SEMI E2.4-93 (Withdrawn 1103)
STANDARD FOR 125 mm QUARTZ AND HIGH TEMPERATURE WAFER CARRIERS

This standard was technically reapproved by the Physical Interfaces & Carriers Committee and is the direct responsibility of the North American Physical Interfaces & Carriers Committee. Current edition approved by the North American Regional Standards Committee in October 1998. Initially available at www.semi.org February 1999; to be published February 1999. Originally published in 1993; previous published revision in 1996.

NOTICE: This document was balloted and approved for withdrawal in 2003.

NOTE: Terms and Dimensions used in this specification are defined in SEMI E2.

	Description	*Style 1 — Non-Contiguous (Figure 1)*	*Style 2 — Contiguous (Figure 2)*
Symbol			
A	Wafer Height	69.1 mm + 0.5 mm (2.72 in. + 0.02 in.)	69.1 mm + 0.5 mm (2.72 in. + 0.02 in.)
B	Base Width	46.0 mm + 0.25 mm (1.80 in. + 0.01 in.)	46.0 mm + 0.25 mm (1.80 in. + 0.01 in.)
D	Lift Access Height	17.8 mm (0.70 in.) min.	17.8 mm (0.70 in.) min.
E	Lift Access Spacing	134.5 mm + 0.50 mm (5.296 in. + 0.02 in.)	109.2 mm + 0.5 mm (4.30 in. ± 0.02 in.)
F	Lift Access Opening	8 mm I.D. (0.315 in. I.D.) min.	8 mm I.D. (0.315 in. I.D.) min.
J	Pocket Size (DIA)	4.935 in. min.	same
K	Base Side to Wafer Centerline	1/2 B ± 0.25 mm (0.01 in.)	same
L	Carrier Region	150° max.	125° max.
P	Separation — Wafer to Wafer	≥ 10% H	≥ 10% H
25 Capacity			
C	Base Length	145.7 mm ± 0.076 mm (5.736 in. ± 0.003 in.)	119.00 mm ± 0.076 mm (4.688 in. ± 0.003 in.)
G	Base End to 1st Slot	15.7 mm ±0.076 mm (0.618 in. ±0.003 in.)	2.390 mm ± 0.076 mm (0.094 in. ± 0.003 in.)
H (See NOTE 1.)	Slot Spacing (non-accumulative)	4.76 mm ± 0.51 mm (0.1875 in. ±0.002 in.)	4.76 mm ± 0.51 mm (0.1875 in. ± 0.002 in.)
I	End Slot to End Slot	114.3 mm ± + 0.076 (4.500 in. ± 0.003 in.)	114.3 mm ± + 0.076 mm (4.500 in. ± 0.003 in.)
50 Capacity			
C	Base Length	145.7 mm ± 0.076 mm (5.736 in. ± 0.003 in.)	121.46 mm ± 0.076 mm (4.782 in. ± 0.003 in.)
G	Base End to 1st Slot	14.50 mm ± 0.076 mm (0.571 in. ± 0.003 in.)	2.390 mm ± 0.076 mm (0.094 in. ± 0.003 in.)
H (See NOTE 2.)	Slot Spacing (non-accumulative)	2.381 mm ± 0.051 mm (0.09375 in. ± 0.002 in.)	2.381 mm ± 0.051 mm (0.09375 in. ± 0.002 in.)
I	End Slot to End Slot	116.69 ± 0.076 mm (4.594 in. ± 0.003 in.)	116.69 mm ± 0.076 mm (4.594 in. ± 0.003 in.)

NOTE 1: 25 capacity slot spacing is derived from SEMI E1.3 and E1.4.

NOTE 2: 50 capacity slot spacing is SEMI E1.3 divided by 2 or E1.4 divided by 2; to insure compatability for wafer transfer between Plastic & High Temperature Carriers, the U.S. customary dimension is carried out to 5 decimals to eliminate accumulation in rounding error when multiplying by 49 spaces to achieve I.

NOTICE: These standards do not purport to address safety issues, if any, associated with their use. It is the responsibility of the user of these standards to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use. SEMI makes no warranties or representations as to the suitability of the standards set forth herein for any particular application. The determination of the suitability of the standard is solely the responsibility of the user. Users are cautioned to refer to manufacturer's instructions, product labels, product data sheets, and other relevant literature respecting any materials mentioned herein. These standards are subject to change without notice.

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SEMI E2.5-93 (Withdrawn 1103)
STANDARD FOR 150 mm QUARTZ AND HIGH TEMPERATURE WAFER CARRIERS

This standard was technically reapproved by the Physical Interfaces & Carriers Committee and is the direct responsibility of the North American Physical Interfaces & Carriers Committee. Current edition approved by the North American Regional Standards Committee in October 1998. Initially available at www.semi.org February 1999; to be published February 1999. Originally published in 1993; previous published revision in 1996.

NOTICE: This document was balloted and approved for withdrawal in 2003.

NOTE: Terms and Dimensions used in this specification are defined in SEMI E2.

	Description	*Style 1 — Non-Contiguous (Figure 1)*	*Style 2 — Contiguous (Figure 2)*
Symbol			
A	Wafer Height	80.0 mm ± 0.5 mm (3.15 in. ± 0.02 in.)	80.0 mm ± 0.5 mm (3.15 in. ± 0.02 in.)
B	Base Width	54.91 mm ± 0.25 mm (2.16 in. ± 0.01 in.)	54.91 mm ± 0.25 mm (2.16 in. ± 0.01 in.)
D	Lift Access Height	17.8 mm (0.70 in.) min.	17.8 mm (0.70 in.) min.
E	Lift Access Spacing	134.5 mm ± 50 mm (5.296 in ± 02 in.)	109.2 mm ± 0.5 mm (4.30 in. ± 0.02 in.)
F	Lift Access Opening	8 mm I.D (0.315 in. I.D.) min.	8 mm I.D (0.315 in. I.D.) min.
J	Pocket Size (DIA)	5.920 in. min.	same
K	Base Side to Wafer Centerline	½ B ± 0.25 mm (.01 in.)	same
L	Carrier Region	150° max.	125° max.
P	Separation — Wafer to Wafer	≥ 10% H	≥ 10% H
25 Capacity			
C	Base Length	145.7 mm ± 0.076 mm (5.736 in. ± 0.003 in.)	119.00 mm ± 0.076 mm (4.688 in. ± 0.003 in.)
G	Base End to 1st Slot	15.7 mm ± 0.076 mm (0.618 in. ± 0.003 in.)	2.390 mm ± 0.076 mm (0.094 in. ± 0.003 in.)
H (See NOTE 1.)	Slot Spacing (non-accumulative)	4.76 mm ± 0.051 mm (0.1875 in. ± 0.002 in.)	4.76 mm ± 0.051 mm (0.1875 in. ± 0.002 in.)
I	End Slot to End Slot	114.3 mm ± 0.076 mm (4.500 in. ± 0.003 in.)	114.3 mm ± 0.076 mm (4.500 in. ± 0.003 in.)
50 Capacity			
C	Base Length	145.7 mm ± 0.076 mm (5.736 in. ± 0.003 in.)	121.46 mm ± 0.76 mm (4.782 in. ± 0.003 in.)
G	Base End to 1st Slot	14.50 mm ± 0.076 mm (0.571 in. ± 0.003 in.)	2.390 mm ± 0.076 mm (0.094 in. ± 0.003 in.)
H (See NOTE 2.)	Slot Spacing (non-accumulative)	2.381 mm ± 0.051 mm (0.09375 in. ± 0.002 in.)	2.381 mm ± 0.051 mm (0.09375 in. ± 0.002 in.)
I	End Slot to End Slot	116.69 mm ± 0.076 mm (4.594 in. ± 0.003 in.)	116.69 mm ± 0.076 mm (4.594 in. ± 0.003 in.)

NOTE 1: 25 capacity slot spacing is derived from SEMI E1.5.

NOTE 2: 50 capacity slot spacing is SEMI E1.5 divided by 2; to insure compatibility for wafer transfer between Plastic & High Temperature Carriers, the U.S. customary dimension is carried out to 5 decimals to eliminate accumulation in rounding error when multiplying by 49 spaces to achieve I.

SEMI E6-0303
GUIDE FOR SEMICONDUCTOR EQUIPMENT INSTALLATION DOCUMENTATION

This guide was technically approved by the Global Facilites Committee and is the direct responsibility of the North American Facilities Committee. Current edition approved by the North American Regional Standards Committee on November 22, 2002. Initially available at www.semi.org January 2003; to be published March 2003. Originally published in 1982; previously published December 1996.

NOTICE: This document was balloted as a complete rewrite of SEMI E6 in 2002.

1 Purpose

1.1 Within the semiconductor industry, the diversity and complexity of equipment creates difficult challenges for facilities design and equipment installation. This guide should benefit equipment suppliers and semiconductor manufacturers by communicating, in a standardized way, the information necessary to prepare the facility and to efficiently install semiconductor equipment.

2 Scope

2.1 This standard applies to the facilities interface of all semiconductor production equipment and supplier-provided support equipment.

2.2 The recommended equipment installation documentation should cover all installation requirements from receiving until hookup is complete.

2.3 The series of data sheets included should address all site facilities necessary to support semiconductor equipment processing.

2.4 The data sheets provide a consistent format for both the equipment supplier and equipment purchaser to use in compiling and interpreting equipment installation data.

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

3 Limitations

3.1 SEMI E6 applies to the facility interface of semiconductor equipment only. Other equipment interfaces, such as the physical interfaces for material handling (see SEMI E106 and related standards) and software interfaces (see SEMI Information and Control Standards) are defined by other SEMI Standards.

3.2 This guide is not intended to address the internal connections of the equipment that are typically completed by the equipment supplier. This document includes only information related to the utility connections on the equipment or support equipment that are the responsibility of the semiconductor manufacturer's equipment installation team.

3.3 This guide is not intended to address the documentation provided for equipment start-up, qualification, or commissioning.

4 Referenced Standards

4.1 *SEMI Standards*

SEMI E30 — Generic Model for Communications and Control of Manufacturing Equipment (GEM)

SEMI E52 — Practice for Referencing Gases Used in Digital Mass Flow Controllers

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

SEMI E70 — Guide for Tool Accommodation Process

SEMI E72 — Specification and Guide for 300 mm Equipment Footprint, Height, and Weight

SEMI E73 — Specification for Vacuum Pump Interfaces - Dry Pumps

SEMI E74 — Specification for Vacuum Pump Interfaces - Turbomolecular Pumps

SEMI E76 — Guide for 300 mm Process Equipment Points of Connection to Facility Services

SEMI E106 — Provisional Overview Guide to SEMI Standards for Physical Interfaces and Carriers for 300 mm Wafers

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

5 Terminology

NOTE 1: A complete list of equipment installation terminology can be found in SEMI E70.

5.1 *Definitions*

5.1.1 *idle* — the condition where the equipment is energized and readied for processing (all systems ready and temperatures controlled) but is not actually performing any active function such as material movement or processing.

5.1.1.1 *idle average flow* — the average flow rate when the equipment is in idle condition. Idle average flow should be measured at the equipment point of connection.

5.1.2 *maximum pressure* — the highest supply pressure that can be used for the equipment to operate correctly. Maximum pressure should be measured at the equipment point of connection and may be driven by process requirements or component limits.

5.1.3 *maximum pressure fluctuation* — the maximum supply pressure change during the processing cycle for the equipment to operate correctly.

5.1.4 *minimum pressure* — the minimum supply pressure that must be maintained or exceeded for the equipment to operate correctly. Minimum pressure should be measured at the equipment point of connection.

5.1.5 *processing cycle* — a sequence wherein all of the material contained in a processing unit is processed. This is often used as a measure of action or time [SEMI E30]. (See Figure 1.)

5.1.5.1 *process average flow* — the average flow rate over the processing cycle. Process average flow should be measured at the equipment point of connection.

6 Ordering and Use

6.1 Semiconductor manufacturers may use this standard when procuring semiconductor equipment to specify type and format of facility interface information to be provided by equipment supplier.

6.2 Orders for semiconductor equipment in accordance with this standard should include the standard number and date of issue. The request should also include documentation due date, the data transmission method, file format for data, file format for drawings, and any additional information to be included that is not covered in SEMI E6.

6.3 *Roles and Responsibilities* — The equipment supplier submits information requested in SEMI E6. Unless otherwise specified, equipment suppliers should submit the utilities and installation information prior to the equipment ship date. The semiconductor manufacturer's equipment engineers, facilities engineers, and installation managers use equipment information provided to prepare the facility and efficiently install the tool.

7 Installation Documentation Recommendations

7.1 Consider every step from receiving until hookup is complete. All requirements should be indicated. The following is a list of recommended equipment installation documentation to be provided by the equipment supplier.

7.1.1 *Administrative Interface Information* — The administrative interface information should include an installation contacts sheet naming all relevant supplier and purchaser contacts for commercial and technical questions. Also included should be installation roles and responsibilities for the supplier and purchaser. (See Related Information 1 at the end of this document.)

7.1.2 *Shipping and Receiving Information* — Documentation should include information such as container inventory, storage, and unpacking instructions. Suppliers should include information about the size, weight, type and number of containers in which this equipment is shipped. Include detailed lists of all supplied components and parts. How the containers are to be received, handled and stored should be documented. Any special staging, inspection, and uncrating instructions should be provided. If containers cannot be unloaded by hand the necessary equipment should be listed. (See Related Information 2.)

7.1.3 *Move-in, Placement, and Assembly Instructions* — Documentation should include information such as moving, positioning, wall mounting, leveling, alignment, floor loading, floor mounting, pedestal mounting, and seismic restraint of equipment. Detailed instructions should be provided for all assembly and hookup steps required to make the equipment functional. List any necessary parts, resources and special equipment to be provided by the purchaser. (See Related Information 3.)

7.1.4 *Installation ESH Information* — Document any concerns relating to environmental, safety, and health aspects of installation of the equipment (see related SEMI Safety Guidelines).

7.1.5 *Data Sheets and Drawings* — Recommended data sheets are defined in the following sections of this document. Equipment suppliers should reference and provide all necessary equipment drawings and schematics with these data sheets. (See Sections 9 through 19.)

NOTE 2: Additional documentation covering items such as testing, training, sign-off, qualification, and commissioning should also be provided as necessary to complete the tool accommodation process making the equipment process capable.

NOTE 3: See SEMI E76 for 300 mm equipment point of connection documentation recommendations, point of connection location recommendations, as well as recommendations for providing pre-facilitation templates and jigs.

8 Data Sheets Overview

8.1 The following table shows the data sheets included in SEMI E6.

Data Sheet Number	*Data Sheet Title*
100	Equipment Identification
200	Environmental Conditions
300	Physical Characteristics
400	Electrical Power
500	Water
600	Bulk Chemicals
700	Drains
800	Gases
900	Vacuum
1000	Exhaust

8.2 Equipment suppliers should provide data for all necessary facilities even if not specifically covered in the data sheets included in this standard. (See Section 19, Other Data Sheets)

8.3 *Data Sheet Format*

8.3.1 The data sheets in this document are designed to facilitate use of electronic communication and database storage of the facility interface information.

8.3.2 The format shown also provides a recommendation for printed output of the information.

8.3.3 The data sheets shown define data relationships that can be used for spreadsheet or database storage of the information.

- A number, 100–1000, identifies each datasheet.
- A letter, starting with A, identifies each column of the data sheet.
- A number, starting with 1, identifies each row of the data sheet.
- Data item names are in the first row of each data sheet.
- Units of measure for the data are in the second row of each data sheet. (In many cases a simple data definition such as text or number is provided in this row.)
- Specific equipment data starts in row 3 of each data sheet. One row per equipment component in data sheets 200 and 300. One row per connection in data sheets 400 through 1000.

8.4 *Data Entry*

8.4.1 As defined above, data entry involves the first three rows. Row 1 identifies data item. Enter the unit of measure for data in row 2. For example: mm. Specific equipment data will be entered starting in row 3.

8.4.1.1 Preferred units of measure are listed in row 2 of each data sheet. If data entered is in units different from the units specified in row 2 change the units specified in row 2 to match the data. If two units of measure are shown in row 2 select the unit of measure that matches the entered data.

8.4.1.2 Data values should be entered in the units of measure used to design the equipment.

8.4.1.3 Data values should be entered as numbers only. For example: 12.0 or 300 (Do NOT enter 300 mm).

8.4.1.4 Not every data item will have a value because all data items do not apply to all equipment. The equipment supplier should insert n/a (not applicable) for any item that does not apply to that particular equipment component or connection. Do NOT use the n/a designation in place of missing data or data that is not available. If data is applicable to the equipment and not available leave the cell blank. If necessary, include reason for blank cells in comments cell.

