *Fitting the Task to the Man: A Textbook of Occupational Ergonomics* (4th Ed.), Taylor & Francis, 1988.

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6 European Committee for Standardization (CEN)/European Committee for Electrotechnical Standardization (CENELEC), Central Secretariat, rue de Stassart 35, B-1050 Brussels, Belgium, Website: www.cenelec.com.

7 National Institute for Occupational Safety and Health, Technical Information Branch, 4676 Columbia Pkwy, Cincinnati, OH 45226. Website: www.niosh.com.my.

8 Society of Automotive Engineers, 400 Commonwealth Drive, Warrendale, PA 15096 USA. Website: www.sae.org.

9 International SEMATECH, 2706 Montopolis Drive, Austin, TX 78741, USA., Website: www.sematech.org

Grether W.F. and Baker C.A., 1972, Visual Presentation of Information in Van Cott and Kincade *Human Engineering to Equipment Design*, Washington DC, US Government Printing Office.

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Pheasant, Stephen, Bodyspace — *Anthropometry, Ergonomics and Design*, Taylor & Francis, 1988.

Salvendy, Gavriel (ed.), *Handbook of Human Factors*, Wiley, 1987.

Sanders, Mark S. and McCormick, Ernest, *Human Factors in Engineering and Design* (7th Ed), McGraw-Hill Book Company, 1993.

Snook, Stover and V. Ciriello, The Design of Manual Handling Tasks — Revised Tables of Maximum Acceptable Weights and Forces, *Ergonomics*, Vol. 34, No. 9, 1991.

VanCott, Harold P. and Kinkade, Robert (eds.), *Human Engineering Guide to Equipment Design*, U. S. Government Printing Office, 1972.

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

APPENDIX 1
SUPPLIER ERGONOMIC SUCCESS CRITERIA (SESC)

NOTICE: The material in this appendix is an official part of SEMI S8 and was approved by full letter ballot procedures by the North American Regional Standards Committee.

Table A1-1 Supplier Ergonomic Success Criteria Checklist

Section	*Indicator*	*Acceptance Criteria* *Metric Units (US Customary Units)*	*Actual*	*Conforms/Does Not Conform/Not Applicable*
1	**Manual Material Handling**			
1.1	Potentially hazardous manual material handling tasks performed as part of operations, maintenance, or service are analyzed utilizing appropriate procedures. NOTE: Two hand lifting or lowering tasks should be analyzed: if the object being handled weighs more than 44.5 N (10 lbf); OR, if the object weighs more than 22.2 N (5 lbf) and the anticipated frequency is greater than 1 lift every 5 minutes. See Appendix 2 for further information.	Analysis and results documentation. Table A2-2, Appendix 2, or the equivalent, should be used to document 2 hand lift/lower analysis.		
2	**Product Loading in a Standing Posture** (Applicable to all media other than wafer cassettes including JEDEC trays, magazines, and reticle cassettes.			
2.1	Clearance provided for finger thickness.	minimum 38 mm (1.5 in.)		
2.2	Clearance provided for hand thickness.	minimum 76 mm (3.0 in.)		
2.3	Reach distance measured from the leading edge of the tool or obstruction to the hand/product coupling point(s).	maximum 330 mm (13 in.)		
2.4	Vertical coupling point of hand to product in load position	maximum 1010 mm (40 in.) minimum 890 mm (35 in.)		
3	**Wafer Cassette Loading**			
3.1	Wafer cassette loading should not require greater than 10 degrees cassette rotation in any axis. NOTE: Unless otherwise specified, you should assume that 200 mm or smaller wafers are transported in the vertical orientation and that 300 mm wafers are transported in the horizontal orientation.	less than 10 degrees rotation in any axis		
3.2	Load port height, vertical distance from standing surface (150–200 mm wafers).	maximum 960 mm (38 in.) minimum 890 mm (35 in.)		
3.3	Maximum lip height in front of cassette load port over which cassette is lifted (150–200 mm wafer cassettes only). Measure lip height from the load surface.	maximum 30 mm (1.2 in.)		
3.4	Reach distance from the leading edge of the tool or obstruction to the coupling point(s) on rotation device or the product grasp point.	maximum 330 mm (13 in.)		

Section	*Indicator*	*Acceptance Criteria Metric Units (US Customary Units)*	*Actual*	*Conforms/Does Not Conform/Not Applicable*
3.5	Minimum hand clearance on either side of the cassette, measured from the side of the cassette to the nearest adjacent object.	minimum 76 mm (3.0 in.)		
4	**Work in Process Storage** (specific to wafer cassettes)			
4.1	Integral wafer cassette/lot box storage shelf height (150 and 200 mm wafer cassette/lot boxes only)	maximum (1 box deep) 1520 mm (60 in.) maximum (2 boxes deep) 1220 mm (48 in.) minimum 460 mm (18 in.)		
5	**Manual Wafer Cassette Rotation Device Design**			
5.1	Handle height, couple point for hand(s) from standing surface.	maximum 1206 mm (47.5 in.) minimum 838 mm (33 in.)		
5.2	Hand grip(s) shall allow for a full “power grip” similar to grabbing a rung on a ladder or holding a pistol.	Allows for a full power grip in either pronated (palm facing down) or neutral (handshake position) posture.		
5.3	Single hand lift force	maximum 37.8 N (8.5 lb.) This value includes a 15% capacity reduction due to cleanroom glove use. Wrist deviation reduces further strength capacity by 15%.		
5.4	Two hand lift force	maximum 64.5 N (14.5 lb.) This value includes a 15% capacity reduction due to cleanroom glove use. Wrist deviation reduces further strength capacity by 15%.		
6	**Handle Design** (Handle dimensions are correct for use of bare hand or use of typical cleanroom gloves) NOTE: See Appendix 3 for depiction of handle types.			
6.1	Handle surface finish	all edges radiused		
6.2	Cylindrical handle			
6.2.1	Cylindrical handle diameter (D)	maximum 38 mm (1.5 in.) minimum 25 mm (1.0 in.)		
6.2.2	Cylindrical handle length (L)	minimum 127 mm (5.0 in.)		
6.3	Circular or triangular handle			
6.3.1	Circular or triangular handle diameter (D)	maximum 90 mm (3.5 in.) minimum 50 mm (2.0 in.)		
6.3.2	Circular or triangular handle height (thickness) (H)	maximum 25 mm (1.0 in.) minimum 19 mm (0.75 in.)		
6.4	Ball handle			
6.4.1	Ball handle diameter	maximum 63 mm (2.5 in.) minimum 38 mm (1.5 in.)		
6.5	Pliers handle			
6.5.1	Pliers handle grip span (S)	maximum 89 mm (3.5 in.) open minimum 38 mm (1.5 in.) closed		

Section	*Indicator*	*Acceptance Criteria Metric Units (US Customary Units)*	*Actual*	*Conforms/Does Not Conform/Not Applicable*
6.5.2	Pliers handle length (L)	minimum 127 mm (5.0 in.)		
6.6	Pistol grip handle			
6.6.1	Pistol grip handle diameter (D)	maximum 63 mm (2.5 in.) minimum 38 mm (1.5 in.)		
6.6.2	Pistol grip handle length (L)	minimum 127 mm (5.0 in.)		
6.7	Enclosed handles NOTE: Handle diameter refers to the surface of the handle presented to the inside of the curled fingers. Enclosed handles need not be made solely from cylindrical stock.			
6.7.1	Enclosed handle, full hand power grip (suitcase handle) Width (W) Depth (D) Diameter (d)	 minimum 127 mm (5.0 in.) minimum 45 mm (1.75 in.) maximum 25 mm (1.0 in.)		
6.7.1.1	Diameter (d), requiring no greater than 71 N (16 lbf) force	minimum 6.3 mm (0.25 in.)		
6.7.1.2	Diameter (d), requiring no greater than 89 N (20 lbf) force	minimum 13 mm (0.5 in.)		
6.7.1.3	Diameter (d), requiring no greater than 180 N (40 lbf) force	minimum 19 mm (0.75 in.)		
6.7.2	Enclosed handle, three fingers Width (W) Depth (D) Diameter (d) Force	 minimum 90 mm (3.5 in.) minimum 38 mm (1.5 in.) minimum 6.3 mm (0.25 in.) maximum 71 N (16 lbf)		
6.7.3	Enclosed handle, two fingers Width (W) Depth (D) Diameter (d) Force	 minimum 60 mm (2.5 in.) minimum 38 mm (1.5 in.) minimum 6.3 mm (0.25 in.) maximum 51 N (11.5 lbf)		
6.7.4	Enclosed handle, one finger Width (W) Depth (D) Diameter (d) Force	 minimum 38 mm (1.5 in.) minimum 38 mm (1.5 in.) minimum 3.2 mm (0.13 in.) maximum 27 N (6 lbf)		
6.8	Hook grasp handle			
6.8.1	Hook grasp handle (four fingers) Opening length (L) Opening width (W) Depth (d) Lip length (l)	 minimum 90 mm (3.5 in.) minimum 38 mm (1.5 in.) minimum 50 mm (2.0 in.) minimum 50 mm (2.0 in.)		
6.8.2	Hook grasp handle pull force (four fingers)	maximum 80 N (18.0 lbf)		
6.9	Finger pull handle			
6.9.1	Finger pull handles (four fingers) Opening length (L) Opening width (W) Depth (d) Lip length (l)	 minimum 90 mm (3.5 in.) minimum 25 mm (1.0 in.) minimum 19 mm (0.75 in.) minimum 19 mm (0.75 in.)		

Section	*Indicator*	*Acceptance Criteria* *Metric Units (US Customary Units)*	*Actual*	*Conforms/Does Not Conform/Not Applicable*
6.9.2	Finger pull handles pull force (four fingers)	maximum 9.8 N (2.2 lbf)		
7	**Maintainability and Serviceability**			
7.1	Minimum lighting level in routine maintenance areas is required where the operator has to read information, use a hand tool, or make a connection. This provision can be met by providing integral lighting or portable lighting which can be temporarily attached such that it does not have to be hand held.	minimum 300 lux (30 fc)		
7.2	Full Body Clearance NOTE: Clearances should be approached from a task analysis point of view. Clearances should be provided based on the nature of the tasks performed in the designated area.			
7.2.1	Any posture: upper body clearance (shoulder width)	minimum 610 mm (24 in.)		
7.2.2	Standing: overhead clearance, measured from the floor forward horizontal clearance #3	 minimum 1980 mm (78 in.) minimum 690 mm (27 in.)		
7.2.3	Sitting-on-Floor: overhead clearance, measured from the floor forward horizontal clearance #3 working height	 minimum 1000 mm (39 in.) minimum 690 mm (27 in.) minimum 280 mm (11 in.)		
7.2.4	Squatting: overhead clearance, measured from the floor forward horizontal clearance #3 working height	 minimum 1220 mm (48 in.) minimum 790 mm (31 in.) minimum 460 mm (18.1 in.)		
7.2.5	Kneeling: overhead clearance, measured from the floor forward horizontal clearance #3 working height	 minimum 1450 mm (57 in.) minimum 1220 mm (48 in.) minimum 640 mm (25.2 in.)		
7.2.6	Kneeling Crawl: overhead clearance, measured from the floor forward horizontal clearance #3	 minimum 740 mm (29 in.) minimum 1520 mm (60 in.)		
7.2.7	Stooping: overhead clearance, measured from the floor forward horizontal clearance #3 working height	 minimum 1450 mm (57 in.) minimum 1020 mm (40 in.) minimum 640 mm (25.2 in.)		
7.2.8	Supine (lying on back): height length	 minimum 430 mm (17 in.) minimum 1980 mm (78 in.)		
7.2.9	Prone or crawl space: height length	 minimum 510 mm (20 in.) minimum 2440 mm (96 in.)		
7.3	Hand/Arm Clearance (where appropriate to do so, dimensions have been adjusted for the use of cleanroom gloves)			