8.4.2 The unique Equipment Component identifier is the first column, A, of each data sheet 200–1000.

8.4.2.1 The data sheets are designed to document all facilities connections including connections made to support equipment; therefore a unique equipment component name should be used to locate each connection. Included equipment components should be the mainframe unit plus any other support equipment provided by the equipment supplier, including but not limited to vacuum pumps, process chambers, load lock pumps, water heaters, gas boxes, gas panels, chillers, radio frequency generators, and electrical power distribution panels.

8.4.3 The unique Connection Number is the second column, B, of each data sheet 400–1000.

8.4.3.1 There should be a unique Connection Number, or identifier, for every connection. If a utility type has more than one connection, each point of connection should have a number.

8.4.3.2 A consistent Connection Numbering system should be used to identify all connections in all documents relating to the equipment.

8.4.4 The Connection Label is the third column, C, of each data sheet 400-1000. The Connection Label and Connection Number system should provide a clear link between all documentation and the actual connection on the equipment.

8.4.5 Utility Type is the fourth column, D, of each data sheet 400–1000. A consistent Utility Type naming convention should be used to identify the utility types in all documents relating to the equipment. (For example SEMI E52 should be used for defining gases.)

8.4.6 Fitting Size, Fitting Material, and Fitting Type (found in most data sheets) refer to connectors or fittings on the equipment; such that the equipment purchaser can identify and procure the matching connector for fit up to the equipment. Do not define the facilities side connectors in these data sheets.

8.4.7 Comments are the last column of each data sheet 400–1000. All comments should be entered in a single cell at the end of the row corresponding to the connection requiring comment. Comments may need to be repeated in comments cell for each similar connection. General comments for equipment model may be included in the comments cell in table 100, or if specific to an equipment component in tables 200 or 300.

8.5 *Data Collection*

8.5.1 Actual measured utility data, based upon representative operating conditions, is preferred over unverified estimates or calculations.

8.5.2 All data measures of flow rate, chemical waste, dump volumes, etc., should be based upon the supplier's standard process and production rate.

8.5.3 All specifications and measurements in data sheets 400–1000 should be at the equipment point of connection.

8.5.4 If utility consumption data entered into the data sheet is not measured data, note in the comments cell how the data was obtained. For example: calculated data or estimated data.

8.6 The following sections, 9 through 19, include recommendations on how to complete each individual data sheet.

9 Equipment Identification Data Sheet

9.1 Include in Data Sheet 100, Equipment Identification the requested information for general equipment identifiers, descriptions, installation documentation references and data sheet set revision.

9.2 The 10 data sheets that follow the equipment identification data sheet are specific to equipment component and connection requirements (for example gases, exhaust, vacuum, etc.) and describe the needs of the equipment identified in the equipment identification data sheet.

9.3 Data Sheet 100, Equipment Identification contains the following items.

NOTE 4: Many of the items in data sheet 100 should be included in a header on each page of any SEMI E6 Data print outs or reports.

9.3.1 *Equipment Install Data ID (100A)* — Enter a unique reference number (or file name) as a reference for this equipment installation data set which includes all data sheets 100 through 1000.

9.3.2 *Equipment Install Data Revision (100B)* — Enter the revision number (or code) for this equipment installation data set.

9.3.3 *Equipment Install Data Revision Date (100C)* — Enter the data of the last revision to this equipment installation data set.

9.3.4 *SEMI Standard Name and Revision Date (100D)* — Enter the name and revision of the version of SEMI E6 that this data set is in conformance with. For example SEMI E6-96.

9.3.5 *Equipment Name (100E)* — Enter the name for this equipment.

9.3.6 *Equipment Model Number (100F)* — Enter the equipment supplier's model number for the equipment.

9.3.7 *Generic Process Type (100G)* — Enter the generic process type the equipment was designed to perform. For example metal etch, Al PVD, or copper CMP.

9.3.8 *Wafer Size (100H)* — Enter in mm the size of wafer the equipment was designed to process. For example: 200 or 300.

9.3.9 *Number of Equipment Components (100I)* — Enter the number of stand-alone modules provided by the supplier that together make the equipment process capable. Typically one for the mainframe plus one for each piece of supplier provided support equipment. These equipment components will be named in column A of data sheets 200 and 300. This number will be the rows required in data sheet 200 and 300.

9.3.10 *Equipment Comments (100J)* — Enter any comments necessary to clarify or add to information given for this equipment.

9.3.11 *Equipment Supplier Name (100K)* — Enter legal name of equipment supplier.

9.3.12 *Equipment Supplier Street Address (100L)* — Enter legal address for equipment supplier.

9.3.13 *Equipment Supplier City, State, Country, Mail Code (100M)* — Enter city, state, country, and mail code corresponding to legal address.

9.3.14 *Equipment Supplier Phone (100N)* — Enter phone number corresponding to legal address.

9.3.15 *Administrative Interface Information Reference (100O)* — Enter reference for document containing relevant supplier and purchaser contacts. (See Section 7.1.1 and Related Information 1)

9.3.16 *Optional Order Specific Data Purchasing Company (100P)* — If needed enter name of company purchasing the equipment.

9.3.17 *Optional Order Specific Data Purchase Order Number (100Q)* — If needed enter the P.O. Number issued by the purchaser for procuring the equipment.

9.3.18 *Optional Order Specific Data Purchaser's Equipment ID (100R)* — If needed enter the number used by the purchaser to track the purchased equipment.

9.3.19 *Optional Order Specific Data Equipment Serial Number (100S)* — If needed enter the number issued by the supplier and used to track the equipment as purchased.

Data Sheet 100 – Equipment Identification (See SEMI E6 Section 9)

100 Equipment Identification				
	A	*B*	*C*	*D*
1	*Equipment Install Data ID*	*Equipment Install Data Revision*	*Equipment Install Data Revision Date*	*SEMI Standard Name and Revision Date*
2	text	text	text	text
3				SEMI E6 mmyy

100 Equipment Identification						
	E	*F*	*G*	*H*	*I*	*J*
1	*Equipment Name*	*Equipment Model Number*	*Generic Process Type*	*Wafer Size*	*Number of Equipment Components*	*Equipment Comments*
2	text	text	text	mm	#	text
3						

100 Equipment Identification					
	K	*L*	*M*	*N*	*O*
1	*Equipment Supplier Name*	*Equipment Supplier Street Address*	*Equipment Supplier City, State, Country, Mail Code*	*Equipment Supplier Phone*	*Administrative Interface Information Reference*
2	text	text	text	text	text
3					

100 Equipment Identification				
	P	*Q*	*R*	*S*
1	*Optional Order Specific Data Purchasing Company*	*Optional Order Specific Data Purchase Order Number*	*Optional Order Specific Data Purchaser's Equipment ID*	*Optional Order Specific Data Equipment Serial Number*
2	text	text	text	text
3				

10 Environmental Conditions Data Sheet

10.1 Include in Data Sheet 200, Environmental Conditions, requested information for the environmental conditions necessary to operate the equipment such as room temperature, room humidity, room cleanliness, heat loading, and vibration. Include only conditions for area surrounding the equipment, do not refer to internally controlled specifications for integrated minienvironments, chambers, or lenses, etc.

10.2 Data Sheet 200, Environmental Conditions, contains the following items.

10.2.1 *Equipment Component (200A)* — Enter the name of the equipment component for the data in this row. The same component names should be used in the following data sheets.

10.2.2 *Maximum Installation Distance from Mainframe (200B)* — Enter the maximum line of sight or straight line distance between the mainframe and equipment component. Also, indicate the limiting factors for this distance. For example: 6 meters, user routing constraints may cause distance to be significantly less.

10.2.3 *Minimum Cleanroom Classification (200C)* — Enter the minimum cleanroom classification that defines the cleanroom environment necessary for equipment to operate correctly.

10.2.4 *Cleanroom Classification Standard (200D)* — Enter a reference for the cleanroom classification standard used to specify the cleanroom class in 200C. For example: Fed Std 209E or ISO 14644.

10.2.5 *Target Room Temperature (200E)* — Enter the optimal temperature setting within the minimum and maximum ranges for the room where the equipment is located.

10.2.6 *Minimum Room Temperature (200F)* — Enter the minimum room temperature for the equipment to operate correctly.

10.2.7 *Maximum Room Temperature (200G)* — Enter the maximum room temperature for the equipment to operate correctly.

10.2.8 *Room Temperature Fluctuation (200H)* — Enter the maximum room temperature change during one hour for the equipment to operate correctly.

10.2.9 *Heat Loading Idle Average (200I)* — Enter the average heat flow rate in idle condition into the room where the equipment component is located. Do not include heat removed by other means such as process cooling water or exhaust. The room should be at target temperature and humidity.

10.2.10 *Heat Loading Process Average (200J)* — Enter the average heat flow rate during the processing cycle into the room where the equipment component is located. Do not include heat removed by other means such as process cooling water or exhaust. The room should be at target temperature and humidity.

10.2.11 *Target Room Relative Humidity (200K)* — Enter the optimal relative humidity at the target temperature for the room where the equipment is located.

10.2.12 *Minimum Room Relative Humidity (200L)* — Enter the minimum relative humidity at the target room temperature for the equipment to operate correctly.

10.2.13 *Maximum Room Relative Humidity (200M)* — Enter the maximum relative humidity at the target room temperature for the equipment to operate correctly.

10.2.14 *Room Relative Humidity Fluctuation (200N)* — Enter the maximum relative humidity change during one hour for the equipment to operate correctly.

10.2.15 *Vibration Sensitivity (200O)* — Enter the vibration requirements or reference a document specifying the ambient vibration sensitivity and ambient acoustic noise sensitivity of the equipment. Include in reference material the description of methods used such as displacement, 1/3 octave band analysis, accelerance, maximum velocity at frequency, maximum ambient sound pressure levels, etc.

10.2.16 *Vibration Generation (200P)* — Enter the vibration generated by the equipment that stimulates the mounting structure or reference a document defining the equipment generated dynamic loads (at the support points defined in the floor loading diagram—see Section 11.2.10) such as impulse force magnitudes in the front-to-rear direction, etc. Include in reference material the description of methods used such as spectral accelerometer measurements of the equipment mounted on a pedestal of specified stiffness, etc. Include equipment-generated acoustic noise, such as the sound pressure level spectra radiated outward from the equipment enclosure.

10.2.17 *Other Vibrations Requirements (200Q)* — Enter or reference any other equipment support vibration requirements such as support pedestal stiffness requirements in all three directions, coupled mass requirements, or minimum building structural stiffness (three axis x, y, z) requirements.

NOTE 5: Vibration sensitivity and generation values for dynamic loads and motions should be specified in the three directions: up and down (z), front to back (y), and side to side (x).

10.2.18 *Other Conditions (200R)* — Include in other any special environmental conditions such as lighting, ESD, electromagnetic, or audible noise conditions for the equipment components.

10.2.19 *Environmental Conditions Comments (200S)* — Enter any comments necessary to clarify or add to information given for this equipment component.

Data Sheet 200 – Environmental Conditions (See SEMI E6 Section 10)

200 Environmental Conditions							
	A	*B*	*C*	*D*	*E*	*F*	*G*
1	*Equipment Component*	*Maximum Installation Distance from Mainframe*	*Minimum Cleanroom Classification*	*Cleanroom Classification Standard*	*Target Room Temperature*	*Minimum Room Temperature*	*Maximum Room Temperature*
2	text	meters	text	text	degrees C	degrees C	degrees C
3							
4							
5							
6							

200 Environmental Conditions							
	H	*I*	*J*	*K*	*L*	*M*	*N*
1	*Room Temperature Fluctuation*	*Heat Loading Idle Average*	*Heat Loading Process Average*	*Target Room Relative Humidity*	*Minimum Room Relative Humidity*	*Maximum Room Relative Humidity*	*Room Relative Humidity Fluctuation*
2	degrees /hour	watts	watts	%	%	%	%/hour
3							
4							
5							
6							

200 Environmental Conditions					
	O	*P*	*Q*	*R*	*S*
1	*Vibration Sensitivity*	*Vibration Generation*	*Other Vibrations Requirements*	*Other Conditions*	*Environmental Conditions Comments*
2	text	text	text	text	text
3					
4					
5					
6					

11 Physical Characteristics Data Sheet

11.1 Include in Data Sheet 300, Physical Characteristics the requested information for physical attributes such as size, weight, layout, clearances, and floor loading data.

11.2 Data Sheet 300, Physical Characteristics contains the following items.

11.2.1 *Equipment Component (300A)* — Enter the name of the equipment component for the data in this row. The name should be the same name used in Data Sheet 200.

11.2.2 *Shipping and Receiving Information Reference (300B)* — Enter reference for document containing all relevant shipping and receiving information. (See Section 7.1.2 and Related Information 2.)

11.2.3 *Number of Shipping Containers (300C)* — Enter the total number of containers or crates used to ship the equipment and all supplier provide support equipment.

11.2.4 *Move-in, Placement and Assembly Instructions Reference (300D)* — Enter reference for document containing all installation instruction. (see Section 7.1.3 and Related Information 3.)

11.2.5 *Number of Cleanroom Move-in Pieces (300E)* — Enter the total number of pieces of equipment to be moved into the manufacturing cleanroom.

11.2.6 *Biggest Move-in Piece Length, Width, Height, Weight (300F, 300G, 300H, 300I)* — Enter the size and weight of the largest single move-in piece of the equipment.

11.2.7 *Installation ESH Information Reference (300J)* — Enter reference for document containing all relevant environmental, safety, and health information related to equipment installation. (See related SEMI Safety Guidelines)

11.2.8 *Assembled Length, Width, Min. Height, Max Height, Weight (300K, 300L, 300M, 300N): 300O)* — Enter the size and weight of the equipment component. Minimum and maximum height should include travel of any provided leveling feet.

11.2.9 *Operational Clearance Front, Right, Left, Back, Top Bottom (300P, 300Q, 300R, 300S, 300T) 300U)* — Enter the operational clearances on all sides of equipment necessary for safety, operation, and maintenance. (Right and left should be as viewed from the front)

11.2.10 *Floor Loading Diagram Reference (300V)* — Enter the reference for the floor-loading diagram showing the static weight loads at each equipment support point.

11.2.11 *Drawing References (300W)* — Enter references, such as drawing numbers, for any drawings, schematics, instructions, jigs or fixtures showing equipment. For example: Equipment Footprint Drawing YYYYY. Submit referenced material to equipment purchaser with this data sheet.

NOTE 6: Information regarding 300mm equipment may be found in SEMI E72 and SEMI E63.

11.2.12 *Physical Conditions Comments (300X)* — Enter any comments necessary to clarify or add to information given for this equipment component.

Data Sheet 300 – Physical Characteristics (See SEMI E6 Section 11)

300 Physical Characteristics							
	A	*B*	*C*	*D*	*E*	*F*	*G*
1	*Equipment Component*	*Shipping and Receiving Information Reference*	*Number of Shipping Containers*	*Move-in, Placement and Assembly Instructions Reference*	*Number of Cleanroom Move-in Pieces*	*Biggest Move-in Piece Length*	*Biggest Move-in Piece Width*
2	text	text	#	text	#	mm	mm.
3							
4							
5							
6							

300 Physical Characteristics							
	H	*I*	*J*	*K*	*L*	*M*	*N*
1	*Biggest Move-in Piece Height*	*Heaviest Move-in Piece Weight*	*Instillation ESH Information Reference*	*Assembled Length*	*Assembled Width*	*Minimum Assembled Height*	*Maximum Assembled Height*
2	mm	kg	text	mm	mm	mm	mm
3							
4							
5							
6							

300 Physical Characteristics							
	O	*P*	*Q*	*R*	*S*	*T*	*U*
1	*Assembled Weight*	*Operational Clearance Front*	*Operational Clearance Right*	*Operational Clearance Left*	*Operational Clearance Back*	*Operational Clearance Top*	*Operational Clearance Bottom*
2	kg	mm	mm	mm	mm	mm	mm
3							
4							
5							
6							

300 Physical Characteristics			
	V	*W*	*X*
1	*Floor Loading Diagram Reference*	*Drawing References*	*Physical Characteristics Comments*
2	text	text	text
3			
4			
5			
6			

12 Electrical Power Data Sheet

12.1 Include in Data Sheet 400, Electrical Power the requested information for equipment connections to facilities systems including but not limited to electrical power distribution and conditioning systems.

12.2 Data Sheet 400, Electrical Power contains the following items.

12.2.1 *Equipment Component (400A)* — Enter the name of the equipment component where the connection is located. The name should the same name used in Data Sheet 200 and 300. For example: Mainframe, Vacuum Pump, or Chiller.

12.2.2 *Electrical Power Connection Number (400B)* — Enter a unique connection number for every utility connection. For example: 401, 402, 403, and so on.

12.2.3 *Connection Label on Equipment (400C)* — Enter the name found on the label that identifies this physical connection on the equipment. For example input power or power ground.

12.2.4 *Utility Type (400D)* — Enter the name of electrical service to be provided through the connection. Examples: Normal Power, Conditioned Power, Uninterruptible Power, Standby Power and Emergency Power. If selection is not Normal Power, specify reason in Electrical Power Comments cell.

12.2.5 *Line Source (400E)* — Identify the source of the supply line for this connection. If the line comes from a provided component covered in the data sheets enter the connection number(s) at the other end of the line. If the line comes from a facilities source enter facilities system. For example: 403 or facilities system.

12.2.6 *Voltage/Phase/Wire (400F)* — Enter the necessary voltage, number of phases, and number of wires for the component connection. Ground wires will be designated separately. For example: 480V/3 Phase/4 Wire + ground or 120V/1 Phase/2 Wire + ground.

12.2.7 *Frequency (400G)* — Enter the power frequency of electrical service specified.

12.2.8 *Equipment Component Connection Type (400H)* — Enter the method of connection to the component and a description of the connection on the equipment. Include the appropriate code (such as NEMA, CEE, CEI, or ICE), suffix for plug connection, and lug type/size for hardwire connection. For examples: Plug NEMA 20P or Hardwire mechanical lug/#6-#2 wire per phase.

12.2.9 *Ampere Interrupting Capacity (400I)* — Enter the ampere interrupting capacity (AIC) rating.

12.2.10 *Full Load Amps Phase A, B, C, Neutral (400J, 400K, 400L, 400M)* — Enter the nameplate full load amperage rating for the electrical utility connection, voltage, and frequency.

12.2.11 *Branch Circuit Protection (400N)* — Enter the supplier recommended fuse or breaker setting necessary to protect the branch circuit supplying power to the equipment connection.

12.2.12 *Real Power Idle Average (400O)* — Enter the average true real power demand for the equipment idle condition. Real power is the time average of the instantaneous product of voltage and current. Real power is expressed in Watts.

12.2.13 *Real Power Process Average (400P)* — Enter the average true real power demand for the equipment processing cycle.

12.2.14 *Real Power Maximum (400Q)* — Enter the maximum one second average true real power demand (value for equipment processing cycle or idle condition, whichever is greater).

12.2.15 *Apparent Power Idle Average (400R)* — Enter the average true RMS apparent power demand for the equipment idle condition. Apparent power is the product of RMS volts and RMS amps. Apparent power is expressed in VA, volt-amps.

12.2.16 *Apparent Power Process Average (400S)* — Enter the average true RMS apparent power demand for the equipment processing cycle.

12.2.17 *Apparent Power Maximum (400T)* — Enter the maximum one second average true RMS apparent power demand (value for the equipment processing cycle or idle condition, whichever is greater).

12.2.18 *Current Idle Average Phase A, B, C, Neutral - (400U, 400V, 400W, 400X)* — Enter the average true RMS current for the equipment idle condition.

12.2.19 *Current Process Average Phase A, B, C, Neutral (400Y, 400Z, 400AA, 400AB)* — Enter the average true RMS current for the equipment processing cycle.

12.2.20 *Current Maximum Phase A, B, C, Neutral (400AC, 400AD, 400AE, 400AF)* — Enter the maximum one second average true RMS current (value for equipment processing cycle or idle condition, whichever is greater).

12.2.21 *Current THD Phase A, B, C, Neutral (400AG, 400AH, 400AI, 400AJ)* — Enter the true RMS current Total Harmonic Distortion (THD) value that is time coincident with the reported Apparent Power Maximum value.

12.2.22 *Process Cycle Energy (400AK)* — Enter the total electrical energy consumed during the equipment processing cycle.

12.2.23 *Power Characterization Plot (400AL)* — Enter yes if power consumed through this connection is represented in the Equipment Power Characterization Plot provided with this data sheet. If entry is No, specify reason in Electrical Power Comments cell. Submit with the electrical power data sheet, a characterization plot of the one second average true power demand (kW) versus time for a complete equipment processing cycle and for equipment idle condition. This plot should represent the electrical power demand of the entire equipment (vs. a single connection). See Figure 1.

12.2.24 *Drawing References (400AM)* — Enter references, such as drawing numbers, for any drawings, schematics, instructions, jigs or fixtures showing this connection. For example: wiring diagram XXXXX or voltage sag characterization test report YYYYY. Be sure to submit referenced material to equipment purchaser with data sheets.

12.2.25 *Electrical Power Comments (400AN)* — Enter any comments necessary to clarify information given for this connection.

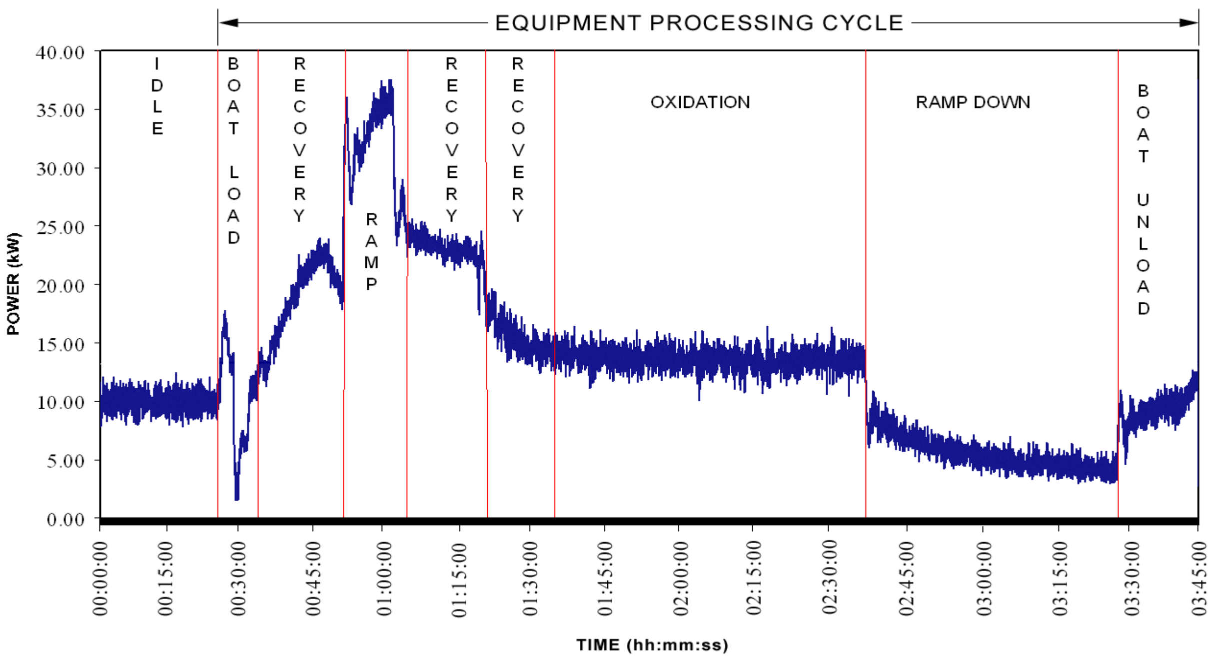

Figure 1
Equipment Power Characterization Plot

Data Sheet 400 - Electrical Power (See SEMI E6 section 12)

400 Electrical Power								
	A	*B*	*C*	*D*	*E*	*F*	*G*	*H*
1	*Equipment Component*	*Electrical Power Connection Number*	*Connection Label on Equipment*	*Utility Type*	*Line Source*	*Voltage/Phase /Wire*	*Frequency*	*Equipment Component Connection Type*
2	text	text	text	text	text	text	Hz	text
3								
4								
5								
6								

400 Electrical Power						
	I	*J*	*K*	*L*	*M*	*N*
1	*Ampere Interrupting Capacity*	*Full Load Amps Phase A*	*Full Load Amps Phase B*	*Full Load Amps Phase C*	*Full Load Amps Neutral*	*Branch Circuit Protection*
2	amps	amps	amps	amps	amps	amps
3						
4						
5						
6						

400 Electrical Power						
	O	*P*	*Q*	*R*	*S*	*T*
1	*Real Power Idle Average*	*Real Power Process Average*	*Real Power Maximum*	*Apparent Power Idle Average*	*Apparent Power Process Average*	*Apparent Power Maximum*
2	kW	kW	kW	kVA	kVA	kVA
3						
4						
5						
6						

400 Electrical Power								
	U	V	W	X	Y	Z	AA	AB
1	*Current Idle Average Phase A*	*Current Idle Average Phase B*	*Current Idle Average Phase C*	*Current Idle Average Neutral*	*Current Process Average Phase A*	*Current Process Average Phase B*	*Current Process Average Phase C*	*Current Process Average Neutral*
2	amps	amps	amps	amps	amps	amps	amps	amps
3								
4								
5								
6								

400 Electrical Power								
	AC	*AD*	*AE*	*AF*	*AG*	*AH*	*AI*	*AJ*
1	*Current Maximum Phase A*	*Current Maximum Phase B*	*Current Maximum Phase C*	*Current Maximum Neutral*	*Current THD Phase A*	*Current THD Phase B*	*Current THD Phase C*	*Current THD Neutral*
2	amps	amps	amps	amps	%	%	%	%
3								
4								
5								
6								

400 Electrical Power				
	AK	*AL*	*AM*	*AN*
1	*Process Cycle Energy*	*Equipment Power Characterization Plot (Is power to this connection included in plot?)*	*Drawing References*	*Electrical Power Comments*
2	kWh	yes or no	text	text
3				
4				
5				
6				

13 Water Data Sheet

13.1 Include in the Water Data Sheet the requested information for equipment connections to facilities systems including (but not limited to) deionized water, ultrapure water (UPW), raw water, hot water, steam, chilled water, and process cooling water systems.

13.2 Data Sheet 500, Water contains the following items.

13.2.1 *Equipment Component (500A)* — Enter the name of the equipment component where the connection is located. The name should the same name used in Data Sheet 200 and 300. For example: Mainframe or Pump.

13.2.2 *Water Connection Number (500B)* — Enter a unique connection number for every utility connection. For example: 501, 502, 503, and so on. For loop distribution utilities, the supply connection could be 502S and the corresponding return connection could be 502R. For loop distribution utilities, return connection data should be entered in the row (in this data sheet) immediately below the supply connection data row.

13.2.3 *Connection Label on Equipment (500C)* — Enter the name found on the label that identifies this physical connection on the equipment. For example UPW Supply.

13.2.4 *Utility Type (500D)* — Enter the name of water service to be provided through the connection. For example: PCW, DI, Hot DI, or city water.

13.2.5 *Line Source (500E)* — Identify the source of the supply line for this connection. If the line comes from a provided component covered in the data sheets enter the connection number(s) at the other end of the line. If the line comes from a facilities source enter facilities system. For example: 503 or facilities system.

13.2.6 *Purity Requirements (500F)* — List minimum purity requirements and basis of purity. If applicable indicate SEMI standards and filtration requirements.

13.2.7 *Contaminants (500G)* — Enter the type and value of any significant impurities.

13.2.8 *Minimum Pressure (500H)* — Enter the minimum supply pressure necessary for the equipment to operate correctly.

13.2.9 *Maximum Pressure (500I)* — Enter the highest supply pressure that can be used to operate the equipment correctly.

13.2.10 *Maximum Pressure Fluctuation (500J)* — Enter the maximum supply pressure change during the processing cycle for the equipment to operate correctly. The data entered for a loop distribution return connection should be n/a (not applicable).

13.2.11 *Minimum Pressure Differential (500K)* — Enter the minimum pressure difference between the supply and return connections for the equipment to operate correctly. The data should be entered in the return connection data row and n/a (not applicable) entered in the supply connection data row.

13.2.12 *Idle Average Flow (500L)* — Enter the average flow rate when equipment is in idle condition.

13.2.13 *Process Average Flow (500M)* — Enter the average flow rate over the processing cycle.

13.2.14 *Maximum Flow (500N)* — Enter the maximum flow rate (for the equipment processing cycle or idle condition whichever is greater).

13.2.15 *Maximum Temperature (500O)* — Enter the maximum supply temperature for the equipment to operate correctly.

13.2.16 *Minimum Temperature (500P)* — Enter the minimum supply temperature of the fluid for the equipment to operate correctly.

13.2.17 *Equipment Component Fitting Size (500Q)* — Enter the line or fitting size of the connection provided on the equipment component. Use the units indicated by the fitting manufacturer. For example: 6 or 0.25. In row 2 enter or select the units of measure for the specified fitting size. For example: mm or inches.

13.2.18 *Equipment Component Fitting Material (500R)* — Enter a general description of the fitting material of the provided connection on the equipment component. For example: 316 Stainless Steel, or PVC Schedule 80.

13.2.19 *Equipment Component Fitting Type (500S)* — Enter the generic style of fitting of the connection provided on the equipment component. Be sure to include type and gender of the fitting. For example: Face Seal or MNPT.

13.2.20 *Drawing References (500T)* — Enter references, such as drawing numbers, for any drawings, schematics, instructions, jigs or fixtures showing this connection. For example: connection template XXXXX and P&ID YYYYY. Submit referenced material to equipment purchaser with this data sheet.

13.2.21 *Water Comments (500U)* — Enter any comments necessary to clarify data provided in this data sheet. For example: Corrosion rate of aluminum in the purchaser-supplied coolant must be less than 0.1 mils per year.

Data Sheet 500 - Water (See SEMI E6 Section 13)

500 Water								
	A	*B*	*C*	*D*	*E*	*F*	*G*	*H*
1	*Equipment Component*	*Water Connection Number*	*Connection Label on Equipment*	*Utility Type*	*Line Source*	*Purity Requirements*	*Contaminants*	*Minimum Pressure*
2	text	text	text	text	text	text	text	kPa
3								
4								
5								
6								

500 Water							
	I	*J*	*K*	*L*	*M*	*N*	*O*
1	*Maximum Pressure*	*Maximum Pressure Fluctuation*	*Minimum. Pressure Differential*	*Idle Average Flow*	*Process Average Flow*	*Maximum Flow*	*Maximum Temperature*
2	kPa	kPa	kPa	lpm	lpm	lpm	degrees C
3							
4							
5							
6							

500 Water						
	P	*Q*	*R*	*S*	*T*	*U*
1	*Minimum Temperature*	*Equipment Component Fitting Size*	*Equipment Component Fitting Material*	*Equipment Component Fitting Type*	*Drawing References*	*Water Comments*
2	degrees C	mm or inches	text	text	text	text
3						
4						
5						
6						

14 Bulk Chemicals Data Sheet

14.1 Include in the Bulk Chemicals Data Sheet the requested information for equipment connections to facilities systems including but not limited to chemical dispense, and slurry dispense.

14.2 Data Sheet 600, Bulk Chemicals contains the following items.

14.2.1 *Equipment Component (600A)* — Enter the name of the equipment component where the connection is located. The name should be the same name used in Data Sheet 200 and 300. For example: Mainframe or Pump.

14.2.2 *Bulk Chemicals Connection Number (600B)* — Enter a unique connection number for every utility connection. For example: 601, 602, 603, and so on. For loop distribution utilities, the supply connection could be 602S and the corresponding return connection could be 602R. For loop distribution utilities, return connection data should be entered in the row immediately below the supply connection data row.

14.2.3 *Connection Label on Equipment (600C)* — Enter the name found on the label that identifies this physical connection on the equipment. For example: Slurry 1 Supply.

14.2.4 *Utility Type (600D)* — Enter the name of the bulk chemical to be provided through the connection. For example: NH_3 or HCL.

14.2.5 *Line Source (600E)* — Identify the source of the supply line for this connection. If the line comes from a provided component covered in the data sheets enter the connection number(s) at the other end of the line. If the line comes from a facilities source enter facilities system. For example: 603 or facilities system.

14.2.6 *Purity Requirements (600F)* — List minimum purity requirements and basis of purity. If applicable indicate SEMI chemical standards and filtration requirements.

14.2.7 *Contaminants (600G)* — Enter the type and value of any significant impurities.

14.2.8 *Minimum Pressure (600H)* — Enter the minimum supply pressure for the equipment to operate correctly.

14.2.9 *Maximum Pressure (600I)* — Enter the highest supply pressure that can be used to operate the equipment correctly.