Section	*Indicator*	*Acceptance Criteria Metric Units (US Customary Units)*	*Actual*	*Conforms/Does Not Conform/Not Applicable*
7.3.1	Clearance provided for finger access, round (dia) or square: one finger 2, 3, or 4 finger twist of small knob	minimum 32 mm (1.25 in.) minimum object diameter + 58 mm (2.3 in.)		
7.3.2	Clearance provided for flat hand to wrist access: height, palm thickness width, palm width	minimum 89 mm (3.5 in.) minimum 114 mm (4.5 in.)		
7.3.3	Clearance provided for fist to wrist access: height, palm thickness width, palm width	minimum height 89 mm (3.5 in.) minimum width 127 mm (5.0 in.)		
7.3.4	Clearance provided for two hands arm to shoulders access (does not ensure visual access): reach width height	maximum 610 mm (24.0 in.) minimum 483 mm (19 in.) minimum 114 mm (4.5 in.)		
7.3.5	Clearance provided for two hands, hand to wrist access (does not ensure visual access): reach width height	maximum 203 mm (8.0 in.) minimum 191 mm (7.5 in.) minimum 114 mm (4.5 in.)		
7.3.6	Clearance provided for one arm to shoulder access, diameter or square area (does not ensure visual access).	minimum 132 mm (5.2 in.)		
7.3.7	Clearance provided for one arm to elbow access, diameter or square area (does not ensure visual access).	minimum 119 mm (4.7 in.)		
7.4	Maintenance and Service Access			
7.4.1	Enclosures or covers must, unless fully removable, be self-supporting, in the open position, and not require manual support during maintenance. Exceptions may be allowed for self closing doors for fire safety or compliance reasons.	Supports present		
7.4.2	Access covers should be equipped with full-handed grasp areas or other means for opening them.	Handles present, refer to Section 6 for design criteria.		
7.4.3	Height of access cover handle over the entire range of motion required for operation or maintenance. There should be no greater than a 254 mm (10 in.) deep obstruction in front of the handle.	maximum 1700 mm (67 in.)		
7.5	Replaceable Components			
7.5.1	Serviceable components are replaceable as modular packages, and are configured for rapid removal and replacement.	Serviceable components configured as described.		
7.5.2	Serviceable components should not be stacked directly on one another (*i.e.*, a lower layer should not support an upper layer).	Serviceable components independently accessible.		

Section	*Indicator*	*Acceptance Criteria Metric Units (US Customary Units)*	*Actual*	*Conforms/Does Not Conform/Not Applicable*
7.5.3	Heavy components (objects which have a lifting index of 0.5 or greater, see SESC, Section 1.0) or bulky components (greater than 36 inches in length) requiring frequent removal/installation should include guide/locating aids to assist in positioning.	Guide/locating pins present.		
7.5.4	Cables, connectors, plugs, and receptacles should be labeled, keyed, color coded, or otherwise configured to make connection easier and prevent cross connection. This feature is assessed only if a SEMI S2 assessment is not being conducted.	Identification present, keyed where needed.		
7.5.5	Circuit boards mounted in a card cage configuration should have gripping or ejecting aids for mounting and removal.	Finger access, gripping, or ejecting aids available.		
8	**Display Location**			
8.1	Location for operator primary interface, standing station. [#1]			
8.1.1	Height of video display terminal (single monitor). Does not include touchscreens, measured from floor to center of screen.	maximum 1470 mm (58 in.) minimum 1320 mm (52 in.)		
8.1.2	Height of video display terminal (stacked monitors). Does not include touchscreens, measured from floor to top line of the top monitor.	maximum 1680 mm (66 in.) The primary monitor in a stacked configuration is the bottom monitor.		
8.1.3	Height of infrequently used video display terminal (viewed briefly less often than once per hour) measured to top line of monitor.	maximum 1680 mm (66 in.)		
8.1.4	Height of very infrequently used video display terminal (viewed briefly less often than once per day) measured to top line of monitor.	maximum 1880 mm (74 in.)		
8.1.5	Height of infrequently viewed visual signal measured to the top of the signal. This guideline does not apply to light towers.	maximum 2130 mm (84 in.)		
8.1.6	Height of touch screen monitor.	maximum 1470 mm (58 in.), measured from floor to uppermost active pad on screen minimum 910 mm (36 in.), measured from floor to lowest active pad on the screen See §9 for horizontal reach criteria.		
8.1.7	Tilt angle of touch screen monitor between 41 and 48 inches in height to top of screen.	Upward minimum 30 degrees		
8.1.8	Tilt angle of touch screen monitor less than 41 inches in height to top of screen.	Upward minimum 45 degrees		
8.2	Location for operator primary interface, seated station [#2]			
8.2.1	Height of video display terminal (single monitor), does not include touchscreens, measured from floor to centerline of monitor.	maximum 1190 mm (47 in.) minimum 940 mm (37 in.)		

Section	*Indicator*	*Acceptance Criteria Metric Units (US Customary Units)*	*Actual*	*Conforms/Does Not Conform/Not Applicable*
8.2.2	Height of video display terminal (stacked monitors), does not include touchscreens, measured from floor to top line of top monitor.	maximum 1400 mm (55 in.) minimum 940 mm (37 in.) The primary monitor in a stacked configuration is the bottom monitor.		
8.2.3	Tilt angle of video display terminal greater than 55 inches in height to top of screen. This line item becomes significant in the event that the maximum height criteria cannot be met.	Downward minimum 15 degrees		
8.2.4	Height of touch screen monitor.	maximum 1070 mm (42 in.) measured from floor to highest active pad on the screen minimum 760 mm (30 in.) measured from floor to lowest active pad on the screen See §9 for horizontal reach criteria.		
8.3	Display characteristics			
8.3.1	Lateral distance from the centerline of the display to the centerline of the input device(s). See MIL-STD-1472 for a depiction of this.	maximum 320 mm (12.6 in.)		
8.3.2	Character height (Specific to Chinese, Korean, and Japanese characters.)	Character height is greater than or equal to the viewing distance divided by 143. Recommended viewing distance is between 457 mm (18 in.) and 762 mm (30 in.)		
8.3.3	Character height (All characters other than Chinese, Korean, and Japanese.)	Character height is greater than or equal to the viewing distance divided by 215. Recommended viewing distance is between 457 mm (18 in.) and 762 mm (30 in.)		
9	**Hand Control Location** (These criteria only apply to controls, tools, and materials accessed for routine production operation and maintenance.)			
9.1	Standing station [#1]			
9.1.1	Vertical location of very infrequently used controls (controls used less often than once every 24 hours) measured from the standing surface to the centerline of the control.	maximum 1640 mm (64.5 in.) minimum 0 mm (0 in.)		

Section	*Indicator*	*Acceptance Criteria Metric Units (US Customary Units)*	*Actual*	*Conforms/Does Not Conform/Not Applicable*
9.1.2	Location of infrequently used and/or critical controls. Maximum reaches are indicated for various heights. Reaches are measured from the leading edge of the equipment or obstacle. Controls should not be located above 1638 mm (64.5 in.) or below 838 mm (33 in.). Interpolate for intermediate values.			
	Height of 1638 mm (64.5 in.)	reach 254 mm (10.0 in.)		
	Height of 1524 mm (60 in.)	reach 368 mm (14.5 in.)		
	Height of 1422 mm (56 in.)	reach 432 mm (17.0 in.)		
	Height of 1321 mm (52 in.)	reach 470 mm (18.5 in.)		
	Height of 1219 mm (48 in.)	reach 483 mm (19.0 in.)		
	Height of 1118 mm (44 in.)	reach 470 mm (18.5 in.)		
	Height of 1016 mm (40 in.)	reach 394 mm (15.5 in.)		
	Height of 914 mm (36 in.)	reach 292 mm (11.5 in.)		
	Height of 838 mm (33 in.)	reach 178 mm (7.0 in.)		
9.1.3	Location of frequently used controls. Maximum reaches are indicated for various heights. Reaches are measured from the leading edge of the equipment or obstacle. Controls should not be located above 1270 mm (50 in.) or below 940 mm (37 in.). Interpolate for intermediate values.			
	Height of 1270 mm (50 in.)	reach 292 mm (11.5 in.)		
	Height of 1219 mm (48 in.)	reach 330 mm (13.0 in.)		
	Height of 1168 mm (46 in.)	reach 368 mm (14.5 in.)		
	Height of 1118 mm (44 in.)	reach 394 mm (15.5 in.)		
	Height of 1067 mm (42 in.)	reach 406 mm (16.0 in.)		
	Height of 1016 mm (40 in.)	reach 394 mm (15.5 in.)		
	Height of 940 mm (37 in.)	reach 318 mm (12.5 in.)		
9.2	Seated station #2			
9.2.1	Location of infrequently used and/or critical controls. Maximum reaches are indicated for various heights. Reaches are measured from the leading edge of the work surface or obstacle. Controls should not be located above 1397 mm (55 in.) or below 533 mm (21 in.). Interpolate for intermediate values.			
	Height of 1397 mm (55 in.)	reach 356 mm (14.5 in.)		
	Height of 1270 mm (50 in.)	reach 432 mm (17.0 in.)		
	Height of 1168 mm (46 in.)	reach 470 mm (18.5 in.)		
	Height of 1067 mm (42 in.)	reach 483 mm (19.0 in.)		
	Height of 965 mm (38 in.)	reach 483 mm (19.0 in.)		
	Height of 864 mm (34 in.)	reach 470 mm (18.5 in.)		
	Height of 762 mm (30 in.)	reach 445 mm (17.5 in.)		
	Height of 660 mm (26 in.)	reach 381 mm (15.0 in.)		
	Height of 533 mm (21 in.)	reach 254 mm (10.0 in.)		