14.2.10 *Maximum Pressure Fluctuation (600J)* — Enter the maximum supply pressure change during the processing cycle for the equipment to operate correctly. The data entered for a loop distribution return connection should be n/a (not applicable).

14.2.11 *Minimum Pressure Differential (600K)* — Enter the minimum pressure difference between the supply and return connections for the equipment to operate correctly. The data should be entered in the return connection data row and n/a (not applicable) entered into the supply connection data row.

14.2.12 *Idle Average Flow (600L)* — Enter the average flow rate when the equipment is in idle condition.

14.2.13 *Process Average Flow (600M)* — Enter the average flow rate over the processing cycle.

14.2.14 *Maximum Flow (600N)* — Enter the maximum flow rate (for the equipment processing cycle or idle condition whichever is greater).

14.2.15 *Maximum Temperature (600O)* — Enter the maximum supply temperature for the equipment to operate correctly.

14.2.16 *Equipment Component Fitting Size (600P)* — Enter the line or fitting size of the connection provided on the equipment component. For double containment this would be the inner fitting. Use the units indicated by the fitting manufacturer. For example: 6 or 0.25. In row 2 enter or select the units of measure for the specified fitting size. For example: mm or inches.

14.2.17 *Equipment Component Fitting Material (600Q)* — Enter a general description of the fitting material of the connection provided on the equipment component. For example: PFA.

14.2.18 *Equipment Component Fitting Type (600R)* — Enter the generic style of fitting of the connection provided on the equipment component. Be sure to include type and gender of the fitting. For example: Flare or Female Pipe Thread (FPT).

14.2.19 *Double Containment (600S)* — Enter yes if double containment is necessary for utility type supplied through the connection, enter no if not necessary.

14.2.20 *Equipment Component Double Containment Fitting Size (600T)* — Enter the line or fitting size of the double containment connection on the equipment. This would be the outer fitting. Use the units indicated by the fitting manufacturer. For example: 12 or 0.50. In row 2 enter or select the units of measure for the specified fitting size. For example: mm.

14.2.21 *Equipment Component Double Containment Fitting Material (600U)* — Enter a general description of the fitting material of the double containment connection the equipment. For example: PFA.

14.2.22 *Equipment Component Fitting Type (600V)* — Enter the generic style of fitting of the double containment connection on the equipment. Be sure to include type and gender of fitting provided on equipment. For example: Flare or Female Pipe Thread (FPT).

14.2.23 *Drawing References (600W)* — Enter references, such as drawing numbers, for any drawings, schematics, instructions, jigs or fixtures showing this connection. For example: connection template XXXXX and P&ID YYYYY. Submit referenced material to equipment purchaser with this data sheet.

14.2.24 *Bulk Chemicals Comments (600X)* — Enter any comments necessary to clarify data provided for this connection. For example: dual containment.

Data Sheet 600 – Bulk Chemicals (See SEMI E6 Section 14)

	600 Bulk Chemicals							
	A	*B*	*C*	*D*	*E*	*F*	*G*	*H*
1	*Equipment Component*	*Bulk Chemicals Connection Number*	*Connection Label on Equipment*	*Utility Type*	*Line Source*	*Purity Requirements*	*Contaminants*	*Minimum Pressure*
2	text	text	text	text	text	text	text	kPa
3								
4								
5								
6								

	600 Bulk Chemicals							
	I	*J*	*K*	*L*	*M*	*N*	*O*	*P*
1	*Maximum Pressure*	*Maximum Pressure Fluctuation*	*Minimum Pressure Differential*	*Idle Average Flow*	*Process Average Flow*	*Maximum Flow*	*Maximum Temperature*	*Equipment Component Fitting Size*
2	kPa	kPa	kPa	kPa	lpm	lpm	lpm	mm or inches
3								
4								
5								
6								

	600 Bulk Chemicals							
	Q	*R*	*S*	*T*	*U*	*V*	*W*	*X*
1	*Equipment Component Fitting Material*	*Equipment Component Fitting Type*	*Double Containment*	*Equipment Component Double Containment Fitting Size*	*Equipment Component Double Containment Fitting Material*	*Equipment Component Double Containment Fitting Type*	*Drawing References*	*Bulk Chemicals Comments*
2	text	text	yes or no	mm or inches	text	text	text	text
3								
4								
5								
6								

15 Drains Data Sheet

15.1 Include in the Drains Data Sheet the requested fluid waste information for equipment connections to facilities systems. This includes, but is not limited to industrial waste, drain, collection, storage, reprocessing, UPW recycle, UPW reclaim, and treatment systems.

15.2 Data Sheet 700, Drains contains the following items.

15.2.1 *Equipment Component (700A)* — Enter the name of the equipment component where the connection is located. The name should the same name used in Data Sheet 200 and 300. For example: Mainframe or Pump.

15.2.2 *Drains Connection Number (700B)* — Enter a unique connection number for every utility connection. For example: 701, 702, 703, and so on.

15.2.3 *Connection Label on Equipment (700C)* — Enter the name found on the label that identifies this physical connection on the equipment. For example Caustic Waste.

15.2.4 *Utility Type (700D)* — Enter the fluid discharged through the connection. The identifying description is for information only and is not intended to act as a specification for the discharged fluid. For example:

- chemical waste—caustic
- chemical waste—acidic
- chemical waste—fluoride
- chemical waste—solvent
- chemical waste—slurry
- chemical waste—acid rinse
- UPW reclaim

15.2.5 *Line Source (700E)* — Identify the source of the drain line for this connection. If the line comes from a provided component covered in the data sheets enter the connection number(s) at the other end of the line. If the line comes from a facilities source enter facilities system. For example: 703 or facilities system.

15.2.6 *Process Name (700F)* — Enter the name of the process the discharged fluids come from in this drain connected. For example: Photoresist Strip.

15.2.7 *Drain Conveyed Process Wastes (700G)* — Enter the specific chemical with typical concentration of total combined stream and any potential byproducts that may come through the referenced drain connection. In particular, identify any discharge that might be regulated by the semiconductor manufacturers' discharge permit. For example: sulfuric acid (75%) combined with H_2O_2 (15%).

15.2.8 *Maximum Discharge Pressure (700H)* — Enter the highest discharge pressure for the equipment processing cycle. For gravity drains the pressure would be 0.

15.2.9 *Maximum Flow (700I)* — Enter the maximum flow rate (for the equipment processing cycle or idle condition whichever is greater). Note in the comments cell if the flow is batch or intermittent, as applicable. Also note in the comments cell any abnormal situation requiring an unusual, high flow rate. For example: Emergency dump rate will be 20 lpm.

15.2.10 *Idle Average Flow (700J)* — Enter the average flow rate when equipment is in idle condition.

15.2.11 *Process Average Flow (700K)* — Enter the average flow rate over the processing cycle.

15.2.12 *Maximum Temperature (700L)* — Enter the maximum expected temperature of the referenced fluid discharged at the outlet of the equipment.

15.2.13 *Equipment Component Fitting Size (700M)* — Enter the line or fitting size of the connection provided on the equipment component. For example: 6 or 0.25. In row 2 enter or select the units of measure for the specified fitting size. For example: mm.

15.2.14 *Equipment Component Fitting Material (700N)* — Enter a general description of the fitting material of the connection provided on the equipment component. For example: Teflon®.

15.2.15 *Equipment Component Fitting Type (700O)* — Enter the generic style of the fitting of the connection provided on the equipment component. Be sure to include type and gender of fitting.. For example: KF or Female Pipe Thread (FPT).

15.2.16 *Drawing References (700P)* — Enter references, such as drawing numbers, for any drawings, schematics, instructions, jigs or fixtures showing this connection. For example: connection template XXXXX and P&ID YYYYYY. Submit referenced material to equipment purchaser with this data sheet.

15.2.17 *Drains Comments (700Q)* — Enter any comments necessary to clarify data provided for this connection. For example: Drain should be adequately vented external to the equipment so that the flow during a batch dump will not create any measurable backpressure.

Data Sheet 700 – Drains (See SEMI E6 Section 15)

700 Drains							
	A	*B*	*C*	*D*	*E*	*F*	*G*
1	*Equipment Component*	*Drains Connection Number*	*Connection Label on Equipment*	*Utility Type*	*Line Source*	*Process Name*	*Drain Conveyed Process Wastes*
2	text	text	text	text	text	text	text
3							
4							
5							
6							

700 Drains						
	H	*I*	*J*	*K*	*L*	*M*
1	*Maximum Discharge Pressure*	*Maximum Flow*	*Idle Average Flow*	*Process Average Flow*	*Maximum Temperature*	*Equipment Component Fitting Size*
2	kPa	lpm	lpm	lpm	degrees C.	mm or inches
3						
4						
5						
6						

700 Drains				
	N	*O*	*P*	*Q*
1	*Equipment Component Fitting Material*	*Equipment Component Fitting Type*	*Drawing References*	*Drains Comments*
2	text	text	text	text
3				
4				
5				

16 Gases Data Sheet

16.1 Include in the Gases Data Sheet the requested information for equipment connections to facilities systems including bulk gas supply and process specialty gas supply. Bulk gases generally run in manifolds throughout the fab, versus specialty gases that have a single, direct connection to a cylinder gas cabinet or panel. Bulk gas supply typically includes house gas supply systems for Natural Gas, Argon, Hydrogen, Helium, Nitrogen, Oxygen, Control Dry Air (CDA) or Oil Free Air (OFA). Do NOT include gas detection systems connection in this data sheet.

16.2 Data Sheet 800, Gases contains the following items.

16.2.1 *Equipment Component (800A)* — Enter the name of the equipment component where the connection is located. The name should the same name used in Data Sheet 200 and 300. For example: Mainframe or Pump.

16.2.2 *Gas Connection Number (800B)* — Enter a unique connection number for every utility connection. For example: 801, 802, 803, and so on.

16.2.3 *Connection Label on Equipment (800C)* — Enter the name found on the label that identifies this physical connection on the equipment. For example N_2 Purge.

16.2.4 *Utility Type (800D)* — Enter the name of gas to be provided through the connection. SEMI E52 should be used for naming gases.

16.2.5 *Line Source (800E)* — Identify the source of the supply line for this connection. If the line comes from a provided component covered in the data sheets enter the connection number(s) at the other end of the line. If the line comes from a facilities source enter facilities system. For example: 803 or facilities system.

16.2.6 *Gas State (800F)* — Enter information regarding the gases properties such as liquefied gas, pure gas, or gas mixture.

16.2.7 *Purity Requirements (800G)* — List minimum purity requirements and basis of purity. For example: ppm, vol.%, wt.%. If applicable indicate SEMI Gas Standards.

16.2.8 *Contaminants (800H)* — Enter the type and value of significant impurities. For example: $CH_4 < 2$ ppm.

16.2.9 *Filtration (800I)* — If a filter is required prior to the equipment point of connection enter the filter specification (% removal at maximum particle size). For example: 100% at 0.02 micron. If not enter n/a.

16.2.10 *Minimum Pressure (800J)* — Enter the minimum supply pressure necessary for the equipment to operate correctly.

16.2.11 *Maximum Pressure (800K)* — Enter the highest supply pressure that can be used to operate the equipment correctly.

16.2.12 *External Regulator (800L)* — If a regulator is required prior to the equipment point of connection enter the regulator specification. If not enter n/a.

16.2.13 *Idle Average Flow (800M)* — Enter the average flow rate when equipment is in idle condition.

16.2.14 *Process Average Rate (800N)* — Enter the average flow rate for the processing cycle.

16.2.15 *Maximum Flow (800O)* — Enter the maximum flow rate (for equipment processing cycle or idle condition, whichever is greater).

16.2.16 *Equipment Component Fitting Size (800P)* — Enter the line or fitting size of the connection provided on the equipment component. For double containment this would be the inner fitting. Use the units indicated by the fitting manufacturer. For example: 6 or 0.25. In row 2 enter or select the units of measure for the specified fitting size. For example: mm or inches.

16.2.17 *Equipment Component Fitting Material (800Q)* — Enter a general description of the fitting material of the connection provided on the equipment component. For example: 316 Stainless Steel or Brass.

16.2.18 *Equipment Component Fitting Type (800R)* — Enter the generic style of fitting of the connection provided on the equipment component. Be sure to include type and gender of the fitting. For example: Face Seal or Female Pipe Thread (FPT).

16.2.19 *Double Containment (800S)* — Enter yes if double containment is necessary for utility type supplied through the connection, enter no if not necessary.

16.2.20 *Equipment Component Double Containment Fitting Size (800T)* — Enter the line or fitting size of the double containment connection on the equipment. This would be the outer fitting. Use the units indicated by the fitting manufacturer. For example: 12 or 0.50. In row 2 enter or select the units of measure for the specified fitting size. For example: mm.

16.2.21 *Equipment Component Double Containment Fitting Material (800U)* — Enter a general description of the fitting material of the double containment connection the equipment. For example: 316 Stainless Steel or Monel.

16.2.22 *Equipment Component Fitting Type (800V)* — Enter the generic style of fitting of the double containment connection on the equipment. Be sure to include the type and gender of fitting provided on equipment. For example: Flare or Female Pipe Thread (FPT).

16.2.23 *Drawing References (800W)* — Enter references, such as drawing numbers, for any drawings, schematics, instructions, jigs or fixtures showing this connection. For example: connection template XXXXX and P&ID YYYYYY. Submit referenced material to equipment purchaser with this data sheet.

16.2.24 *Gases Comments (800X)* — Enter any comments necessary to clarify data provided for this connection. For example: Enter any important information about the character of the gas, gas line, or connection that is not indicated in any of the other cells related to this connection.

Data Sheet 800 – Gases (See SEMI E6 Section 16)

800 Gases						
	A	*B*	*C*	*D*	*E*	*F*
1	*Equipment Component*	*Gas Connection Number*	*Connection Label on Equipment*	*Utility Type*	*Line Source*	*Gas State*
2	text	text	text	text	text	text
3						
4						
5						
6						

800 Gases						
	G	*H*	*I*	*J*	*K*	*L*
1	*Purity Requirements*	*Contaminants*	*Filtration*	*Minimum Pressure*	*Maximum Pressure*	*External Regulator*
2	text	text	text	Pa	Pa	text
3						
4						
5						
6						

800 Gases						
	M	*N*	*O*	*P*	*Q*	*R*
1	*Idle Average Flow*	*Process Average Flow*	*Maximum Flow*	*Equipment Component Fitting Size*	*Equipment Component Fitting Material*	*Equipment Component Fitting Type*
2	lpm	lpm	lpm	mm or inches	text	text
3						
4						
5						
6						

800 Gases						
	S	*T*	*U*	*V*	*W*	*X*
1	*Double Containment*	*Equipment Component Double Containment Fitting Size*	*Equipment Component Double Containment Fitting Material*	*Equipment Component Double Containment Fitting Type*	*Drawing References*	*Gases Comments*
2	yes or no	mm or inches	text	text	text	*text*
3						
4						
5						
6						

17 Vacuum Data Sheet

17.1 Include in the Vacuum Data Sheet the requested information for equipment connections to centralized process vacuum systems and local vacuum pump systems.

17.2 Data Sheet 900, Vacuum contains the following items.

17.3 *Equipment Component (900A)* — Enter the name of the equipment component where the connection is located. The name should be the same name used in Data Sheet 200 and 300. For example: Mainframe, Vacuum Pump, or Chiller.

17.3.1 *Vacuum Connection Number (900B)* — Enter a unique connection number for every vacuum connection. For example: 901, 902, 903, and so on.

17.3.2 *Connection Label on Equipment (800C)* — Enter the name found on the label that identifies this physical connection on the equipment. For example Process Vac.

17.3.3 *Utility Type (900D)* — Enter the name of vacuum service to be provided through the connection. For example: Process Vacuum System or Local Vacuum Pump.

17.3.4 *Line Source (900E)* — Identify the source of the vacuum line for this connection. If the line comes from a provided component covered in the data sheets enter the connection number(s) at the other end of the line. If the line comes from a facilities source enter facilities system. For example: 903 or facilities system.

17.3.5 *Vacuum Conveyed Process Wastes (900F)* — Enter the specific chemical(s) of any potential byproducts that may come through the referenced vacuum connection. In particular, identify any discharge that might be regulated by the semiconductor manufacturers' discharge permit. For example: tungsten-fluorine-oxygen precipitates or pyrophosphoric acid condensates.

17.3.6 *Minimum Vacuum (900G)* — Enter the minimum vacuum for the equipment to operate correctly.

17.3.7 *Maximum Vacuum (900H)* — Enter the highest vacuum that can be used to operate the equipment correctly.

17.3.8 *Maximum Vacuum Fluctuation (900I)* — Enter the maximum vacuum change during the processing cycle for the equipment to operate correctly.