Section	*Indicator*	*Acceptance Criteria Metric Units (US Customary Units)*	*Actual*	*Conforms/Does Not Conform/Not Applicable*
9.2.2	Location of frequently used controls. Maximum reaches are indicated for various heights. Reaches are measured from the leading edge of the work surface or obstacle. Controls should not be located above 1067 mm (42 in.) or below 762 mm (30 in.). Interpolate for intermediate values. Height of 1067 mm (42 in.) Height of 1016 mm (40 in.) Height of 965 mm (38 in.) Height of 914 mm (36 in.) Height of 864 mm (34 in.) Height of 813 mm (32 in.) Height of 762 mm (30 in.)	 reach 330 mm (13.0 in.) reach 368 mm (14.5 in.) reach 394 mm (15.5 in.) reach 406 mm (16.0 in.) reach 419 mm (16.5 in.) reach 419 mm (16.5 in.) reach 419 mm (16.5 in.)		
10	**Workstation Design**			
10.1	Standing station [#1]			
10.1.1	Work surface edge radius where the operator can assume a static posture in contact with the edge.	minimum 6.4 mm (0.25 in.) radius		
10.1.2	Height of keyboard, trackball, or mouse (to home row, top of ball/mouse). NOTE: In applications where input devices (keyboard, trackball, or mouse) are used more like machine controls (intermittent one finger entry on the keyboard, intermittent short term use of the mouse or trackball) than for standard typing (continuous use of keyboard for entry of long character strings, extended use of trackball or mouse in graphical environment), it is appropriate to use the height and reach locations described in §9, Hand Control Location (standing station).	maximum 1020 mm (40 in.) minimum 970 mm (38 in.)		
10.1.3	Height of microscope eyepieces. Should be adjustable through at least this range.	Range includes 1270 mm (50 in.) to 1730 mm (68 in.)		
10.2	Seated station [#2]			
10.2.1	Height of keyboard, trackball, or mouse. (to home row, top of ball/mouse). NOTE: In applications where input devices (keyboard, trackball, or mouse) are used more like machine controls (intermittent one finger entry on the keyboard, intermittent short term use of the mouse or trackball) than for standard typing (continuous use of keyboard for entry of long character strings, extended use of trackball or mouse in graphical environment), it is appropriate to use the height and reach locations described in §9, Hand Control Location (seated station).	maximum 760 mm (30 in.) minimum 710 mm (28 in.)		
10.2.2	Vertical leg clearance.	minimum 673 mm (26.5 in.)		
10.2.3	Horizontal leg clearance, depth at knee level.	minimum 508 mm (20 in.)		
10.2.4	Horizontal leg clearance, depth at foot level.	minimum 660 mm (26 in.) depth × 254 mm (10 in.) vertical foot clearance		

Section	*Indicator*	*Acceptance Criteria Metric Units (US Customary Units)*	*Actual*	*Conforms/Does Not Conform/Not Applicable*
10.2.5	Horizontal leg clearance, width.	minimum 610 mm (24 in.)		
10.2.6	Height of microscope eyepiece. Should be adjustable through at least this range. Note: Assumes a 711 mm (28 in.) to 762 mm (30 in.) worksurface.	Range includes 1220 mm (48 in.) to 1370 mm (54 in.)		
10.2.7	Thickness of work surface.	maximum 51 mm (2.0 in.)		
10.2.8	Work surface edge radius where the operator can assume a static posture in contact with the edge.	minimum 6 mm (0.25 in.) radius		

[#1] A standing station is one where the operator can assume a standing posture or a seated posture in a tall stool which places the operator at approximately the same stature.

[#2] A seated station is one where a short cylinder office style chair is used.

[#3] Distance measured away from the equipment or obstruction for body clearance in the given posture.

APPENDIX 2
LIFTING, STRENGTH, AND MATERIALS HANDLING

NOTICE: The material in this appendix is an official part of SEMI S8 and was approved by full letter ballot procedures by the North American Regional Standards Committee.

A2-1 General Considerations

A2-1.1 For recommended guidelines regarding the percentage of a user's maximum grip strength to be exerted in execution of a task see Related Information 1, Table R1-3.

A2-1.2 Where standard product or containers are to be handled at equipment load and unload stations, mechanization should be considered for orientation and handling. Where manual handling is necessary, the design should reduce extended reaching, lifting, pulling, and awkward postures. Simultaneous lifting and twisting should be avoided. Load, unload, and lift over points should be located such that the floor to hand height is 84–107 cm (33–42 in.), optimal design target is 102 cm (40 in.).

A2-1.3 Handles or cutouts should be designed to facilitate use of the power grip (e.g., similar to that used to hold a pistol). Avoid handles that require pinch grips or awkward postures. Handles should allow carrying close to the body.

A2-1.4 Lifting and handling tasks performed in a stooping position should be avoided. Stooping occurs when the vertical material handling height is less than 84 cm (33 in.), or the horizontal reach distance is greater than 46 cm (18 in.) in front of body.

A2-1.5 For two handed push/pull activities the floor to hand height should be between 97 cm (38 in.) and 112 cm (44 in.).

A2-1.6 Consideration should be given to the standing surface to minimize the risk of slips and falls.

A2-1.7 Awkward postures should be avoided. Refer to Related Information 1, Table R1-2 for a list of recommended ranges of awkward postures to avoid.

A2-1.8 For a 2-person handling task, there should be adequate coupling locations and adequate body clearance for the activity. Analyses need to be performed and documented for each person lifting if any of the parameters (e.g., horizontal reach) are different.

A2-2 Selecting and Using the Appropriate MMH Analysis Tool(s)

A2-2.1 Three general MMH evaluation tools are identified in the following matrix. The three tools are the “Application manual for the Revised NIOSH Lifting Equation” lifting equation, biomechanical models, and psychophysical capacity tabular data. Table A2-1 was designed to assist in determining which analysis tools are appropriate for a particular task. For each unique characteristic of the task, a checkmark in the analysis tool column indicates that the analysis tool is appropriate. If there is any aspect of the task that does not show a check mark in a particular tools column, that analysis tool is not appropriate to evaluate the task. Note that in many situations multiple tools are appropriate. In situations where the 1991 NIOSH equation is appropriate, the assessor should use it, because it typically will provide the most conservative results. In other situations, the assessor may use any of the appropriate tools.

A2-2.2 Correct application of the 1991 NIOSH equation is described in Waters, Thomas, et. al., Application manual for the Revised NIOSH Lifting Equation, U.S. Department of Health and Human Services (NIOSH), Cincinnati, OH, 1994.

A2-2.3 There are many sources of psychophysical data. One such source is A. Mital, A.S. Nicholson, M.M. Ayoub, A Guide to Manual Materials Handling, Taylor and Francis, London, 1993.

A2-2.4 Biomechanical analysis can be completed using biomechanical modeling software.

Table A2-1 Criteria to Determine Appropriate MH Analysis Tool(s)

MH Type	*"If" Condition*	*NIOSH (1991)*	*Bio Model*	*Psycho Physical*
2 Hand Lift or Lower	F < 1 lift/5 minutes	4	4	4
	F > 1 lift/5 minutes	4		4
	F > 9 lifts/minute	4		
	Twisting Occurs	4	4 (3D)	4
	Handle Design is an Issue	4		4
	Limited Headroom During Lift			4
	Work Duration > 8 hours			4
	Load Placement Clearance is an Issue	4		4
	Load Asymmetry is an Issue	4	4 (3D)	4
	Length of Object Measured in Frontal Plane of Body > 26"		4 (3D)	
	Exposure to Heat Stress			4
1 Hand Lifts	Posture = Standing		4	4
	Posture = Kneeling or Seated			4
1 or 2 Hand Carry	NOTE: Carry is Operationally Defined as Horizontal Movement of Load ≥ 7 feet			4
1 or 2 Hand Push/Pull	Distance < 7 feet and F < 1 Push/Pull/5 minutes		4	4
	Distance ≥ 7 feet and F ≥ 1 Push/Pull/5 minutes			4
	Push/Pull Task Requires Significant Sustained Forces (e.g., slide box along floor)			4
Lift/Lower in Non-Standard Postures	Kneeling, Sitting, or Lying			4

[#1] Under Bio Model, 3D indicates that only a 3-dimensional biomechanical model is appropriate for the task condition.

Table A2-2 Two Hand Lift/Lower Manual Material Handling Analysis Documentation

NIOSH Analysis

Horizontal (origin)	Horizontal (destination)	Vertical	Distance	Asymmetry (origin)	Asymmetry (destination)	Frequency	Duration	Coupling
measure	measure	measure	measure	measure	measure	measure	measure	measure
multiplier	multiplier	multiplier	multiplier	multiplier	multiplier	multiplier	multiplier	multiplier

Precision placement req.

Recom-mended weight limit	Lifting index

Psychophysical Analysis

Box size	Range of lift	Frequency

MAWL

Headroom limitation	Load clearance	Load asymmetry	Asymmetry	Work duration	Coupling
measure	measure	measure	measure	measure	measure
multiplier	multiplier	multiplier	multiplier	multiplier	multiplier

Adjusted MAWL	Lifting index

Conclusions

one person lift	Recommended weight limit	Lifting index

two person lift	Recommended weight limit	Lifting index

APPENDIX 3
HANDLE DESIGN DIAGRAMS

NOTICE: The material in this appendix is an official part of SEMI S8 and was approved by full letter ballot procedures by the North American Regional Standards Committee.

A3-1 Handle Design

A3-1.1 The following diagrams are intended to clarify the criteria described in §6 of Appendix 1.

A3-1.1.1 *Cylindrical Handle*

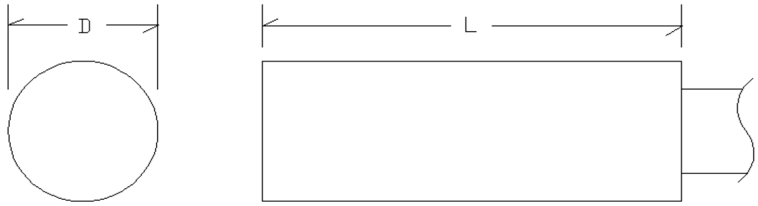


Figure A3-1
Cylindrical Handle

D - Handle diameter
L - Handle length

A3-1.1.2 *Circular Handle, or Triangular Handle*

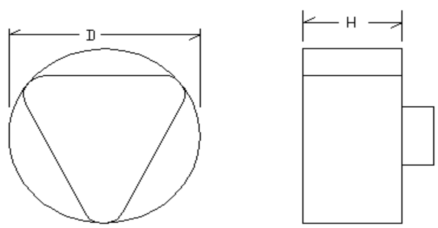


Figure A3-2
Circular Handle, or Triangular Handle

D - Handle diameter
H - Handle height (thickness)

A3-1.1.3 *Pliers Handle*

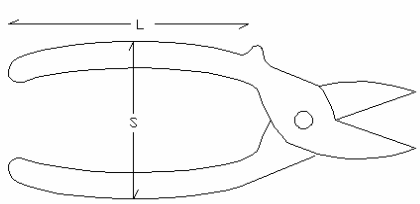


Figure A3-3
Pliers Handle

L - Handle length
S - Handle grip span

A3-1.1.4 *Pistol Grip Handle*

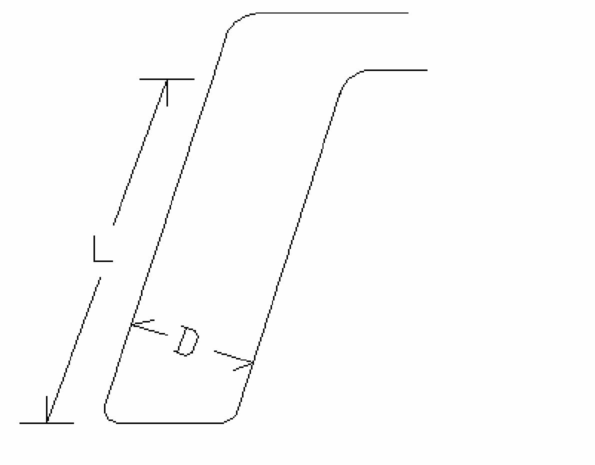


Figure A3-4
Pistol Grip Handle

D - Handle diameter
L - Handle length

A3-1.1.5 *Enclosed Handle*

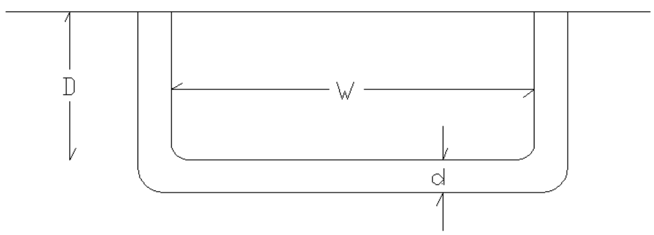


Figure A3-5
Enclosed Handle

D - Handle depth
W - Handle width
d - Handle diameter

A3-1.1.6 *Hook Grasp Handle, or Finger Pull Handle*

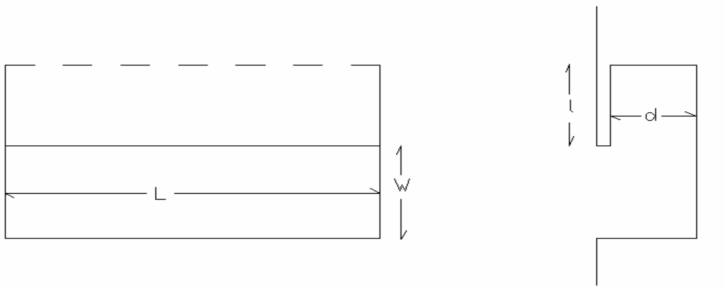


Figure A3-6
Hook Grasp Handle, or Finger Pull Handle

W - Handle opening width
L - Handle opening length
l - Handle lip length
d - Handle depth

RELATED INFORMATION 1
ANTHROPOMETRIC RESOURCE DATA

NOTICE: This related information is not an official part of SEMI S8 and is not intended to modify or supersede the official guidelines. It was derived from the work of the originating task force. Publication was authorized by full ballot procedures. Determination of the suitability of the material is solely the user's responsibility.