17.3.9 *Maximum Flow (900J)* — Enter the maximum flow rate (for the equipment processing cycle or idle condition whichever is greater).

17.3.10 *Heating and Insulating (900K)* — Enter any foreline heating and insulating requirements.

17.3.11 *Equipment Component Fitting Size (900L)* — Enter the fitting size of the connection provided on the equipment component. In row 2 enter or select the units of measure for the specified fitting size. For example: mm or inches.

17.3.12 *Equipment Component Fitting Material (900M)* — Enter a general description of the fitting material of the connection provided on the equipment component. For example: 316 SS.

17.3.13 *Equipment Component Fitting Type (900N)* — Enter the generic style of fitting of the connection provided on the equipment component. Be sure to include type and gender of the fitting. For example: ISO KF Flange.

NOTE 7: SEMI E73 specifies the physical and electrical interfaces for dry pump and SEMI E74 specifies the physical and electrical interfaces for turbomolecular pumps.

17.3.14 *Drawing References (900O)* — Enter references, such as drawing numbers, for any drawings, schematics, instructions, jigs or fixtures showing this connection. For example: connection template XXXXX and P&ID YYYYY. Submit referenced material to equipment purchaser with this data sheet.

17.3.15 *Vacuum Comments (900P)* — Enter any comments necessary to clarify data provided for this connection. For example: vacuum switch will initiate tool alarm if vacuum falls below 10^{-4} Torr (1.33×10^{-2} Pa), maximum allowed foreline length, maximum number of bends or condensate cleaning requirements.

Data Sheet 900 – Vacuum (See SEMI E6 Section 17)

900 Vacuum						
	A	*B*	*C*	*D*	*E*	*F*
1	*Equipment Component*	*Vacuum Connection Number*	*Connection Label on Equipment*	*Utility Type*	*Line Source*	*Vacuum Conveyed Process Wastes*
2	text	text	text	text	text	text
3						
4						
5						
6						

900 Vacuum					
	G	*H*	*I*	*J*	*K*
1	*Minimum Vacuum*	*Maximum Vacuum*	*Maximum Vacuum Fluctuation*	*Maximum Flow*	*Heating and Insulating*
2	Pa	Pa	Pa	cmh	text
3					
4					
5					
6					

900 Vacuum					
	L	*M*	*N*	*O*	*P*
1	*Equipment Component Fitting Size*	*Equipment Component Fitting Material*	*Equipment Component Fitting Type*	*Drawing References*	*Vacuum Comments*
2	mm or inches	text	text	text	text
3					
4					
5					
6					

18 Exhaust Data Sheet

18.1 Include in the Exhaust Data Sheet the requested information for equipment connections to facilities systems (including but not limited to) heat exhaust and process chemical exhaust systems.

18.2 Data Sheet 1000, Exhaust contains the following items.

18.3 *Equipment Component (1000A)* — Enter the name of the equipment component where the connection is located. The name should the same name used in Data Sheet 200 and 300. For example: Mainframe, Vacuum Pump, or Chiller.

18.3.1 *Exhaust Connection Number (1000B)* — Enter a unique connection number for every utility connection. For example: 1001, 1002, and so on.

18.3.2 *Connection Label on Equipment (1000C)* — Enter the name found on the label that identifies this physical connection on the equipment. For example: Acid Exhaust.

18.3.3 *Utility Type (1000D)* — Enter the type of exhaust service to be provided through the connection. For example: Heat Exhaust, Acid Exhaust, Caustic Exhaust, or Solvent Exhaust.

18.3.4 *Line Source (1000E)* — Identify the source of the exhaust line for this connection. If the line comes from a provided component covered in the data sheets enter the connection number(s) at the other end of the line. If the line comes from a facilities source enter facilities system. For example: 1003 or facilities system.

18.3.5 *Exhaust Conveyed Process Wastes (1000F)* — Enter the specific chemical(s) of any potential byproducts that may come through the referenced exhaust connection. In particular, identify any discharge that might be regulated by the semiconductor manufacturers' discharge permit. For example: acid condensates.

18.3.6 *Minimum Static Pressure (1000G)* — Enter the minimum static pressure for the equipment to operate correctly.

18.3.7 *Maximum Static Pressure (1000H)* — Enter the highest static pressure for the equipment to operate correctly.

18.3.8 *Maximum Static Pressure Fluctuation (1000I)* — Enter the maximum negative static pressure change during the processing cycle for the equipment to operate correctly.

18.3.9 *Idle Average Flow (1000J)* — Enter the average flow rate when the equipment is in idle condition.

18.4 *Process Average Flow (1000K)* — Enter the average flow rate over the processing cycle.

18.5 *Maximum Temperature (1000L)* — Enter the maximum exhaust temperature.

18.5.1 *Equipment Component Fitting Size (1000M)* — Enter the fitting size of the connection provided on the equipment component. In row 2 enter or select the units of measure for the specified fitting size. For example: mm or inches.

18.5.2 *Equipment Component Fitting Size Dimension (1000N)* — Enter ID if fitting size in 100M is measured as inner diameter. Enter OD if fitting size in 100M is measured as outer diameter.

18.5.3 *Equipment Component Fitting Material (1000O)* — Enter a general description of the fitting material of the connection provided on the equipment component. For example: Polypropylene.

18.5.4 *Equipment Component Fitting Type (1000P)* — Enter the generic style of fitting of the connection provided on the equipment component. Be sure to include type and gender of the fitting. For example: Collar, Flange, or Butt.

18.5.5 *Flow Loss Coefficient, C (1000Q)* — Enter the flow loss coefficient (C). The flow loss coefficient can be calculated by measuring the static pressure loss through the equipment (SP), at the design flow rate, and calculating velocity pressure (VP) as follows:

C = Flow loss coefficient (unit less) = SP/VP

Where:

SP = Static pressure loss through equipment (Pa)

VP = Velocity pressure (Pa) = $\rho V^2/2$

ρ = Air density (Kg/m^3)

V = Air velocity (m/s)

18.5.6 *External Damper Required (1000R)* — Enter yes if a balancing or isolation damper should be provided by the equipment purchaser in the exhaust system line that will be connected to the connection. Enter no if a damper is not required or the equipment supplier provides the damper with the equipment. Clarify as required in the Exhaust Comments cell.

18.5.7 *Drawing References (1000S)* — Enter references, such as drawing numbers, for any drawings, schematics, instructions, jigs or fixtures showing this connection. For example: connection template XXXXX and P&ID YYYYY. Submit referenced material to equipment purchaser with this data sheet.

18.5.8 *Exhaust Comments (1000T)* — Enter any comments necessary to clarify information given for this connection. For example: pressure switch will alarm if exhaust static pressure falls below 0.5 inches H_2O. Also enter the design or test altitude so the equipment user can make adjustments, as necessary, for installation location altitude. For example: exhaust requirements are based on equipment operation at sea level.

Data Sheet 1000 – Exhaust (See SEMI E6 Section 18)

1000 Exhaust						
	A	*B*	*C*	*D*	*E*	*F*
1	*Equipment Component*	*Exhaust Connection Number*	*Connection Label on Equipment*	*Utility Type*	*Line Source*	*Exhaust Conveyed Process Wastes*
2	text	text	text	text	text	text
3						
4						
5						
6						

1000 Exhaust						
	G	*H*	*I*	*J*	*K*	*L*
1	*Minimum Static Pressure*	*Maximum Static Pressure*	*Maximum Static Pressure Fluctuation*	*Idle Average Flow*	*Process Average Flow*	*Maximum Temperature*
2	Pa	Pa	Pa	cmh	cmh	Degrees C
3						
4						
5						
6						

1000 Exhaust						
	M	*N*	*O*	*P*	*Q*	*R*
1	*Equipment Component Fitting Size*	*Equipment Component Fitting Size Dimension*	*Equipment Component Fitting Material*	*Equipment Component Fitting Type*	*Flow Loss Coefficient*	*External Damper Required*
2	mm or inches	ID or OD	text	text	unit less	yes or no
3						
4						
5						
6						

1000 Exhaust		
	S	*T*
1	*Drawing References*	*Exhaust Comments*
2	text	text
3		
4		
5		
6		

19 Other Data Sheets

19.1 Include data sheets or reference information for any other connections such as connections for life safety systems, gas detection systems, fire protection systems, equipment control and communication systems, material handling systems etc.

20 Related Documents

20.1 *SEMI Standards*

SEMI E36 — Semiconductor Equipment Manufacturing Information Tagging Specification

SEMI E49.1 — Guide for Tool Final Assembly, Packaging, and Delivery

SEMI E51 — Guide for Typical Facilities Services and Termination Matrix

SEMI E72 — Specification and Guide for 300 mm Equipment Footprint, Height, and Weight

SEMI E78 — Electrostatic Compatibility - Guide to Assess and Control Electrostatic Discharge (ESD) and Electrostatic Attraction (ESA) for Equipment

SEMI F34 — Guide for Liquid Chemical Pipe Labeling

SEMI F47 — Specification for Semiconductor Processing Equipment Voltage Sag Immunity

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

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

20.2 *Federal Standard*[1]

Federal Standard 209E — Airborne Particulate Cleanliness Classes in Clean rooms and Clean Zones

20.3 *ISO Standard*[2]

ISO 14644 – Cleanrooms and Associated Controlled Environments – Part 1 Classification of Air Cleanliness

20.4 *Other Documents*

International SEMATECH 00043939ATR[3] — Utility Measurement Protocol for Semiconductor Tools

International SEMATECH 980134474ASTD — Guide to Documenting Tool Accommodation Time and Cost

NOTICE: SEMI makes no warranties or representations as to the suitability of the standards set forth herein for any particular application. The determination of the suitability of the standard is solely the responsibility of the user. Users are cautioned to refer to manufacturer's instructions, product labels, product data sheets, and other relevant literature respecting any materials mentioned herein. These standards are subject to change without notice.

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1 General Service Administration, Federal Supply Service Bureau, Specification Section, Suite 8167, 470 East L' Enfant Place SW, Washington, D.C. 20407

2 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: http://www.iso.ch

3 SEMATECH, 2706 Montopolis Drive, Austin, TX 78741, website: www.sematech.org

RELATED INFORMATION 1
ADMINISTRATIVE INTERFACE INFORMATION

NOTICE: This related information is being balloted, but is not an official part of SEMI E6 and is not intended to modify or supersede the official standard. It has been derived from the work of the originating task force. Determination of the suitability of the material is solely the responsibility of the user.

R1-1 Installation Contacts

R1-1.1 Table R1-1 shows an example of the administrative interfaces information – installation contacts sheet to be included with equipment installation documentation as recommended in SEMI E6 Section 7.1.1.

R1-2 Installation Roles and Responsibilities

R1-2.1 In addition to contacts, an explanation of supplier's installation responsibilities and purchaser's responsibilities should be included to complete the administrative interface information.

Table R1-1 Example of Administrative Interface Information – Installation Contacts

	Supplier	*Purchaser*
Company Name		
Address		
Administrative Contact:		
Name/Title		
Phone/Fax		
Email:		
Sales/Purchasing Contact:		
Name/Title		
Phone/Fax		
Email:		
Shipping Contact:		
Name/Title		
Phone/Fax		
Email:		
Technical Support Contact:		
Name/Title		
Phone/Fax		
Process Support Contact:		
Name/Title		
Phone/Fax		
Email:		
ESH Contact:		
Name/Title		
Phone/Fax		
Email:		

RELATED INFORMATION 2
SHIPPING AND RECIEVING INFORMATION

NOTICE: This related information is being balloted, but is not an official part of SEMI E6 and is not intended to modify or supersede the official standard. It has been derived from the work of the originating task force. Determination of the suitability of the material is solely the responsibility of the user.

R2-1 Container Inventory

R2-1.1 Table R2-1 shows an example of the shipping and receiving information – container inventory sheet to be included with equipment installation documentation as recommended in SEMI E6 Section 7.1.2.

R2-1.2 Include detailed lists of all supplied components and parts.

R2-2 Container Storage

R2-2.1 In addition to a container inventory, any special receiving and handling instructions should be provided along with the onsite storage requirements for crates.

R2-2.2 The following storage information should be included for containers or crates:

- storage location (such as outside, storeroom, out of weather, dry location, or cleanroom),
- storage temperature range, and
- storage relative humidity range.

R2-3 Unpacking Instructions

R2-3.1 In addition to container inventory and storage information, include any special staging, inspection and unpacking instructions to complete the shipping and receiving information.

R2-3.2 If containers cannot be unloaded by hand, list the necessary equipment.

Table R2-1 Example of Shipping and Receiving Information – Container Inventory

Crate Number	*ID number on Crate*	*Crate Size Length*	*Crate Size Width*	*Crate Size Height*	*Crate Weight*	*Crate Contents*	*Crate Storage Requirements*
1							
2							
3							
4							
5							
6							

RELATED INFORMATION 3
MOVE-IN, PLACEMENT AND ASSEMBLY INSTRUCTIONS

NOTICE: This related information is being balloted, but is not an official part of SEMI E6 and is not intended to modify or supersede the official standard. It has been derived from the work of the originating task force. Determination of the suitability of the material is solely the responsibility of the user.

R3-1 Instructions

R3-1.1 Consider every step from receiving until hookup is complete when writing installation instructions. The installation process usually includes the need for tools, transportation equipment, and personnel (quantity, duration, and skills). All requirements should be indicated so availability can be assured. The following is a sample outline for the instructions recommended in SEMI E6 Section 7.1.3.

R3-1.1.1 *Move in* — Provide instructions for transport and location of the equipment in the cleanroom. List any special equipment required to move the equipment.

R3-1.1.2 *Placement* — Include procedures for items such as but not limited to the following:

- Use of templates and jigs if provided,
- Through-the-wall mounting,
- 3-dimension alignment,
- Leveling the equipment,
- Floor loading,
- Floor mounting,
- Pedestal mounting, and
- Seismic restraint.

R3-1.1.3 *Assembly* — Provide instructions for all necessary steps required to make the equipment functional. List necessary parts, and special equipment to be provided by the equipment purchaser. List necessary contractors, and include estimated schedule and duration information. Include procedures for:

- Component assembly and attachment,
- Electrical power hookup,
- Water hookup,
- Bulk chemical hookup,
- Drain hookup,
- Gas hookup,
- Vacuum hookup,
- Exhaust hookup,
- Inspection, and
- Energizing equipment.

SEMI E7-91 (Reapproved 1104)
SPECIFICATION FOR ELECTRICAL INTERFACES FOR THE U.S. ONLY

This specification was technically approved by the Global Physical Interfaces & Carriers Committee and is the direct responsibility of the North American Physical Interfaces & Carriers Committee. Current edition approved by the North American Regional Standards Committee on July 11, 2004. Initially available at www.semi.org September 2004; to be published November 2004. Originally published in 1984; last published June 1999.

For Japan electrical interface requirements, see SEMI E31.

1 Purpose

1.1 The purpose of this standard is to simplify the design and implementation of future semiconductor facilities where both equipment suppliers and users can be assured of the exact electrical interfaces required.

2 Scope

2.1 This standard presents recommendations for the selection of specific electrical power interfaces:

- Service categories by voltage, current and phase for systems, motors, and other electrical loads
- Electrical connectors
- Cordage

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

3 Referenced Standards

3.1 *Other Standards*

NEMA — National Electrical Manufacturer's Association[1]

NFPA 70-1981 — National Electrical Code, (NEC) National Fire Protection Association[2]

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

4 Terminology

None.

5 Service Categories

5.1 Voltage, current, and phase for motors and other electrical/electronic loads:

5.2 *Motors* — (From Article 430-148, 150 of National Electrical Code)

Power	*Recommended Phase & Voltage*	*Recommended Current Range*
Motors 1/6 to 3/4 HP	120V 1Ø 208V 1Ø 230V 1Ø	4.4 to 13.8 AMPs 2.4 to 7.6 AMPs 2.2 to 6.9 AMPs
Motors 3/4 to 5 HP	208V 3Ø 230V 3Ø	3.1 to 16.7 AMPs 2.8 to 15.2 AMPs
Motors 5 HP and Larger	480V 3Ø	7.6 AMPs and up

5.3 *Other Loads* — (By Calculation)

	Ampere Range for Recommended Volts & Phases			
Power	120V 1Ø	208V 1Ø	208V 3Ø	480V 3Ø
0-3000 Watts	0 to 25 A.	0 to 14 A.	0 to 8 A.	
3000-5000 Watts		14 to 24 A.	8 to 14 A.	
5000-30,000 Watts			13 to 83 A.	
30,000 and Above				36 A. and up

6 Electrical Connectors

6.1 The NEMA types listed below are available in many forms from many manufacturers. For example, the "receptacle" configurations shown also apply to connectors and flanged outlets.