R1-1 Selected 5th Percentile Female and 95th Percentile Male Standing and Seated Dimensions

Table R1-1 Selected Body Dimensions for Females and Males (see Figures R1-1 and R1-2)

Criteria	*Label*	*5th Percentile Female (Asian)*		*95th Percentile Male (U.S.)*	
Standing Dimensions[#1]		**mm**	**inch**	**mm**	**inch**
Stature[#2]	(A)	1471	57.9	1895	74.6
Eye Height[#2]	(B)	1356	53.4	1763	69.4
Shoulder height[#2]	(C)	1206	47.5	1572	61.9
Elbow height[#2]	(D)	894	35.2	1214	47.8
Knuckle height[#2]	(E)	676	26.6	831	32.7
Seated Dimensions[#1]		**mm**	**inch**	**mm**	**inch**
Seated height	(F)	780	30.7	973	38.3
Eye height	(G)	660	26.0	843	33.2
Shoulder height	(H)	510	20.1	645	25.4
Elbow height	(I)	165	6.5	287	11.3
Buttock-knee length	(J)	470	18.5	650	25.6
Popliteal height[#2]	(K)	350	13.8	521	20.5
Knee height[#2]	(L)	434	17.1	632	24.9
Reach Distances[#1]		**mm**	**inch**	**mm**	**inch**
Standing vertical grip reach[#2]	(M)	1712	67.4	2134	84.0
Sitting vertical grip reach	(N)	855	33.7	1356	53.4
Forward grip reach	(O)	580	22.8	787	31.0

[#1] Dimensions based on Pheasant (1988), MIL-STD-1472D (1994), and SAE J833 (1989).
[#2] An allowance of 25mm (1 inch) has been made for shoes on all vertical dimensions where the feet touch the floor.

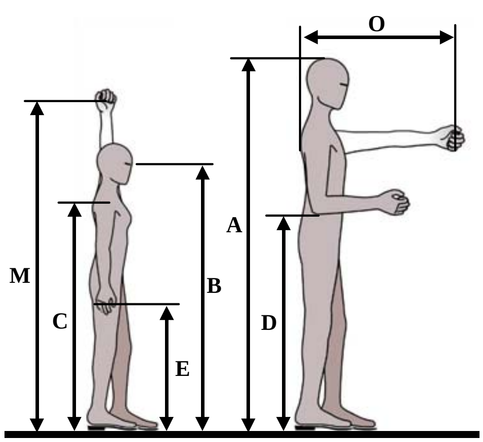


Figure R1-1
Standing Dimensions

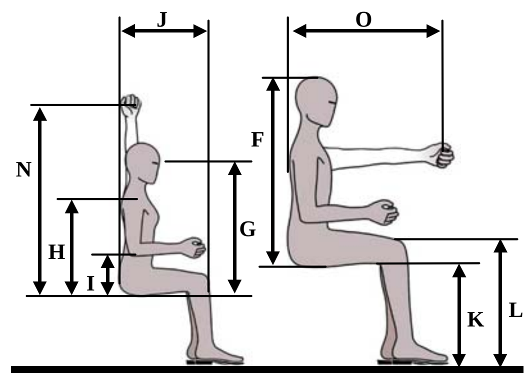


Figure R1-2
Seated Dimensions

R1-2 Neutral and Awkward Postures

R1-2.1 An important concept in the field of ergonomics is the “neutral posture”. A neutral posture is the body position that minimizes stresses on the joints and is the posture where a person has the greatest strength potential. The neutral posture for each joint is near the middle of its range of motion. Generally, the body in its neutral position is standing erect with the eyes looking forward, and the arms hanging by the sides, as defined by ¶5.2.25.

R1-2.2 Neutral postures are shown for standing and seated tasks in Table R1-2. The joint angles of these neutral postures are used as the origin when measuring angular deviations of body part(s) to determine if a posture is awkward.

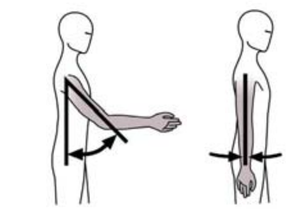
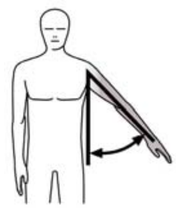
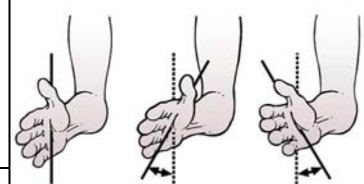
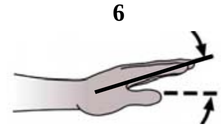
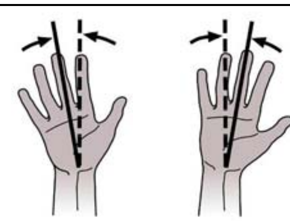
R1-2.3 When the body is in a non-neutral posture, potential strength and efficiency decrease. Table R1-3 depicts selected awkward postures. Angular deviations of the body part(s) from a neutral posture are shown for the appropriate joint(s).

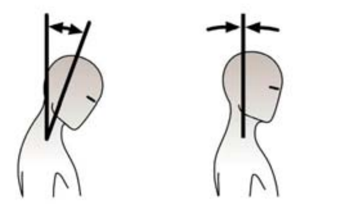
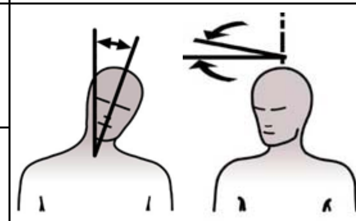
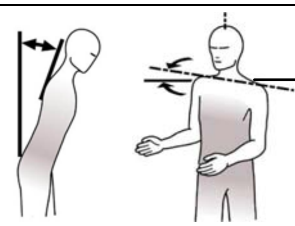
R1-2.4 It is not always practicable to design equipment and tasks so that personnel remain in neutral postures. The intent of these tables is to show the neutral postures for reference and the awkward postures that, according to the normative portions of this document (e.g., ¶6.1.1 and ¶A2-1.2) should be avoided.

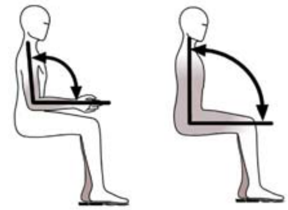
Table R1-2 Neutral Postures for Standing and Seated Tasks

Posture	*Image*
Standing Task	
Arms loosely at the sides with the shoulders relaxed Forearms parallel with the floor Hands in the “handshake” position Back has a natural “S” curve Knees slightly bent Feet are shoulder-width apart, pointing slightly outward Head looking forward and slightly downward	
Seated Task	
Arms loosely at the sides with the shoulders relaxed Forearms parallel with floor Hands in the “handshake” position Back has a natural “S” curve Knee angle greater than 95 degrees Feet are shoulder-width apart, pointing slightly outward Head looking forward and slightly downward	

Table R1-3 Awkward Postures by Body Part

Body Part	*Awkward Posture*[#1] *(angle in degrees from neutral)*	*Comments*	*Image*
Upper Extremities			
1. Shoulder flexion	> 45	Shoulder flexion is defined as reach in front of body mid-line.	 **1 2**
2. Shoulder extension	> 0	Shoulder extension is defined as reach behind body mid-line.	
3. Shoulder abduction	> 45	Abduction is movement of elbow away from body.	 **3**
4. Forearm pronation	> 30	Pronation is “palm facing down.” Measured from neutral (handshake) position. Note: Forearm pronation is less stressful than either supination or forearm rotation about the elbow.	 **Neutral 4 5**
5. Forearm supination	> 30	Supination is “palm facing up”. Measured from neutral (handshake) position.	
6. Wrist flexion	> 10	Flexion is closing (reducing) the angle of the wrist.	 **6**
7 Wrist extension	> 15	Extension is opening (increasing) the angle of the wrist.	 **7**
8. Wrist ulnar deviation	> 10	Ulnar deviation is bending the wrist in the direction of the little finger.	 **8 9**
9. Wrist radial deviation	> 10	Radial deviation is bending the wrist in the direction of the thumb.	

Body Part	*Awkward Posture*[#1] *(angle in degrees from neutral)*	*Comments*	*Image*
Head / Neck			
10. Neck flexion	> 20	Neck flexion is bending the neck forward (e.g., looking downward).	 **10** **11**
11. Neck extension	> 0	Neck extension is bending the neck back (e.g., looking up).	
12. Neck lateral flexion	> 20	Neck bent with the ear toward the shoulder.	 **12** **13**
13. Head rotation	> 45	Neck rotation is turning the neck (e.g., looking to the side).	
Back (Standing)			
14. Back bend, forward flexion	> 20	Definition of “Awkward Posture” applies if posture is static.	 **14** **15**
15. Back twist	> 30	Measured from mid-sagittal plane of body. Note: mid-sagittal plane is defined as a plane line drawn down the mid-line of the body, perpendicular to the back.	
16. Lateral bend	> 20	Bend to the side of the body.	 **16**

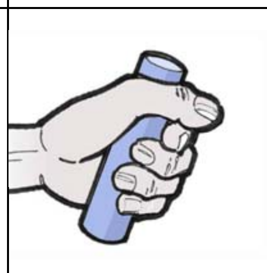
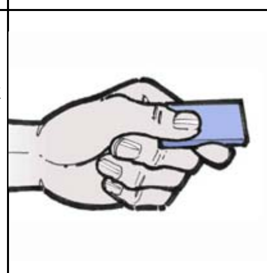
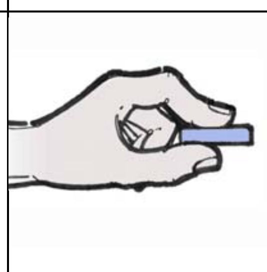
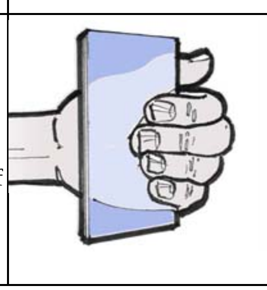
Body Part	*Awkward Posture*[#1] *(angle in degrees from neutral)*	*Comments*	*Image*
Seated Postures			
17. Elbow flexion	< 90, OR > 120	A 90 elbow angle is defined as the theoretical “neutral” position.	 **17** **18**
18. Back trunk-thigh angle	< 90	Increasing the trunk-thigh angle reduces pressure on the lower back.	
19. Knee angle	< 90	Increasing the angle at the knees reduces stress at the knees.	 **19**

[#1] Joint angles adapted from *Humanscale 7/8/9*, The MIT Press, Massachusetts Institute of Technology, Cambridge, MA, 1981.

R1-3 Maximum Recommended Grip Forces

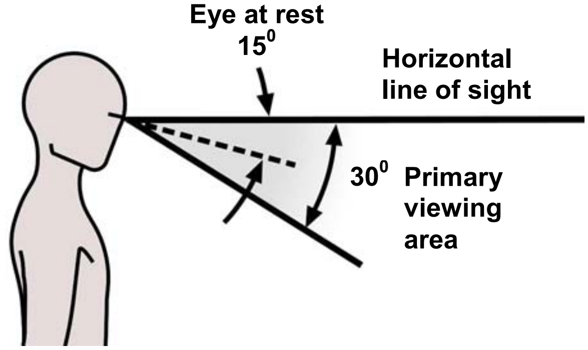
R1-3.1 The grip forces in Table R1-4 are based upon percentages of maximum one-time grip forces. These values differ from maximum hand grip force values in Appendix 1: Supplier Ergonomic Success Criteria ¶6.7.1.1 through ¶6.9.2, which are maximum values for lift or pull forces based upon comfort and contact pressure against the hand.

Table R1-4 Maximum Recommended Grip Forces

Grip Type	*Image*	*Glove Use*	*Maximum Force*		
			Infrequent Tasks *Repetition is less than once every 5 minutes*	*Occasional Tasks* *Tasks with a repetition rate between that of an infrequent and a frequent task*	*Static or Frequent Tasks* *Duration greater than 4 seconds or repeated more than once every 30 seconds*
Power Grip: The fingers of the hand wrap around the object, and the thumb overlaps the index finger (e.g., gripping a hammer).		Grip without gloves	137 N (30.9 lbf.)	82 N (18.5 lbf.)	41 N (9.4 lbf.)
		Grip with cleanroom gloves	116 N (26.3 lbf.)	70 N (15.7 lbf.)	35 N (8.0 lbf.)
		Grip with chemical gloves	111 N (25.0 lbf.)	66 N (15.0 lbf.)	33 N (7.6 lbf.)
Lateral Pinch: Object is held between the thumb and the side of the index finger (often referred to as key grip).		Grip without gloves	35 N (7.9 lbf.)	21.8 N (4.9 lbf.)	10.7 N (2.4 lbf.)
		Grip with cleanroom gloves	30 N (6.7 lbf.)	19 N (4.2 lbf.)	9 N (2.0 lbf.)
		Grip with chemical gloves	28 N (6.4 lbf.)	18 N (4.0 lbf.)	9 N (1.9 lbf.)
Tip Pinch: Object held between the tips of the thumb and index finger.		Grip without gloves	24.5 N (5.5 lbf.)	14.7 N (3.3 lbf.)	7.6 N (1.7 lbf.)
		Grip with cleanroom gloves	21 N (4.7 lbf.)	13 N (2.8 lbf.)	7 N (1.4 lbf.)
		Grip with chemical gloves	20 N (4.5 lbf.)	12 N (2.7 lbf.)	6 N (1.4 lbf.)
Palmar Pinch: Fingers pressed against the palm of the hand, with the object held between the fingers and the palm. Thumb is not used (e.g., picking up a sheet of plywood).		Grip without gloves	36 N (8.2 lbf.)	21.6 N (4.85 lbf.)	11.1 N (2.5 lbf.)
		Grip with cleanroom gloves	31 N (7.0 lbf.)	18 N (4.1 lbf.)	9 N (2.1 lbf.)
		Grip with chemical gloves	29 N (6.6 lbf.)	18 N (3.9 lbf.)	9 N (2.0 lbf.)

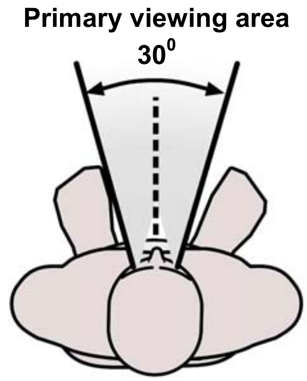
R1-4 Viewing Zones

R1-4.1 The Figures R1-3 and R1-4 depict the primary viewing areas for visual displays. This area is conical.



NOTE: This figure is based on data from: Pheasant, Stephen., *Bodyspace: Anthropometry Ergonomics and Design*, Taylor and Francis, 1996.

Figure R1-3
Side View of Primary Viewing Area for Visual Displays



NOTE: This figure is based on data from: Eastman Kodak Company, *Ergonomic Design for People at Work (2nd Ed.)*, John Wiley & Sons Inc., 2004.

Figure R1-4
Top View of Primary Viewing Area for Visual Displays

RELATED INFORMATION 2
WORKSTATION DESIGN

NOTICE: This related information is not an official part of SEMI S8 and is not intended to modify or supersede the official guidelines. It was derived from the work of the originating task force. Publication was authorized by full ballot procedures. Determination of the suitability of the material is solely the user's responsibility.

R2-1 General Considerations

R2-1.1 To enable good system performance, equipment and workspaces should be designed to accommodate the physical dimensions of greater than 90 percent of user population. For recommended anthropometric data see Related Information 1, Table R1-1, Figures R1-1 and R1-2.

R2-1.2 Where impairment of safety might result in danger to life, such as the inability to exit or escape under emergency conditions, wider percentile ranges should be used (e.g., 1st through 99th percentile range).

R2-1.3 Many anthropometric databases cite unclothed dimensions.

R2-1.4 Critical and frequently used equipment, tools, and work items should be placed in the operator's primary viewing area.

R2-1.5 Provision for placement of required materials and informational items used during operation should be accommodated in the design. Examples of materials/items include product boxes, wafer boxes, maintenance manuals, and shop orders.

R2-2 Working Postures

R2-2.1 Workspace configurations that require static or frequent awkward postures (where the limbs or torso deviate from a neutral position) should be avoided. For ranges of posture to avoid see Related Information 1.

R2-2.2 Equipment should be designed to avoid unsupported awkward static postures for operational tasks lasting more than 20 seconds and unsupported awkward static postures for maintenance and service tasks lasting for more than 40 seconds.

R2-2.3 Where applicable to tasks performed, equipment should be designed to allow both sitting and standing operation.

R2-2.4 Controls, tools, and materials should be located so that the most frequent activities are performed from a neutral posture.

R2-2.5 To prevent users from bending at the waist, the design should place users close to the point of operation by providing adequate leg and foot clearance and keeping work materials at an appropriate height. See the "Supplier Ergonomics Success Criteria" in Appendix 1 for design criteria.

R2-3 Standing Workstations

R2-3.1 See the "Supplier Ergonomics Success Criteria" in Appendix 1 for standing workstation design criteria.

R2-3.2 Display screens should be perpendicular to the normal line of sight and the angle of the screen should be adjustable or positioned to minimize glare.

R2-4 Sitting Workstations

R2-4.1 See the "Supplier Ergonomics Success Criteria" in Appendix 1 for seated workstation design criteria.

R2-4.2 Sit/stand workstations are workstations where the operator can assume a standing posture or a seated posture using a task stool.

RELATED INFORMATION 3
DESIGN FOR MAINTAINABILITY AND SERVICEABILITY

NOTICE: This related information is not an official part of SEMI S8 and is not intended to modify or supersede the official guidelines. It was derived from the work of the originating task force. Publication was authorized by full ballot procedures. Determination of the suitability of the material is solely the user's responsibility.

R3-1 General Considerations

R3-1.1 Equipment design should facilitate rapid and positive fault detection and isolation of defective items.

R3-1.2 Standard parts should be used whenever prac-ticable. Where practical, components should be replace-able as modular packages and configured for rapid re-moval and replacement (e.g., use of a standard fastener throughout a design).

R3-1.3 Equipment requiring periodic calibration and adjustment should be readily accessible without disassembly.

R3-1.4 Use of cleanroom gloves reduces maximum allowable grip forces listed in Related Information 1, Table R1-3 by 15%.

R3-1.5 Use of cotton gloves reduces maximum allowable grip forces listed in Related Information 1, Table R1-3 by 26%.

R3-1.6 Use of chemical protective gloves reduces maximum allowable grip forces listed in Related Information 1, Table R1-3 by 19%.

R3-1.7 Component design should preclude improper mounting and installation of any component.

R3-1.8 Guides, tracks, or stops should be provided as necessary to facilitate handling and prevent damage to equipment or injury to personnel.

R3-1.9 Refer to ANSI/IES "Practice for Industrial Lighting" for recommended illumination based on task characteristics.

R3-1.10 Structural members or permanently installed equipment should not visually or physically prevent adjustment, servicing, removal of replaceable equipment, or other required maintenance tasks.

R3-1.11 Items which require rapid or frequent maintenance should be most accessible. Predicted or known high failure-rate items should be accessible for replacement with minimal removal of nearby or adjacent non-failed items. If it is necessary to remove non-failed items, then the total ergonomic impact must be assessed to determine conformance.

R3-1.12 Sufficient space should be provided for the use of standard test equipment and required maintenance tools without difficulty or hazard. Self-checking or built-in test features are recommended.

R3-2 Cables, Connectors, Plugs, Receptacles, and Circuit Boards

R3-2.1 Connectors which may need to be disconnected and reinstalled during the life of the tool that are mounted in close proximity should have clearance so that each one can be easily removed and reinstalled.

R3-3 Equipment Enclosures

R3-3.1 Equipment enclosures should be easily removable or sufficiently larger than the item they cover to facilitate installation and removal of components.

R3-3.2 Cover or shield holes should be large enough for fastener clearance without precise alignment.

R3-3.2.1 Access openings should be designed to permit unobstructed physical and visual operation. Size and shape of the access should allow for easy passage of equipment and body parts of a 95th percentile North American male with necessary PPE and tools, as appropriate.

R3-3.2.2 Unless prohibited from a microcontamination standpoint, access covers should be hinged or sliding. Lift off covers will require manual material handling analysis.

R3-3.3 The number and diversity of fasteners used should be minimized. Fasteners requiring non-standard tools should be avoided, except where access is to be restricted.

R3-3.3.1 Hinges, tongue-and-slot catches, and mounting pins should be used to minimize the number of fasteners required. Pin and hook arrangements are preferred to hinges for contamination control.

R3-3.3.2 Captive fasteners should be used where dropping or loss of such items could cause damage to equipment or create difficult or hazardous removal. Captive fasteners should also be provided for access covers requiring frequent removal.

R3-3.3.3 Fasteners should require the minimum number of turns compatible with mechanical stress, alignment, positioning, and load considerations. Items requiring removal for daily or more frequent inspection and servicing should use quick release fasteners.

RELATED INFORMATION 4
HAZARD ALERTS, LABELS, AND ALARMS

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R4-1 Hazard Alerts

R4-1.1 Potential hazards to the user, equipment, or product should be identified and documented. An evaluation should be made as to the appropriate method(s) of alert, alert content, and location. More than one method of hazard alert may be necessary. Refer to SEMI S1.

R4-1.2 Hazard alerts should be consistent with information provided in operator and maintenance manuals and other training information materials.

R4-1.3 Hazard alerts can be provided by labels, signs, placards, visual alerts, auditory alarms, status indicators, or hazard alert systems integral with the equipment's operating system (e.g., displayed through the video display).

R4-1.4 Hazard alerts and fault messages should be specific and communicate the consequences of engaging hazards.

R4-2 Labels

R4-2.1 Hazard alert labels should be located such that they are readily visible to the intended viewer and alert the viewer to the potential hazard in time to take appropriate action.

R4-3 Audible Alarms

R4-3.1 To avoid noise pollution, alarms should be reserved for situations requiring immediate intervention to prevent personal injury, equipment damage, process disruption, or product damage.