6.1.1 125 Volt, 1Ø, 20 AMPs max., straight blade

1 National Electrical Manufacturer's Association, 1300 N. 17th Street, Suite 1847, Rosslyn, VA, 22209, (703) 841-3200, fax (703) 841-5900, http://www.nema.org/

2 National Fire Protection Association, 1 Batterymarch Park Quincy, Massachusetts, 02169-7471, +1 617 770-3000, fax +1 617 770-0700, http://www.nfpa.org

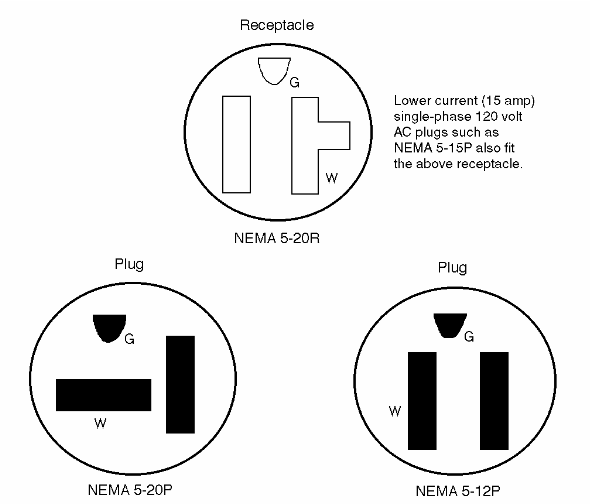

Figure 1

Dead front plugs are preferred.

6.1.2 120 Volt, Ø, 30 AMPs max., locking type.

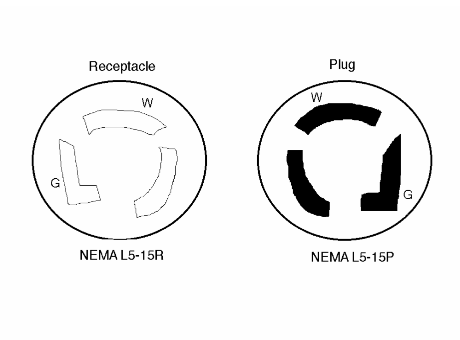

Figure 2

6.1.3 120 Volt, 1Ø, 30 AMPs max., locking blade type.

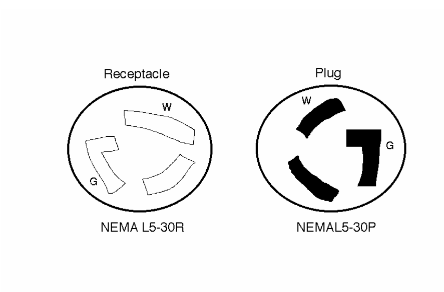

Figure 3

6.1.4 250 Volt, 1Ø, 30 AMPs max., locking type

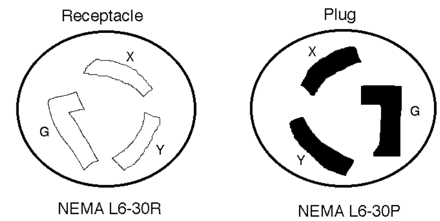

Figure 4

6.1.5 120/208 Volt, 3ØY, 30 AMPs max., locking type (4 pole, 5-wire grounding)

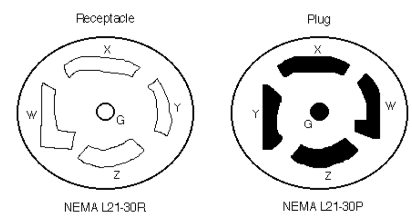

Figure 5

6.1.6 Above 10,000 watts, use of connectors is discouraged. Wherever possible, such loads should be wired into junction boxes using appropriate crimped or pressure terminations.

7 Cordage and Cables

7.1 The flexible cord and cable types shown are examples; for more detail see the National Electrical Code.

7.2 The following table gives the allowable ampacity for the specified number of current-carrying copper conductors in a cord.

7.3 Type SO-ST-STO preferred with 600 Volt insulation.

AWG	*#18*	*#16*	*#14*	*#12*	*#10*	*#8*	*#6*	*#4*
2 cond.	10	13	18	25	30	40	55	70
3 cond.	7	10	15	20	25	35	45	60
4 cond.	5.6	8	12	16	20	28	36	48
5 cond.	5.6	8	12	16	20	28	36	48

Table 1 Flexible Cord and Cable Conductor Color Code

No. Phases	*No. Wires*	*Voltage*	*ØA*	*BØ*	*CØ*	*N*	*Grd*
1	2#3	120	Blk			Wht#1	
1	2#3	208	Blk	Red			
1	3	120	Blk			Wht#1	Green#2
1	3	208	Blk	Red			Green#2
1	4	208/480	Blk	Red		Wht#1	Green#2
3	4	208/480	Blk	Red	Orange		Green#2
3	5	208/480	Blk	Red	Orange	Wht#1	Green#2

#1: Natural Grey or Light Blue may be used. Under no circumstances may White, Natural Grey or Light Blue be used for any purpose other than to identify neutral or rounded conductors.

#2: Green/Yellow may be used. Green/Yellow willbe Green with one or more Yellow stripes (Green = 50 to 70%; Yellow = 50 to 30%). Green/Yellow is the only color internationally accepted for use as an equipment grounding conductor. Under no circumstances may Green/Yellow, Green or Yellow be used for any purpose other than to identify grounding conductors.

#3: For double insulated machines only.

8 Related Documents

8.1 The following are sources of further information concerning electrical interfaces:

Electrical Industries Association (EIA), 2001 I Street, N.W., Washington, DC 20006

Joint Industrial Council (JlC), 7901 Westpark Dr., McLean, VA 22101

Western Electric Co., Inc. (WECO), "Standards for Electrical Design and Construction," Drawing #C-284805, Machine Design Dept., Allentown Works, Allentown, PA 18103

Occupational Safety & Health Administration, Standards (OSHA) Part 1910, Title 29, Code of Federal Regulations, Dated 7 Nov. 1978, Dept. of Labor, Washington, DC

Underwriter's Laboratories, Inc. (UL), 207 E. Ohio St., Chicago, IL 60611

IBM Corporate Bulletin, "Nonproduct Equipment Design Standard," "CB 3-0502-202 Support Equipment Standard," 1983-05, or succession thereto

American National Standards Institute, C73.73, American National Standards Institute, 1430 Broadway, New York, NY 10018

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SEMI E10-0304^E
SPECIFICATION FOR DEFINITION AND MEASUREMENT OF EQUIPMENT RELIABILITY, AVAILABILITY, AND MAINTAINABILITY (RAM)

This specification was technically approved by the Global Metrics Committee and is the direct responsibility of the North American Metrics Committee. Current edition approved by the North American Regional Standards Committee on October 15, 2003. Initially available at www.semi.org February 2004; to be published March 2004. Originally published in 1986; previously published July 2001.

E This standard was editorially modified in February 2004 to include changes omitted from the previous edition. Changes were made to Table 1, Table R1-3, and Section R1-7.

1 Purpose

1.1 This document establishes a common basis for communication between users and suppliers of semiconductor manufacturing equipment by providing standards for measuring RAM performance of that equipment in a manufacturing environment.

2 Scope

2.1 The document defines six basic equipment states into which all equipment conditions and periods of time must fall. The equipment states are determined by functional issues, independent of who performs the function. The measurement of equipment reliability in this specification concentrates on the relationship of equipment failures to equipment usage, rather than the relationship of failures to total elapsed time.

2.2 Section 5 (Equipment States) defines how equipment time is categorized. Section 6 (RAM Measurement) defines formulas for measurement of equipment performance. Section 7 (Uncertainty Measurement) gives additional methods for evaluating the statistical significance of calculated performance metrics.

2.3 Effective application of this specification requires that equipment performance (RAM) be tracked with regard to time and/or equipment cycles. Automated tracking of equipment states is not within the scope of this specification, but is covered by SEMI E58. Clear and effective communication among users and suppliers promotes continuous improvement in equipment performance.

2.4 The RAM indices in this specification may be applied directly to non-cluster tools at the whole equipment and sub-system levels. The RAM indices may be applied at the sub-system level (e.g., process module) for multi-path cluster tools.

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

3 Referenced Standards

3.1 *SEMI Standards*

SEMI E58 — Automated Reliability, Availability, and Maintainability Standard (ARAMS)

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

4 Terminology

4.1 *Definitions*

4.1.1 *availability* — the probability that the equipment will be in a condition to perform its intended function when required.

4.1.2 *cluster tool* — a manufacturing system made up of integrated processing modules mechanically linked together (the modules may or may not come from the same supplier).

4.1.2.1 *single path cluster tool* — a cluster tool with only one process flow path (as used).

4.1.2.2 *multi-path cluster tool* — a cluster tool with more than one independent process flow path (e.g., multiple load ports/load-locks, multiple process chambers of the same type) and used as such.

4.1.3 *cycle* — one complete operational sequence (including unit load and unload) of processing, manufacturing, or testing steps for an equipment system or subsystem. In single unit processing systems, the number of cycles equals the number of units processed. In batch systems, the number of cycles equals the number of batches processed.

4.1.4 *downtime (DT)* — the time when the equipment is not in a condition, or is not available, to perform its intended function. It does not include any portion of non-scheduled time.

4.1.5 *downtime event* — a detectable occurrence significant to the equipment that causes the equipment to go from an uptime state to either a scheduled or an unscheduled downtime state.

4.1.6 *failure* — any unscheduled downtime event that changes the equipment to a condition where it cannot perform its intended function. Any part failure, software or process recipe problem, facility or utility supply malfunction, or human error could cause the failure.

NOTE 1: It is important to categorize and qualify failures in ways that facilitate the resolution of problems and improve overall equipment performance. Use of this specification requires agreement between supplier and user on categorizing failures.

4.1.7 *equipment-related failure* — any unplanned event that changes the equipment to a condition where it cannot perform its intended function solely caused by the equipment.

4.1.8 *host* — the intelligent system that communicates with the equipment, acts as a supervisory agent, and represents the factory and the user to the equipment.

4.1.9 *intended function* — a manufacturing function that the equipment was built to perform. This includes transport functions for transport equipment and measurement functions for metrology equipment, as well as process functions such as physical vapor deposition and wire bonding. Complex equipment may have more than one intended function.

4.1.10 *maintainability* — the probability that the equipment will be retained in, or restored to, a condition where it can perform its intended function within a specified period of time.

4.1.11 *maintenance* — the act of sustaining equipment in or restoring it to a condition to perform its intended function. In this document, maintenance refers to function, not organization; it includes adjustments, change of consumables, software upgrades, repair, preventive maintenance, etc., no matter who performs the task.

4.1.12 *manufacturing time* — the sum of productive time and standby time.

4.1.13 *non-scheduled time* — the time when the equipment is not scheduled to be utilized in production.

4.1.14 *operations time (oper-time)* — total time minus non-scheduled time.

4.1.15 *operator* — any person who communicates locally with the equipment through the equipment's control panel.

4.1.16 *product* — units produced during productive time (see unit).

4.1.17 *ramp-down* — the portion of a maintenance procedure required to prepare the equipment for hands-on work. It includes purging, cool-down, warm-up, software backup, storing dynamic values (e.g., parameters, recipes), etc. Ramp-down is only included in scheduled and unscheduled downtime.

4.1.18 *ramp-up* — the portion of a maintenance procedure required, after the hands-on work is completed, to return the equipment to a condition where it can perform its intended function. It includes pump down, warm-up, stabilization periods, initialization routines, software load, restoring dynamic values (e.g., parameters, recipes), control system reboot, etc. It does not include equipment or process test time. Ramp-up is only included in scheduled and unscheduled downtime.

4.1.19 *reliability* — the probability that the equipment will perform its intended function, within stated conditions, for a specified period of time

4.1.20 *shutdown* — the time required to put the equipment in a safe condition when entering a non-scheduled state. It includes any procedures necessary to reach a safe condition. Shutdown is only included in non-scheduled time.

4.1.21 *specification (equipment operation)* — the documented set of intended functions within stated conditions for equipment operation as agreed upon between user and supplier.

4.1.22 *start-up* — the time required for equipment to achieve a condition where it can perform its intended function, when leaving a non-scheduled state. It includes pump down, warm-up, cool-down, stabilization periods, initialization routines, software load, restoring dynamic values (e.g., parameters, recipes), control system reboot, etc. Start-up is only included in non-scheduled time.

4.1.23 *support tool* — a tool that, although not part of a piece of equipment, is required by and becomes integral with it during the course of normal operation (e.g., cassettes, wafer carriers, probe cards, computerized controllers/monitors).

4.1.24 *total time* — all time (at the rate of 24 hrs/day, 7 days/week) during the period being measured. In order to have a valid representation of total time, all six basic equipment states must be accounted for and tracked accurately.

4.1.25 *training (off-line)* — the instruction of personnel in the operation and/or maintenance of equipment done outside of operations time. Off-line training is only included in non-scheduled time.

4.1.26 *training (on-the-job)* — the instruction of personnel in the operation and/or maintenance of equipment done during the course of normal work functions. On-the-job training typically does not interrupt operation or maintenance activities and can therefore be included in any equipment state (except standby and non-scheduled) without special categorization.

4.1.27 *unit* — any wafer, substrate, die, packaged die, or piece part thereof.

4.1.28 *uptime* — the time when the equipment is in a condition to perform its intended function. It includes productive, standby, and engineering time, and does not include any portion of non-scheduled time.

4.1.29 *user* — any entity interacting with the equipment, either locally as an operator or remotely via the host. From the equipment's view point, both the operator and the host represent the user.

4.1.30 *utilization* — the percent of time the equipment is performing its intended function during a specified time period.

4.1.31 *verification run* — a single cycle of the equipment (using units or no units) used to establish that it is performing its intended function within specifications.

5 Equipment States

5.1 To clearly measure equipment performance (RAM), this document defines six basic equipment states into which all equipment conditions and periods of time must fall.

5.2 The equipment states are determined by function, not by organization. Any given maintenance procedure, for example, is classified the same way no matter who performs it, an operator, a production technician, a maintenance technician, or a process engineer.

5.3 Figure 1 is a stack chart of the six basic equipment states. These basic equipment states can be divided into as many sub-states as are required to achieve the equipment tracking resolution that a manufacturing operation desires. SEMI E10 makes no attempt to list all possible sub-states, but does give some examples for guidance.

5.4 Key blocks of time associated with the basic states and example substates are given in Figure 2. These blocks of time are used in the RAM equations given later in this document. The blocks of time associated with the basic states and example substates are described in the following sections.

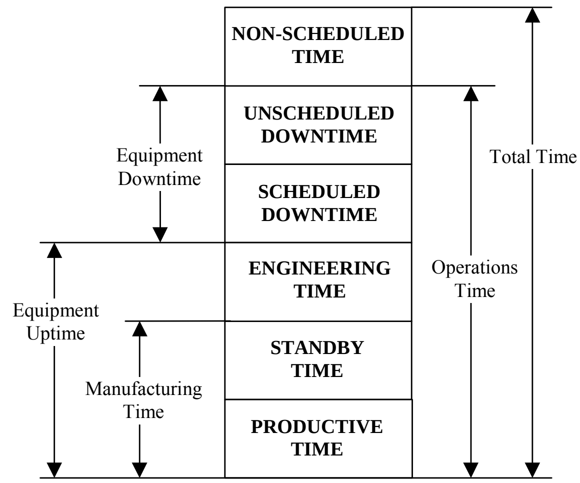

Figure 1
Equipment States Stack Chart

5.5 *PRODUCTIVE STATE* — The time (productive time) when the equipment is performing its intended function. The productive state includes:

- Regular production (including loading and unloading of units),
- Work for third parties,
- Rework, and
- Engineering runs done in conjunction with production units (e.g., split lots and new applications).

5.6 *STANDBY STATE* — The time (standby time), other than non-scheduled time, when the equipment is in a condition to perform its intended function, chemicals and facilities are available, but it is not operated. The standby state includes:

- No operator available (including breaks, lunches, and meetings),
- No units available (including no units due to lack of available support equipment, such as metrology tools),
- No support tools (e.g., cassettes, wafer carriers, probe cards), and
- No input from external automation systems (i.e., host).

5.7 *ENGINEERING STATE* — The time (engineering time) when the equipment is in a condition to perform its intended function (no equipment or process problems exist), but is operated to conduct engineering experiments. The engineering state includes:

- Process engineering (e.g., process characterization),
- Equipment engineering (e.g., equipment evaluation), and
- Software engineering (e.g., software qualification).