R4-3.2 Alarm design should take into account impairments that may be caused by clothing and hearing and eye protection.

R4-3.3 Users should be provided with an input device for acknowledging and canceling alarms without erasing information that accompanies the alarm. The capability to cancel alarms should be evaluated for its impact on safety.

R4-3.4 Alarm decibel levels will require a setpoint above the background noise levels sufficient to meet local regulations.

RELATED INFORMATION 5
CONTROLS AND DISPLAYS

NOTICE: This related information is not an official part of SEMI S8 and is not intended to modify or supersede the official guidelines. It was derived from the work of the originating task force. Publication was authorized by full ballot procedures. Determination of the suitability of the material is solely the user's responsibility.

R5-1 General Considerations

R5-1.1 The selection and/or design of controls and displays should be based on careful analysis of equipment functionality requirements. This will determine what information the operator needs to make appropriate decisions and responses, thus reducing potential design-induced error.

R5-1.2 Potential errors due to inattention, stress, fatigue, sensory overload, etc., need to be considered during system design. This can be accomplished by ensuring that critical controls and displays attract the user's attention and that controls and displays are clearly labeled and arranged to reduce confusion. Whenever possible, functionally related controls and displays should be grouped together.

R5-1.3 Appropriate feedback should be provided for system status, mode of operation, operator input actions, and equipment malfunctions.

R5-1.4 Controls and displays should be clearly labeled/identified by function. Controls and displays can be coded by color, size, shape, or location to help discriminate between functions and identify critical information. Colors should be in accordance with NFPA 79 and EN 60204-1.

R5-1.5 Placement of labels should be consistent on pieces of equipment (e.g., either below or above controls and displays).

R5-1.6 To accommodate color blind users, color should be supplemental to other means of coding such as icons, words, flashing, shape, etc.

R5-2 Controls

R5-2.1 In general, the design of controls should consider the following criteria:

R5-2.2 Control movement or activation should be compatible with users' expectations and provide positive evidence that an input has been accepted or that control action is being accomplished. Feedback can be visual, auditory, tactile, or a combination thereof.

R5-2.3 Controls should be designed and located to minimize awkward postures.

R5-2.4 Controls should be designed, positioned, or protected to prevent inadvertent actuation.

R5-2.5 The maximum width of frequently used control panels should be 68.6 cm (27 in.).

R5-2.6 Controls should be located away from chemical, thermal, radiation, electrical, or mechanical hazards. If such a location cannot be avoided, controls should be appropriately shielded and labeled.

R5-2.7 Control force requirements should be designed in accordance with HumanScale, NFPA 79, EN 60204-1, or another recognized standard.

R5-3 Visual Displays

R5-3.1 The type of visual display selected should depend on the nature of information conveyed and conditions of use. The effectiveness and utility of a visual display generally depends on visibility, legibility, and meaningfulness.

R5-3.2 Further information may be found in MIL-STD-1472 for non-VDT displays, and ISO 9241 for VDTs.

R5-3.3 The visibility of a display is determined by the viewing distance, the size of the display, the location, angle of view, local illumination characteristics, obstructions, or reflections.

R5-3.4 Critical and frequently used displays should be placed in the operator's primary viewing area.

R5-3.5 The display should be positioned so the user has a clear line of sight. Displays should not be located where they are obstructed (by controls, equipment, body parts, etc.) or subject to glare. Display viewing should not require awkward body postures.

R5-3.6 The legibility of a display is determined primarily by its visual angle and luminance contrast with the background.

R5-3.7 There should be sufficient contrast between the object, letters, or numbers on a display to separate them from the background, minimum ratio 3:1, preferred is 7:1 (ISO 9241). Too much contrast may result in glare.

R5-3.8 The ability of displayed information to communicate with the user clearly and precisely depends on the amount of information displayed. Display design should emphasize simplicity and usability to:

R5-3.8.1 Reduce error and decrease response time.

R5-3.8.2 Provide only the amount of information necessary and only at a level of precision required.

R5-3.8.3 Display content in a directly usable form with no transformation required.

R5-4 Auditory Displays

R5-4.1 Auditory coding or signals may be used to alert a user to critical conditions or operations. Auditory coding should be supplementary to visual coding. Auditory displays can be used effectively when:

R5-4.1.1 Vision is overburdened or degraded,

R5-4.1.2 The message requires immediate action,

R5-4.1.3 The job requires the operator or maintainer to move around frequently,

R5-4.1.4 The message is simple and short,

R5-4.1.5 The message signals an event in time, or

R5-4.1.6 The message does not need to be referred to later.

R5-5 Control - Display Relationships

R5-5.1 The relationship between associated controls and displays (their organization and layout) is critical to optimizing system performance and minimizing operator error.

R5-5.2 Controls and displays should be organized into functional groups and positioned according to criticality, sequence of operation, and frequency of use.

R5-5.3 Control-display compatibility refers to the extent to which the relationship between a control operation and its effect is predictable by the user. Predictability is determined by individual and population cultural stereotypes (user expectations, previous experience, an idea of the way equipment works, etc.). Lack of compatibility degrades speed, accuracy of performance, and increases probability of error. Types of compatibility include sequential arrangement, spatial organization, and direction of movement. Technology transfer and utilization by a multi-cultural or multi-ethnic work force, as well as across global user populations should consider the impact of cultural and behavioral stereotypes.

R5-5.4 Display layout, control location, and operation should be similar throughout a particular type and/or model of equipment or system. Consistency is particularly important for color, shape, and size of controls, scale markings on displays, and labeling.

RELATED INFORMATION 6
USER COMPUTER INTERFACE

NOTICE: This related information is not an official part of SEMI S8 and is not intended to modify or supersede the official guidelines. It was derived from the work of the originating task force. Publication was authorized by full ballot procedures. Determination of the suitability of the material is solely the user's responsibility.

R6-1 Operator Interaction

NOTE R6-1: Refer to ISO 9241 for detailed guidance.

R6-1.1 The dialogue should be suitable for the task.

NOTE R6-2: A dialogue is suitable for a task when it supports the user in the effective and efficient completion of the task.

R6-1.1.1 The dialogue should present the user only with information related to the completion of the task.

R6-1.1.2 The information displayed should be in a directly usable form to avoid the need to transpose, compute, interpolate, or translate.

R6-1.1.3 Help information should be task dependent.

R6-1.1.4 Any actions that can appropriately be allocated to the interface software for automatic execution should be carried out by the software without user involvement.

R6-1.1.5 When designing the dialogue, consideration should be given to the complexity of the task with respect to the users' skills and abilities.

R6-1.1.6 The format of input and output should be appropriate to the given task and user requirements.

R6-1.1.7 The dialogue should support the user when performing recurrent tasks.

R6-1.1.8 If default input capabilities exist for a given task (e.g., standard default values) it should not be necessary for the user to input such values. It should also be possible to replace default values with other values or other appropriate default values.

R6-1.1.9 During performance of a task in which data is changed, the original data should remain accessible if the task requires it.

R6-1.1.10 The dialogue should avoid forcing unnecessary task steps.

R6-1.2 The dialog should be self-descriptive.

NOTE R6-3: A dialogue is self-descriptive when each dialogue step is immediately comprehensible through feedback from the system or is explained to the user on request.

R6-1.2.1 After any user action, the dialogue should provide feedback, where appropriate. If severe consequences result from the user action, the system should provide explanation and request confirmation before carrying out the action.

R6-1.2.2 Feedback or explanations should be presented in consistent terminology, which is derived from the task environment, rather than from the dialogue system technology (e.g., when the user wants to input an order to load a cassette, LOAD should be the command rather than a code followed by pressing the ENTER key).

R6-1.2.3 Feedback or explanations should assist the user in gaining a general understanding of the dialogue system as a possible supplement to user training.

R6-1.2.4 Feedback or explanations should be based on the level of knowledge which the typical user may be expected to have.

R6-1.2.5 Feedback or explanations varying in types and length, based on user needs and characteristics, should be available for the user.

R6-1.2.6 To enhance their value for the user, feedback or explanations should strictly relate to the situation for which they are needed.

R6-1.2.7 The quality of feedback or explanations should minimize the need to consult user manuals and other external information, thus avoiding frequent media switches.

R6-1.2.8 If defaults exist for a given task they should be made available to the user.

R6-1.2.9 The user should be informed about changes in the dialog system status that are relevant to the task.

R6-1.2.10 When input is requested, the dialogue system should give information to the user about the expected input.

R6-1.2.11 The requirement to learn special program codes, long sequences, and special instructions should be avoided.

R6-1.3 The dialogue should be controllable.

NOTE R6-4: A dialogue is controllable when the user is able to initiate and control the direction and pace of the interaction until the point at which the goal has been met

R6-1.3.1 The speed of interaction should not be dictated by the operation of the system. It should always be under the control of the user according to the user's needs and characteristics.

R6-1.3.2 The dialogues should give the user control over how to continue with the dialogue. Exceptions may be made for critical alarms, fault situations, as well as process and safety reasons. User interrupt or abort options to terminate interactions should be provided.

R6-1.3.3 If the dialogue has been interrupted, the user should have the ability to determine the point of restart when the dialogue is resumed, if the task permits.

R6-1.3.4 If interactions are reversible and the task permits, it should be possible to undo at least the last dialogue step.

R6-1.3.5 Different user needs and characteristics require different levels and methods of interaction.

R6-1.3.6 The way that input/output data are represented (format and type) should be under the control of the user.

R6-1.3.7 Where alternative input/output devices exist, the user should have the option of which one to use.

R6-1.4 The dialogue should conform with user expectations.

NOTE R6-5: A dialogue conforms with user expectations when it is consistent and corresponds to the user characteristics, such as task knowledge, education, experience, and to commonly accepted conventions.

R6-1.4.1 Dialogue behavior and appearance within a dialogue system should be consistent.

R6-1.4.2 State change actions should be implemented consistently.

R6-1.4.3 Dialogues used for similar tasks should be similar so that the user can develop common task solving procedures.

R6-1.4.4 Immediate feedback on user input should be given where appropriate to user expectations. It should be based on the level of knowledge of the user.

R6-1.4.5 The cursor should be located where the input is wanted.

R6-1.4.6 If a response time is likely to deviate considerably from the expected response time, the user should be informed of this.

R6-1.5 The dialogue should be error tolerant.

NOTE R6-6: A dialogue is error tolerant if, despite evident errors in input, the intended result may be achieved with either no or minimal corrective action by the user.

R6-1.5.1 The application should assist the user in detecting and avoiding errors in input. The dialogue system should prevent any user input from causing undefined dialogue system states or dialogue system failures.

R6-1.5.2 Errors should be explained to help the user to correct them.

R6-1.5.3 Depending on the task, it may be desirable to apply special effort in presentation techniques to improve the recognition of error situations and their subsequent recovery.

R6-1.5.4 In cases where the dialogue system is able to correct errors automatically, it should advise the user of the execution of the corrections and provide the opportunity to override the corrections.

R6-1.5.5 User needs and characteristics may require that error situations are deferred, leaving the decision to the user when to handle them.

R6-1.5.6 Additional explanations should be provided during error correction on request.

R6-1.5.7 Validation/verification of data should take place before attempting to process the input.

R6-1.5.8 Additional controls should be provided for commands with serious consequences.

R6-1.5.9 Error correction should be possible without switching dialogue system states, where the task permits.

R6-1.6 The dialogue should be capable of individualization.

NOTE R6-7: A dialogue is capable of individualization when the interface software can be modified to suit the task needs, individual preferences, and skills of the user.

NOTE R6-8: Although, in many cases, providing users with customization capabilities is very desirable, it is not an acceptable substitute for ergonomically designed dialogues. In addition, customization capabilities should be provided only within certain limits such that modifications cannot cause users any potential discomfort (e.g., unacceptable noise levels with user configured auditory feedback).

R6-1.6.1 Mechanisms should be provided to allow the dialogue system to be adapted to the user's language and culture, individual knowledge and experience of task domain, perceptual, sensory-motor, and cognitive abilities.

R6-1.6.2 The amount of explanation (e.g., details in error messages, help information) should be modifiable according to the level of knowledge of the user.

R6-1.6.3 The user should be allowed to incorporate their own vocabulary to establish individual naming for objects and actions if it suits the contexts and tasks. It should also be possible for the user to add individualized commands.

R6-1.6.4 The user should be able to set up operational time parameters to match their individual needs.

R6-1.6.5 Users should be able to choose between different dialogue techniques for different tasks.

R6-1.6.6 Log in should be a separate procedure that is completed before a user may select an operational step. Passwords should be used to protect (limit access to) parts of the operating system which may be beyond the user’s skill level to control safely.

R6-1.7 The dialogue should be suitable for learning.

NOTE R6-9: A dialogue is suitable for learning when it supports and guides the user in learning to use the system.

R6-1.7.1 Rules and underlying concepts which are useful should be made available to the users, thus allowing the users to build up their own grouping strategies and rules for memorizing activities.

R6-1.7.2 Relevant learning strategies, (e.g., comprehension oriented, learning by doing, learning by example) should be provided.

R6-1.7.3 Relearning facilities should be supported.

R6-1.7.4 A number of different means to help the user to become familiar with the dialogue elements should be provided.

R6-2 Video Display Terminals

NOTE R6-10: Refer to ISO 9241 and EN 894-2 for detailed guidelines.

R6-2.1 Display characteristics should be selected to suit the specific conditions of use. For example, the expected viewing distance, ambient levels of illumination, and lighting color (e.g., yellow illumination) in the work area should be considered.

R6-2.2 Displays should be perpendicular to the user’s normal line of sight. The angle of the screen should be adjustable or positioned to minimize glare.

R6-2.3 Surfaces immediately adjacent to the display should have a matte finish to control glare.

R6-2.4 Areas coded by luminance only should differ in display luminance with respect to each other by ratio of at least 1.5:1.

R6-2.5 Where blink coding is used solely to attract attention, a single blink frequency of 1Hz to 5Hz with a duty cycle of 50% is recommended. Where readability is required during blinking, a single blink rate of 1/3Hz to 1Hz with a duty cycle of 70% is recommended. It should be possible to switch off the blinking of the cursor.

R6-2.6 The number of colors simultaneously presented on a display should be based on the performance requirements of the task. In general, the number of colors simultaneously presented should be minimized. For accurate identification, the default color set(s) should consist of no more than eleven colors in each set.

R6-3 Input Devices

NOTE R6-11: Refer to ISO 9241 and EN 894-3 for detailed guidelines.

R6-3.1 Input characteristics should be selected to suit the specific conditions of use. For example, the performed task, workstation arrangement, ambient levels of illumination in the work area, and related tasks should be considered.

R6-3.2 Keyboards should permit easy repositioning on the work surface. Other than for special applications with clearly defined tasks, the keyboard should be detachable. The keyboard should be stable during use (i.e., it should not slip or rock).

R6-3.3 Keyboard support surfaces should be adjustable to accommodate standing or seated operation where suitable.

RELATED INFORMATION 7
SEMI S8 SUPPLIER ERGONOMIC SUCCESS CRITERIA (SESC) CHECKLIST APPLICATIONS GUIDE

RELATED INFORMATION 7
SEMI S8 SUPPLIER ERGONOMIC SUCCESS CRITERIA (SESC) CHECKLIST APPLICATIONS GUIDE

NOTICE: This related information is not an official part of SEMI S8 and was derived by the EHS Ergonomics Task Force. This related information was approved for publication by full letter ballot on September 3, 2003.

R7-1 Purpose

R7-1.1 This section is provided as a companion to the SEMI S8 Supplier Ergonomic Success Criteria (SESC) checklist as an aid to help equipment designers and evaluators understand how to apply the checklist when designing equipment or assessing machine designs or prototypes.

R7-1.2 This applications guide follows the numbering scheme of the SESC checklist. When appropriate, notes, illustrations and diagrams have been added to clarify each item.

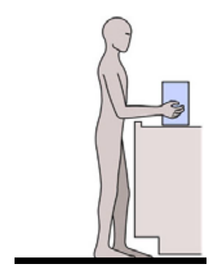
NOTE R7-1: For the purpose of this document, "weight" is defined as the force of gravity and units are specified in Newtons (N), and pound-force (lbf.). One lbf. is the force of gravity on a one-pound mass (lb.) and 9.81 N is the force of gravity on a one-kilogram mass (kg.).

Table R7-1 Supplier Ergonomic Success Criteria Checklist Applications Guide

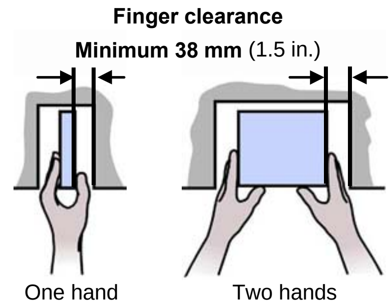
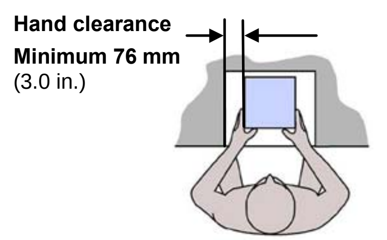
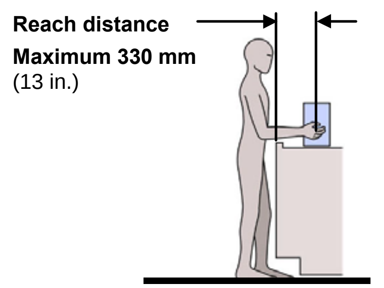
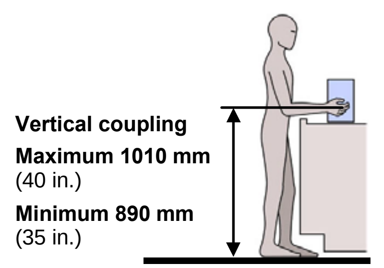
Section 1: Manual Material Handling

Section	*Indicator*
1.1	Potentially hazardous manual material handling tasks performed as part of operations, maintenance, or service are analyzed utilizing appropriate procedures. NOTE: Two hand lifting or lowering tasks should be analyzed: if the object being handled weighs more than 44.5 N (10 lbf); OR, if the object weighs more than 22.2 N (5 lbf) and the anticipated frequency is greater than 1 lift every 5 minutes. See Appendix 2 for further information. Acceptance criterion: Analysis and results documentation. Table A2-2, Appendix 2, or the equivalent, should be used to document 2-hand lift/lower analysis.

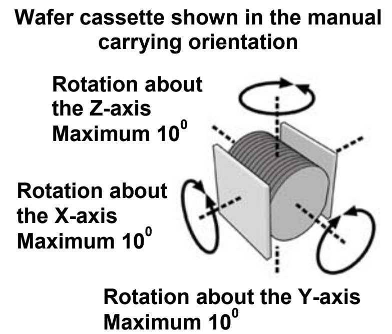
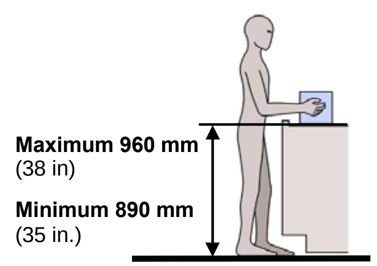
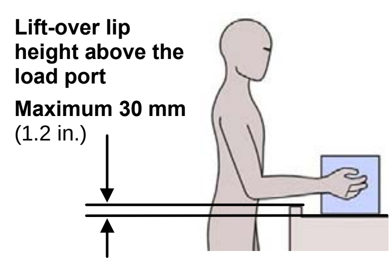
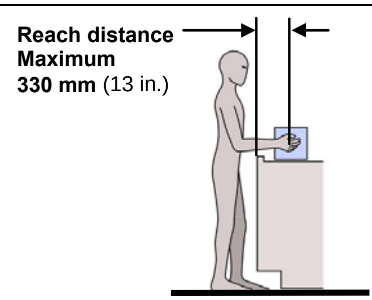
Section 2: Product Loading in a Standing Posture

Section	*Indicator*	*Figure*
2.0	**Product Loading in a Standing Posture** (Applicable to all media other than wafer cassettes including JEDEC trays, magazines and reticle cassettes. NOTE A: The criteria of this section should be applied only to production operations where media will be loaded and unloaded by people. NOTE B: This guideline may also be applied to manually loaded FOUPs. NOTE C: A load port is the surface upon which the machine operator places the media or the base of the media when it is placed on a machine arm or in a receptacle. NOTE D: Coupling point is the center of a handle or the center of the large middle knuckle of the hand when it grasps an object.	

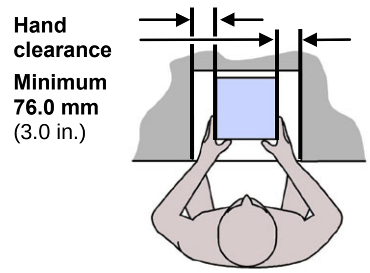
Section 2: Product Loading in a Standing Posture

Section	*Indicator*	*Figure*
2.1	Clearance provided for finger thickness. Acceptance criterion: minimum 38 mm (1.5 in.) NOTE: Minimum clearance should be provided for the finger clearance for the hand when it is in the orientation used to grip the item. If the object is grasped from the sides, there should be finger clearance on both sides. If the object is grasped from above and below, such as when inserting or removing a reticle container, there should be minimum finger clearance above and below the object.	
2.2	Clearance provided for hand thickness. Acceptance criterion: minimum 76 mm (3.0 in.)	
2.3	Reach distance measured from the leading edge of the tool or obstruction to the hand/product coupling point(s). Acceptance criterion: maximum 330 mm (13 in.) NOTE: Reach distances should be measured from the leading edge of the machine housing or any obstruction between the machine operator and the load port. Obstructions include keyboard trays, drip trays, anti-vibration platforms and machine load-bearing pads.	
2.4	Vertical coupling point of hand to product in load position. Acceptance criteria: maximum 1010 mm (40 in.) minimum 890 mm (35 in.) NOTE: Machine height variables such as the presence of load-bearing pads, anti-vibration platforms, casters or the adjustment of leveling feet should be specified when measuring the load port height.	