5.8 *SCHEDULED DOWNTIME STATE* — The time (scheduled downtime) when the equipment is not available to perform its intended function due to planned downtime events. The scheduled downtime state includes:

- Maintenance delay (maint-delay),
- Production test,
- Preventive maintenance,
- Change of consumables/chemicals,
- Setup, and
- Facilities related (fac-rel).

5.8.1 *Maintenance Delay* — The time (maint-delay downtime) during which the equipment cannot perform its intended function because it is waiting for either user or supplier personnel or parts (including consumables/chemicals) associated with maintenance. Maintenance delay may also be due to an administrative decision to leave the equipment down and postpone maintenance.

5.8.1.1 Maintenance delays may occur at any point in the maintenance process. These maintenance delay downtimes must be tracked separately from maintenance time. Delay downtime is included in time off-line, but not in time to repair (see Sections 6.3 and 6.4 Equipment Availability and Maintainability).

5.8.2 *Production Test* — The time (production test downtime) for the planned interruption of equipment availability for evaluation of units, as defined in the specifications of equipment operation, to confirm that the equipment is performing its intended function within specifications. It does not include testing that can be done in parallel with, or transparent to, the running of production, nor does it include any testing done following a preventive maintenance, setup, or repair procedure.

5.8.3 *Preventive Maintenance* — The sum of the times (preventive maintenance downtimes) for:

- Preventive action: A predefined maintenance procedure (including equipment ramp-down and ramp-up), at scheduled intervals, designed to reduce the likelihood of equipment failure during operation. Scheduled intervals may be based upon time, equipment cycles, or equipment conditions.
- Equipment test: The operation of equipment to demonstrate equipment functionality; (e.g., system reaches base pressure, wafers transfer without problem, gas flow is correct, plasma ignites, source reaches specified power).
- Verification run: The processing and evaluation of units after preventive action to establish that the equipment is performing its intended function within specifications.

NOTE 2: Equipment suppliers are responsible for specifying a preventive maintenance program to achieve a predetermined equipment performance level. Users are obligated to identify any deviation from the recommended program if they expect the supplier to meet or improve that performance level.

5.8.4 *Change of Consumables/Chemicals* — The time (change of consumables/chemicals downtime) for the scheduled interruption of operation to replenish the raw materials of semiconductor processing. It includes changes of gas bottles, acids, targets, sources, etc., and any purging, cleaning, or flushing normally associated with those changes. It does not include delays in obtaining those consumables/chemicals.

5.8.5 *Setup* — The sum of the times (setup downtimes) for:

- Conversion: The time required to complete an equipment alteration necessary to accommodate a change in process, unit, package configuration, etc. (excluding modifications, rebuilds, and upgrades).
- Equipment test: The operation of equipment to demonstrate equipment functionality; (e.g., system reaches base pressure, wafers transfer without problem, gas flow is correct, plasma ignites, source reaches specified power).
- Verification run: The processing and evaluation of units after conversion to establish that equipment is performing its intended function within specifications.

NOTE 3: Equipment suppliers are responsible for providing procedures which achieve setup conversion and testing within predetermined specifications. Users are obligated to identify any deviation from the procedures if they expect the supplier to make setups fall within those specifications.

5.8.6 *Facilities Related* — The time (facilities-related downtime) when the equipment cannot perform its intended function solely as a result of out of specification facilities. Those facilities include:

- Environmental (e.g., temperature, humidity, vibration, particle count),
- House hookups (e.g., power, cooling water, house gases, exhaust, LN2), and

- Communications links with other equipment or host computers.

5.8.6.1 Any downtime created by the items listed above shall be included in facilities-related downtime. For example, if, as a result of a scheduled 15-minute power outage an otherwise unnecessary cryo pump regeneration is needed, all time required to return the equipment to a condition where it can perform its intended function is included in facilities-related downtime.

5.9 *UNSCHEDULED DOWNTIME STATE* — The time (unscheduled downtime) when the equipment is not in a condition to perform its intended function due to unplanned downtime events:

- Maintenance delay (maint-delay)
- Repair
- Change of consumables/chemicals
- Out-of-spec input
- Facilities related (fac-rel)

5.9.1 *Maintenance Delay* — The time (maint-delay downtime) during which the equipment cannot perform its intended function because it is waiting for either user or supplier personnel or parts (including consumables/chemicals) associated with maintenance. Maintenance delay may also be due to an administrative decision to leave the equipment down and postpone maintenance.

5.9.1.1 Maintenance delays may occur at any point in the maintenance process. These maintenance delay downtimes should be tracked separately from maintenance time. Delay downtime is included in time off-line, but not in maintenance time (see Sections 6.3 and 6.4 Equipment Availability and Maintainability).

5.9.2 *Repair* — The sum of the times (repair downtimes) for:

- Diagnosis: The procedure of identifying the source of an equipment problem or failure.
- Corrective action: The maintenance procedure (including equipment ramp-down and ramp-up, re-booting, resetting, recycling, restarting, reverting to a previous software version, etc.) employed to address an equipment failure and return the equipment to a condition where it can perform its intended function.
- Equipment test: The operation of equipment to demonstrate equipment functionality (e.g., system reaches base pressure, wafers transfer without problem, gas flow is correct, plasma ignites, source reaches specified power).
- Verification run: The processing and evaluation of units after corrective action to establish that the equipment is performing its intended function within specifications.

5.9.3 *Change of Consumables/Chemicals* — The time (change of consumables/chemicals downtime) for the unscheduled interruption of operation to replenish the raw materials of semiconductor processing. It includes changes of gas bottles, acids, targets, sources, etc., and any purging, cleaning, or flushing normally associated with those changes. It does not include delays in obtaining these consumables/chemicals.

5.9.4 *Out-of-Spec Input* — The time (out-of-spec input downtime) when the equipment cannot perform its intended function solely as a result of problems created by out-of-specification or faulty inputs. Those inputs include:

- Support tools (e.g., warped cassettes or wafer carriers, faulty probe cards, reticles),
- Unit (e.g., upstream process problems, warped wafers, contaminated wafers, warped lead frames),
- Test data (e.g., metrology tool out of calibration, misread charts, erroneous data interpretation/entry), and
- Consumables/chemicals (e.g., contaminated acid, leaky target bond, degraded photo resist, degraded mold compound).

5.9.4.1 Any downtime created by the items listed above shall be included in out-of-specification input downtime. For example, if, as a result of an intermittent probe card short, a prober/tester system is put down for repair, all downtime incurred prior to identifying the problem is re-categorized as out-of-specification input downtime.

5.9.5 *Facilities Related* — The time (facilities-related downtime) when the equipment cannot perform its intended function solely as a result of out-of-specification facilities. Those facilities include:

- Environmental (e.g., temperature, humidity, vibration, particle count),
- House hookups (e.g., power, cooling water, house gases, exhaust, LN2), and
- Communications links with other equipment or host computers.

5.9.5.1 Any downtime created by the items listed above shall be included in facilities-related downtime. For example, if, as a result of an unscheduled 15-minute power outage, an otherwise unnecessary cryo pump regeneration is needed, all time required to return the equipment to a condition where it can perform its intended function is included in facilities-related downtime.

5.10 *NON-SCHEDULED STATE* — The time (non-scheduled time) when the equipment is not scheduled to be utilized in production, such as unworked shifts, weekends, and holidays (including shutdown and start-up).

5.10.1 If equipment is out of the production plan due to off-line training or an installation, modification, rebuild, or upgrade (hardware or software) that cannot be accommodated by the regular preventive maintenance schedule, its status is the non-scheduled state. This includes any qualification time required to bring the equipment to a condition where it can perform its intended function from one of these states.

5.10.2 Any maintenance done to equipment during these periods cannot be counted in the non-scheduled state, since all maintenance must fall into either scheduled or unscheduled downtime (this includes automatic maintenance routines such as a programmed cryo pump regeneration).

5.10.3 By the same convention, any production or engineering work done during these periods must fall into either productive or engineering time (this includes an unattended operation that may shut itself off "after hours").

6 RAM Measurement

6.1 Reliability, availability, and maintainability are measures of equipment performance which have been used widely in industry for decades. This section defines them for the semiconductor industry in a manner that is consistent with existing industrial standards. Along with the definitions for RAM are given indicators by which these measures can be quantified.

6.2 *EQUIPMENT RELIABILITY* — The probability that the equipment will perform its intended function, within stated conditions, for a specified period of time.

NOTE 4: Two different methods of measuring this are presented, productive time (Sections 6.2.1 and 6.2.2) and equipment cycles (Sections 6.2.3 and 6.2.4):

- Productive time only considers what happens while making units (useful for manufacturing operation purposes).
- Equipment cycles take into account the wear and tear created by every machine cycle during all equipment states (useful for equipment reliability purposes).

6.2.1 *MTBF$_p$* — Mean (productive) time between failures; the average time the equipment performed its intended function between failures; productive time divided by the number of failures during that time. Only productive time is included in this calculation. Failures that occur when an attempt is made to change from any state to a productive state are included in this calculation. Using $MTBF_p$, therefore, requires that the user not only have the capability of capturing failure information, but also tracking and categorizing total time accurately.

$$MTBF_p = \frac{\textit{productive time}}{\textit{\# of failures that occur during productive time}}$$

6.2.2 *E-MTBF$_p$* — Mean (productive) time between equipment-related failures; the average time the equipment performed its intended function between these equipment-related failures; productive time divided by the number of equipment-related failures during that time. Only productive time is included in this calculation. Equipment-related failures that occur when an attempt is made to change from any state to a productive state are included in this calculation. Using E-$MTBF_p$, therefore, requires that the user not only have the capability of capturing failure information, but also tracking and categorizing total time and the root causes of failures accurately.

$$E\text{–}MTBF_p = \frac{\textit{productive time}}{\textit{\# of equipment-related failures that occur during productive time}}$$

6.2.3 *MCBF* — Mean cycles between failures; the average number of equipment cycles between failures; total equipment cycles divided by the number of failures during those cycles. This calculation transcends equipment states to include all cycles that the system, or subsystem, being considered experiences. It does not require tracking equipment states, only equipment cycles and equipment failures.

$$MCBF = \frac{\textit{total equipment cycles}}{\textit{\# of failures}}$$

6.2.4 *E-MCBF* — Mean cycles between equipment-related failures; the average number of equipment cycles between these equipment-related failures; total equipment cycles divided by the number of equipment-related failures during those cycles. This calculation transcends equipment states to include all cycles that the system, or subsystem, being considered experiences. It does not require tracking equipment states, only equipment cycles and equipment-related failures and their root causes.

$$E\text{–}MCBF = \frac{\textit{total equipment cycles}}{\textit{\# of equipment-related failures}}$$

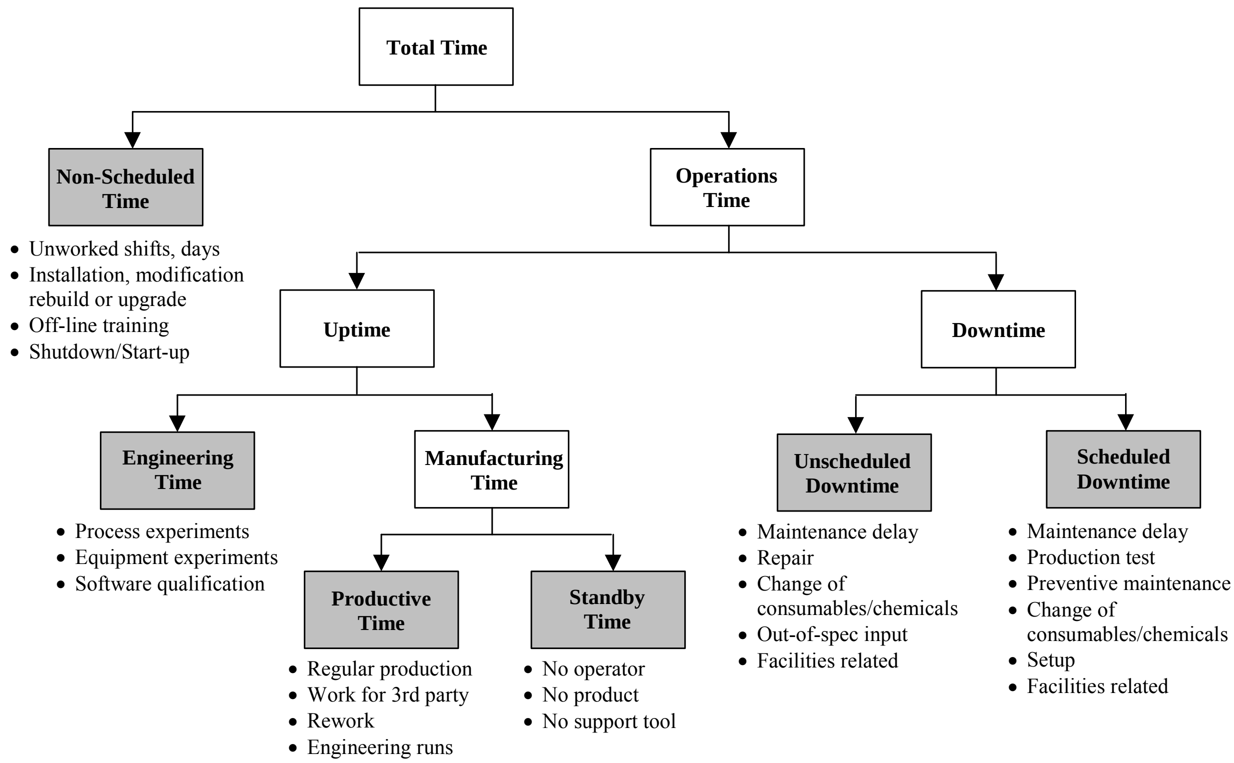

Figure 2
SEMI E10 Summary of Time

6.3 *EQUIPMENT AVAILABILITY* — The probability that the equipment will be in a condition to perform its intended function when required.

6.3.1 *Equipment Dependent Uptime* — The percent of time the equipment is in a condition to perform its intended function during the period of operations time minus the sum of all maintenance delay downtime, out-of-spec input downtime, and facilities-related downtime. This calculation is intended to reflect equipment reliability and maintainability based solely on equipment merit.

$$\textit{equipment dependent uptime (\%)} = \frac{\textit{equipment uptime} \times 100}{\textit{(oper-time – (all maint-delay DT + out-of-spec input DT + fac-rel DT))}}$$

6.3.2 *Supplier Dependent Uptime* — The percent of time the equipment is in a condition to perform its intended function during the period of operations time minus the sum of user maintenance delay downtime, out-of-spec input downtime, and facilities-related downtime. This calculation subtracts only user maintenance delay downtime from the period, thereby taking into account supplier delays for parts and service. The intention is to provide an effective performance measurement for use in supplier service contracts.

$$\textit{supplier dependent uptime (\%)} = \frac{\textit{equipment uptime} \times 100}{\textit{(oper-time – (user maint-delay DT + out-of-spec input DT + fac-rel DT))}}$$

6.3.3 *Operational Uptime* — The percent of time the equipment is in a condition to perform its intended function during the period of operations time. This calculation is intended to reflect overall operational performance for a piece of equipment.

$$\textit{operational uptime } (\%) = \frac{\textit{equipment uptime} \times 100}{\textit{operations time}}$$

6.4 *EQUIPMENT MAINTAINABILITY* — The probability that the equipment will be retained in, or restored to, a condition where it can perform its intended function within a specified period of time.