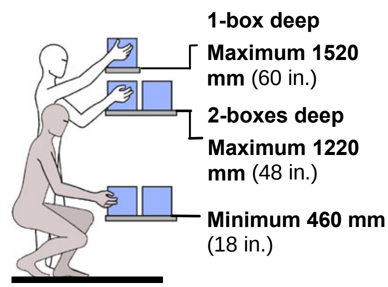
Section 3: Wafer Cassette Loading

Section	*Indicator*	*Figure*
3.0	NOTE A: The criteria of this section should only be applied to production operations where production materials will be loaded and unloaded by people. NOTE B: A load port is the surface upon which the machine operator places the wafer cassette or the base of the wafer cassette when it is placed on a machine arm or in a receptacle. NOTE C: Coupling point is the center of a handle or the large middle knuckle of the hand when it grasps an object.	
3.1	Wafer cassette loading should not require greater than 10 degrees cassette rotation about any axis. Unless otherwise specified, you should assume that 200 mm or smaller wafers are transported in the vertical orientation and that 300 mm wafers are transported in the horizontal orientation. Acceptance criteria: less than 10 degrees rotation about any axis. NOTE: Manual and powered wafer cassette rotation devices are a means to provide controlled rotation of wafer cassettes. See section 5.0, "Manual Wafer Cassette Rotation Device Design" for design recommendations.	
3.2	Load port height, vertical distance from standing surface (150–200 mm wafers). Acceptance criteria: maximum 960 mm (38 in.) minimum 890 mm (35 in.) NOTE: Machine height variables such as the presence of load bearing pads, anti-vibration platforms, casters or the adjustment of leveling feet should be specified when measuring the load port height.	
3.3	Maximum lip height in front of cassette load port over which the cassette is lifted (150–200 mm wafer cassettes only). Measure lip height from the load surface. Acceptance criterion: maximum 30 mm (1.2 in.) NOTE: For machines where the wafer cassette is loaded on a machine arm, measure the vertical distance from the base of the wafer cassette when it's on the arm to the highest obstruction the wafer cassette must be lifted over when loading or unloading.	
3.4	Reach distance from the leading edge of the tool or obstruction to the coupling point(s) on a rotation device or the product grasp point. Acceptance criterion: maximum 330 mm (13 in.) NOTE: Reach distances should be measured from the leading edge of the machine housing or any obstruction between the machine operator and the load port. Obstructions include keyboard trays, drip trays, anti-vibration platforms and machine load-bearing pads.	

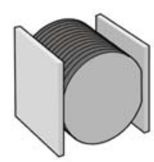
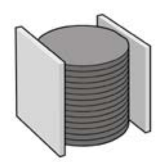
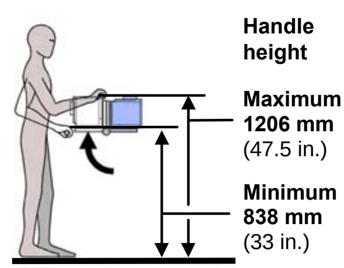
Section 3: Wafer Cassette Loading

Section	*Indicator*	*Figure*
3.5	Minimum hand clearance on either side of the cassette, measured from the side of the cassette to the nearest adjacent object. Acceptance criterion: minimum 76 mm (3.0 in.) NOTE: Clearance must be provided on both sides of the cassette.	

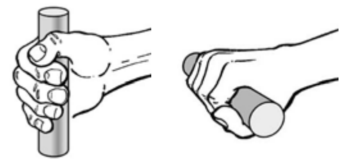
Section 4: Work in Process Storage (specific to wafer cassettes)

Section	*Indicator*	*Figure*
4.1	Integral wafer cassette/lot box storage shelf height (150 and 200 mm wafer cassette/lot boxes only). Acceptance criteria: maximum (1 box deep) 1520 mm (60 in.) maximum (2 boxes deep) 1220 mm (48 in.) minimum 460 mm (18 in.)	

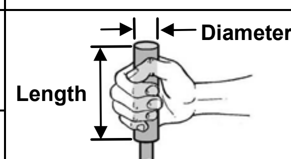
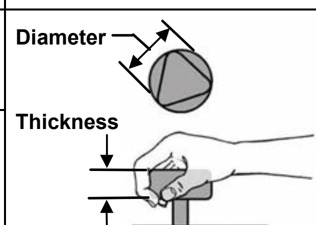
Section 5: Manual Wafer Cassette Rotation Device Design

Section	*Indicator*	*Figure*
5.0	NOTE A: Some machines process wafers horizontally. 150–200mm wafers are normally carried vertically, so to load these machines, the operator must rotate the wafer cassette to orient the wafers for processing. NOTE B: Manual rotation of wafer cassettes can increase stress on the machine operator's upper extremities, which may lead to physical strain over time and/or damage to wafers, especially if the wafer cassettes do not have handles. NOTE C: Manual and powered wafer cassette rotation devices are a way to provide controlled rotation of wafer cassettes as a means to reduce the machine operator's physical stress and lower the potential for wafer damage.	 Manual handling orientation for a 150-200 mm wafer cassette  Machine handling orientation for a 150-200 mm wafer cassette
5.1	Handle height, couple point for hand(s) from standing surface. Acceptance criteria: maximum 1206 mm (47.5 in.) minimum 838 mm (33 in.) NOTE: Coupling point is the center of a handle or the large middle knuckle of the hand when it grasps an object.	

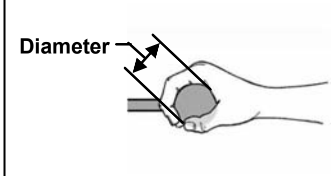
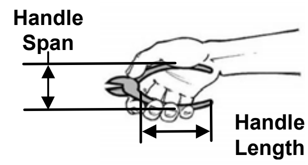
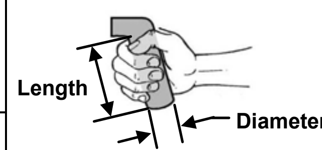
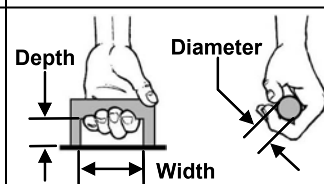
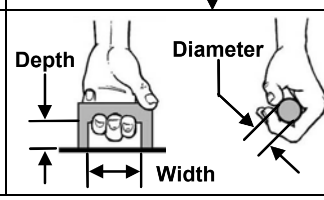
Section 5: Manual Wafer Cassette Rotation Device Design

Section	*Indicator*	*Figure*
5.2	Hand grip(s) shall allow for a full “power grip” similar to grabbing a rung on a ladder or holding a pistol. Acceptance criterion: allows for a full power grip in either pronated (palm facing down) or neutral (handshake position) posture. NOTE A: Acceptable handle types include cylindrical, circular, triangular, or enclosed. NOTE B: See §6 for handle design recommendations.	**Power Grips** 
5.3	Single hand lift force Acceptance criterion: maximum 37.8 N (8.5 lbf). This value includes a 15% capacity reduction due to cleanroom glove use.	
5.4	Two hand lift force Acceptance criterion: maximum 64.5 N (14.5 lbf). This value includes a 15% capacity reduction due to cleanroom glove use.	

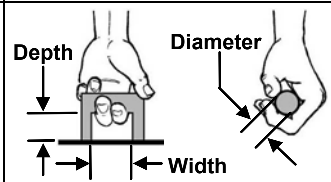
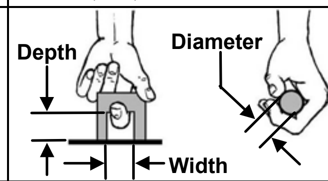
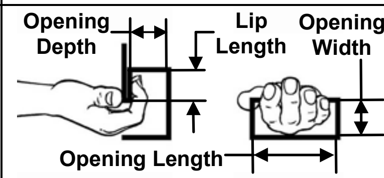
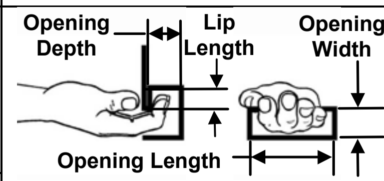
Section 6: Handle Design

Section	*Indicator*	*Figure*
6.0	(Handle dimensions are correct for use of bare hand or use of typical cleanroom gloves). NOTE A: A recommended practice for selecting a handle design is to first determine the force requirements before choosing a handle design that is best suited for the intended forces, motions and environment. Handle design recommendations for various hand forces and handgrips are located in ¶¶6.2–6.6. NOTE B: Handles should anticipate the use of gloved hands.	
6.1	Handle Surface finish**:** Acceptance criterion: all edges radiused	
6.2	Cylindrical handle	
6.2.1	Cylindrical handle diameter (D). Acceptance criteria: maximum 38 mm (1.5 in.) minimum 25 mm (1.0 in.)	
6.2.2	Cylindrical handle length (L) Acceptance criterion: minimum 127 mm (5.0 in.)	
6.3	Circular or triangular handle	
6.3.1	Circular or triangular handle diameter (D) Acceptance criteria: maximum 90 mm (3.5 in.) minimum 50 mm (2.0 in.)	
6.3.2	Circular or triangular handle height (thickness) (H) Acceptance criteria: maximum 25 mm (1 in.) minimum 19 mm (0.75 in.)	

Section 6: Handle Design

Section	*Indicator*	*Figure*
6.4	Ball handle	
6.4.1	Ball handle diameter Acceptance criteria: maximum 63 mm (2.5in.) minimum 19 mm (1.5 in.)	
6.5	Pliers handle	
6.5.1	Pliers handle grip span (S) Acceptance criteria: maximum 89 mm (3.5in.) open minimum 38 mm (1.5 in.) closed	
6.5.2	Pliers handle grip length (L) Acceptance criterion: minimum 127 mm (5 in.)	
6.6	Pistol grip handle	
6.6.1	Pistol grip handle diameter (D) Acceptance criteria: maximum 63 mm (2.5 in.) minimum 38mm (1.5 in.)	
6.6.2	Pistol grip handle length (L) Acceptance criterion: minimum 127 mm (5.0 in.)	
6.7	Enclosed handles NOTE: Handle diameter refers to the surface of the handle presented to the inside of the curled fingers. Enclosed handles need not be made solely from cylindrical stock.	
6.7.1	Enclosed handle, full power grip (suitcase handle) Width (W): minimum 127 mm (5.0 in.) Depth (D): minimum 45 mm (1.75 in.) Diameter (d): maximum 25 mm (1.0 in.)	
6.7.1.1	Diameter requiring no more than 71 N (16 lbf.) force Diameter: minimum 6.3 mm (0.25 in.)	
6.7.1.2	Diameter requiring no more than 89 N (20 lbf.) force Diameter: minimum 13 mm (0.50 in.)	
6.7.1.3	Diameter requiring no more than 200 N (40 lbf.) force Diameter: minimum 19 mm (0.75 in.)	
6.7.2	Enclosed handle, three fingers Width (W): minimum 90 mm (3.5 in.) Depth (D): minimum 38 mm (1.5 in.) Diameter (d): minimum 6.3 mm (0.25 in.) Force: maximum 71 N (16 lbf)	

Section 6: Handle Design

Section	*Indicator*	*Figure*
6.7.3	Enclosed handle, two fingers Width (W): minimum 60 mm (2.5 in.) Depth (D): minimum 38 mm (1.5 in.) Diameter (d): minimum 6.3 mm (0.25 in.) Force maximum: 51 N (11.5 lbf)	
6.7.4	Enclosed handle, one finger Width (W): minimum 38 mm (1.5 in.) Depth (D): minimum 38 mm (1.5 in.) Diameter (d): minimum 3.2 mm (0.13 in.) Force: maximum 27 N (6 lbf)	
6.8	Hook Grasp Handle	
6.8.1	Hook Grasp Handle (4 fingers) Opening length (L): minimum 90 mm (3.5 in.) Opening width (W): minimum 38 mm (1.5 in.) Depth (d): minimum 50 mm (2.0 in.) Lip length (l): minimum 50 mm (2.0 in.)	
6.8.2	Hook grasp handle pull force (four fingers) Pull force: maximum 80 N (18.0 lbf)	
6.9	Finger Pull Handle	
6.9.1	Finger pull Handle (4 fingers) Opening length (L): minimum 90 mm (3.5 in.) Opening width (W): minimum 25 mm (1.0 in.) Depth (d): minimum 19mm (0.75 in.) Lip length (l): minimum 19mm (0.75 in.)	
6.9.2	Finger pull handles pull force (four fingers) Pull force: maximum 9.8 N (2.2 lbf)	