6.4.1 *MTTR* — Mean time to repair; the average time to correct a failure and return the equipment to a condition where it can perform its intended function; the sum of all repair time (elapsed time not necessarily total man hours) incurred during a specified time period (including equipment and process test time, but not including maintenance delay downtime), divided by the number of failures during that period.

$$MTTR = \frac{\text{total repair time}}{\#\text{ of failures}}$$

6.4.2 *E-MTTR* — Mean time to repair equipment-related failures; the average time to correct an equipment-related failure and return the equipment to a condition where it can perform its intended function; the sum of all equipment-related failure repair time (elapsed time, not necessarily total man hours) incurred during a specified time period (including equipment and process test time, but not including maintenance delay downtime), divided by the number of equipment-related failures during that period.

$$E\text{–}MTTR = \frac{\text{total repair time for equipment-related failures}}{\#\text{ of equipment-related failures}}$$

6.4.3 *MTOL* — Mean time off-line; the average time to maintain the equipment in or return the equipment to a condition where it can perform its intended function when downtime is incurred; the sum of all downtime (scheduled and unscheduled) during a specified time period, divided by the number of downtime events during that period.

$$MTOL = \frac{\text{total equipment downtime}}{\#\text{ of DT events}}$$

6.4.4 *Equipment Dependent Scheduled Downtime* — The percent of time the equipment is not available to perform its intended function due to scheduled downtime events such as preventive maintenance. This time period does not include any maintenance delay downtime caused either by supplier or user. This calculation is intended to reflect the need for preventive maintenance based solely on equipment design.

$$\text{equipment dependent scheduled downtime (\%)} = \frac{\text{equipment scheduled downtime} \times 100}{(\text{oper-time} - (\text{all maint-delay DT} + \text{out-of-spec input DT} + \text{fac-rel DT}))}$$

6.4.5 *Supplier Dependent Scheduled Downtime* — The percent of time the equipment is not available to perform its intended function due to scheduled downtime events, such as preventive maintenance. This time period does not include any maintenance delay downtime caused by the user. This calculation is intended to reflect the need for preventive maintenance based solely on equipment design and supplier response to service.

$$\text{supplier dependent scheduled downtime (\%)} = \frac{\text{equipment scheduled downtime} \times 100}{(\text{oper-time} - (\text{user maint-delay DT} + \text{out-of-spec input DT} + \text{fac-rel DT}))}$$

6.5 *EQUIPMENT UTILIZATION* — The percent of time the equipment is performing its intended function during a specified time period.

6.5.1 *Operational Utilization* — The percent of productive time during operations time. This calculation is intended to be used for equipment utilization comparisons between operations with different work shift configurations, since it does not include non-scheduled time.

$$\text{operational utilization (\%)} = \frac{\text{productive time} \times 100}{\text{operations time}}$$

6.5.2 *Total Utilization* — The percent of productive time during total time. This calculation is intended to reflect bottom-line equipment utilization.

$$\text{total utilization (\%)} = \frac{\text{productive time} \times 100}{\text{total time}}$$

Table 1 RAM Measurement Metric Summary

EQUIPMENT RELIABILITY		
Metric	*How It Is Measured*	*Ref #*
MTBF$_p$: Mean (productive) time between failures	productive time/ # of failures that occur during productive time	6.2.1
E-MTBF$_p$: Mean (productive) time between equipment-related failures	productive time/ # of equipment-related failures that occur during productive time	6.2.2
MCBF: Mean cycles between failures	total equipment cycles/ # of failures	6.2.3
E-MCBF: Mean cycles between equipment-related failures	total equipment cycles/ # of equipment-related failures	6.2.4
EQUIPMENT AVAILABILITY		
Metric	*How It Is Measured*	*Ref #*
equipment dependent uptime (%)	equipment uptime × 100/(oper-time – (all maint-delay DT + out-of-spec input DT + fac-rel DT))	6.3.1
supplier dependent uptime (%)	equipment uptime × 100/(oper-time – (users maint-delay DT + out-of-spec input DT + fac-rel DT))	6.3.2
operational uptime (%)	equipment uptime × 100/ operations time	6.3.3
EQUIPMENT MAINTAINABILITY		
Metric	*How It Is Measured*	*Ref #*
MTTR: Mean time to repair	total repair time/ # of failures	6.4.1
E-MTTR: Mean time to repair for equipment-related failures	total repair time for equipment-related failures/ # of equipment-related failures	6.4.2
MTOL: Mean time off-line	total equipment downtime/ # of DT events	6.4.3
equipment dependent scheduled downtime (%)	equipment scheduled downtime × 100/(oper-time – (all maint-delay DT + out-of-spec input DT + fac-rel DT))	6.4.4
supplier dependent scheduled downtime (%)	equipment scheduled downtime × 100/(oper-time – (user maint-delay DT + out-of-spec input DT + fac-rel DT))	6.4.5
EQUIPMENT UTILIZATION		
Metric	*How It Is Measured*	*Ref #*
operational utilization (%)	productive time × 100/ operations time	6.5.1
total utilization (%)	productive time × 100/ total time	6.5.2

NOTE: oper-time = operational time, DT = Downtime, fac-rel = facilities related, maint-delay = maintenance delay

7 Uncertainty Measurement

7.1 The measures of equipment reliability, availability, and maintainability defined in Section 6 are single value estimates. They do not indicate the uncertainty or precision of the estimate. Precision varies depending upon the number of failures observed and the amount of productive time contained within the observation period.

7.2 Precision is described by calculating a lower and upper confidence limit for the $MTBF_p$ and presenting this interval along with the $MTBF_p$ point estimate.

7.3 These procedures assume that the failure rate is constant and the times between failures are independently distributed according to the exponential distribution. Therefore, there are no improvement or degradation trends and it is meaningful to calculate $MTBF_p$. Section 8 applies when the failure times indicate that a non-constant failure rate is present (for example, when there is reliability growth or degradation). Section 8 would typically apply during prototype reliability improvement testing.

7.4 Since MTTR distributions are unlikely to follow an exponential distribution assumption, applying these procedures to put confidence limits on MTTR would be inappropriate.

7.5 Note that all procedures and tables referred to in this section apply equally well to measuring the precision of estimates for similar metrics, where hours are replaced by cycles or units, for example. These procedures apply to E-$MTBF_p$ or E-MCBF in the same way. It is also appropriate to combine data from identical tools being used the same way, in order to improve the precision of $MTBF_p$ estimates.

7.6 *Calculation of Lower and Upper Confidence Limits* — To obtain lower and upper $MTBF_p$ limits, multiply the $MTBF_p$ estimate by factors obtained by table look-up (Tables A1-1 and A1-2 in Appendix 1). For the case when there are zero failures during the measurement period, lower confidence limit factors for the $MTBF_p$ are given in the first row of Table A1-1 (they multiply the amount of productive time that had no failures to obtain the desired $MTBF_p$ lower limit). There is no upper limit estimate for performance when there are zero failures.

7.6.1 *Calculation of the $MTBF_p$ Lower Limit* — Use Table A1-1 in Appendix 1 to obtain a $k_{r;conf}$ factor, where *r* is the number of failures observed during the measurement period and *conf* is the confidence level desired. The rows of Table A1-1 correspond to different values of *r* and the columns correspond to different values of *conf*. Confidence levels ranging from 80 percent to 95 percent are typical choices.

7.6.1.1 Since the equipment being measured has demonstrated (at a given confidence level) that it is at least as good as the $MTBF_p$ lower limit, this lower limit is an important and useful performance statistic, and is often used contractually.

7.6.1.2 Note that the factors in Table A1-1 for 90% confidence are less than 0.5 until the number of failures equals or exceeds 4. This means that when the number of failures is under 4, the $MTBF_P$ lower limit will be less than half the $MTBF_p$ estimate, and confidence intervals will be wide. From the point of view of precision, it is advantageous to have had 4 or more failures.

7.6.1.3 *Example*: During a given calendar quarter, a tool was productive for 1200 hours and had 6 failures. The $MTBF_p$ estimate is 1200/6 = 200 hours. A 90 percent lower limit factor from Table A1-1 (corresponding to $r = 6$ failures) is 0.570. That means that $200 \times 0.570 = 114.0$ hours is a 90 percent lower confidence limit for the true tool $MTBF_p$.

7.6.2 *Calculation of the $MTBF_p$ Upper Limit* — Use Table A1-2 in Appendix 1 to obtain a $k_{r;conf}$ factor, where *r* is the number of failures observed during the measurement period and *conf* is the confidence level desired. The rows of Table A1-2 correspond to different values of *r* and the columns correspond to different values of *conf*. Confidence levels ranging from 80 percent to 95 percent are typical choices.

7.6.2.1 *Example*: During a given calendar quarter, a tool was productive for 1200 hours and had 6 failures. The $MTBF_p$ estimate is 1200/6 = 200 hours. A 90 percent upper limit factor from Table A1-2 (corresponding to $r = 6$ failures) is 1.904. That means that $200 \times 1.904 = 380.8$ hours is a 90 percent upper confidence limit for the true tool $MTBF_p$.

7.6.3 *Calculation of a Confidence Interval for the $MTBF_p$* — Lower and upper $100 \times (1 - \alpha/2)$ confidence limits for the $MTBF_p$ can be combined to give a $100 \times (1 - \alpha)$ confidence interval. Here $\alpha/2$ is the chance of missing on either end of the interval. A 90 percent lower limit has an $\alpha/2 = 0.1$ chance of not being low enough to capture the true $MTBF_p$, and the same is true for a 90 percent upper limit. Therefore, a 90 percent lower limit and a 90 percent upper limit combine to give an 80 percent confidence interval. Similarly, a 95 percent lower limit and a 95 percent upper limit would combine to give a 90 percent confidence interval.

7.6.3.1 *Example*: During a calendar quarter, a tool was productive for 1200 hours and had 6 failures. The $MTBF_p$ estimate is 1200/6 = 200 hours. The 90 percent lower and upper limits are 114 and 380.8 respectively (see Sections 7.6.1 and 7.6.2). The interval (114, 380.8) is then an 80 percent confidence interval for the true tool $MTBF_p$.

7.6.4 *Calculation of the $MTBF_p$ Lower Bound when there are Zero Failures* — Use the first row of Table A1-1 (corresponding to r = 0) to obtain a $k_{0;conf}$ factor corresponding to the desired confidence level. Multiply the length of the measurement period by this factor to obtain the lower limit estimate.

7.6.4.1 *Example*: During a calendar quarter, a tool was productive for 1200 hours and had zero failures. From Table A1-1, the 90% confidence level lower limit factor is 0.434. That means that 1200 × 0.434 = 520.8 hours, is a 90% lower confidence limit estimate for the true tool $MTBF_p$.

7.6.5 Choosing a test length in order to be able to demonstrate a required $MTBF_p$ at a given confidence, we first must pick a maximum number of failures, r, that can occur during the test period and still allow us to confirm a required $MTBF_p$ objective at a given confidence level. Next, the length of test time needed can be calculated using the factors in Table A1-4 in Appendix 1. The required $MTBF_p$ is multiplied by a factor based on r and the desired confidence level to obtain the total test time needed.

7.6.5.1 Note that minimum test times are obtained by allowing no failures. The cost, however, of using a minimum test length is to increase the possibility of an acceptable tool failing the test by chance. As mentioned in the discussion in Section 6.2.1, it is advantageous to design a test that allows up to 4 failures, whenever possible.

7.6.5.2 *Example*: We would like to confirm a tool $MTBF_p$ of 400 hours at an 80% confidence level. We want to be able to pass a qualification test with 4 or less failures. We look up the appropriate factor from Table A1-4 and find 6.72. That means the length of test time required is 400 × 6.72 = 2688 hours. We can do this on one tool or split the test time across several tools. When we have accumulated 2688 hours and if 4 or less failures have occurred, the $MTBF_p$ objective of 400 hours will have been confirmed at (at least) the 80% confidence level.

8 Reliability Growth or Degradation Measurement

8.1 The previous calculations are meaningful only when the $MTBF_p$ (or MCBF) and E-$MTBF_p$ (or E-MCBF) are constant over the measurement period. If reliability is improving (typical during design verification and debug and also early life run-in) or if reliability is degrading (typical near the end of life for the piece of equipment, or if certain sub-assemblies have been over-stressed and are wearing out) then an overall $MTBF_p$ calculation is inappropriate and misleading and other methods must be used. Exact time of failure recording is required in order to detect reliability improvement or reliability degradation trends, and to fit appropriate models.

8.2 *Exact Time of Failure Recording* — Clock times of failure must be converted to durations of cumulative productive time as measured from the initial productive use of the tool (set as time 0). This is easily accomplished if total time is continuously monitored by duration within each of the six equipment states.

8.2.1 *Example*: A machine is intended for use during first shift operation five days a week. For simplicity, assume 100% productive utilization. After the first three weeks of use, it fails half-way through the day, and is not repaired until the start of the next day's operation. No more failures occur before the end of the first four weeks of operation. The exact time of failure is 124 hours (three weeks of 5 × 8 = 40 hours per week plus half of an 8 hour day). If a second failure occurred two hours into the third day of the fifth week, the exact time of failure would be 174 hours.

8.3 *Reliability Growth (Degradation) Models* — A useful family of reliability growth (degradation) models was developed by the U.S. Army Materials Systems Analysis Activity. These AMSAA models are described in Appendix 2, along with a general test for reliability growth (degradation) trends. Exact time of failure data is needed to test for trends, fit an AMSAA model, and test the fit for adequacy. The failures used to fit the model must occur during productive time (other failures can occur, but these are not used to fit reliability models).

APPENDIX 1
CONFIDENCE BOUND FACTORS

NOTICE: This appendix was approved as an official part of SEMI E10 by full letter ballot procedure. It offers detailed information related to Section 7.

A1-1 Introduction

A1-1.1 E-$MTBF_p$ may be substituted for $MTBF_p$ in all calculations in this section.

A1-1.2 Tables A1-1 and A1-2 contain factors that multiply an $MTBF_p$ point estimate to obtain upper and lower confidence limits. Table A1-1 applies in the common case where the equipment is observed for a fixed period of time and the number of failures that will occur is unknown in advance (time censored data). The alternative is failure censored data, where the number of failures is specified in advance and the equipment is observed until that many failures occur. Table A1-3 contains lower limit factors for failure censored data. Since failure censored data rarely occurs in tool or equipment reliability measurement, Table A1-3 is only included for completeness. The upper limit factors given in Table A1-2 apply to both kinds of censored data.

A1-1.3 Table A1-4 can be used to plan equipment assessment or qualification tests in order to be able to demonstrate a desired $MTBF_p$ at a given confidence level. In order to use Table A1-4, you must first choose a maximum number of failures, *r*, you might observe during the test period and still be able to meet the required $MTBF_p$ objective.

A1-1.4 For reference, here are the formulas for the lower and upper confidence limit factors for time censored data found in Tables A1-1 and A1-2:

$$MTBF_{LOWER} = \frac{2r}{X^2_{2r+2;1-\alpha}} \times MTBF_p$$

$$where\ r = \#\ of\ failures$$

$$MTBF_{UPPER} = \frac{2r}{X^2_{2r;\alpha}} \times MTBF_p$$

A1-1.5 In both cases, the confidence level is 100 × (1 – α) that the true $MTBF_p$ is above $MTBF_{LOWER}$ and below $MTBF_{UPPER}$ and chi square distribution tables are used.

A1-1.6 For 0 fails, use:

$$MTBF_{LOWER} = \frac{productive\ time}{-\log_e \alpha}$$

A1-1.7 Factors to use when there are 0 failures based on this formula are given in the first row of Table A1-1.

A1-1.8 For failure censored data, $MTBF_{UPPER}$ is the same, but the lower limit factor in Table A1-3 is:

$$MTBF_{LOWER} = \frac{2r}{X^2_{2r;1-\alpha}} \times MTBF_p$$

Table A1-1 1-Sided Lower Confidence Bound Factors for the $MTBF_p$ (Time or Cycle Censored Data or Fixed Length Test)

Use for time or cycle censored data to multiply the $MTBF_p$ or MCBF estimate to obtain a lower bound at the given confidence level.
For 0 failures, multiply the operating hours or cycles by the factor corresponding to the desired confidence level.

	CONFIDENCE LEVEL						
# FAILS *r*	60%	70%	80%	85%	90%	95%	97.5%
0	1.091	0.831	0.621	0.527	0.434	0.334	0.271
1	0.494	0.410	0.334	0.297	0.257	0.211	0.179
2	0.644	0.553	0.467	0.423	0.376	0.318	0.277
3	0.718	0.630	0.544	0.499	0.449	0.387	0.342
4	0.763	0.679	0.595	0.550	0.500	0.437	0.391
5	0.795	0.714	0.632	0.589	0.539	0.476	0.429
6	0.817	0.740	0.661	0.618	0.570	0.507	0.459
7	0.834	0.760	0.684	0.642	0.595	0.532	0.485
8	0.848	0.777	0.703	0.662	0.616	0.554	0.508
9	0.859	0.790	0.719	0.679	0.634	0.573	0.527
10	0.868	0.802	0.733	0.694	0.649	0.590	0.544
12	0.883	0.821	0.755	0.718	0.675	0.617	0.572
15	0.899	0.841	0.780	0.745	0.704	0.649	0.606
20	0.916	0.864	0.809	0.777	0.739	0.688	0.647
30	0.935	0.892	0.844	0.816	0.783	0.737	0.700
50	0.953	0.918	0.879	0.856	0.829	0.790	0.759
100	0.969	0.943	0.915	0.897	0.877	0.847	0.822
500	0.987	0.976	0.962	0.954	0.944	0.929	0.916

Table A1-2 1-Sided Upper Confidence Bound Factors for the $MTBF_p$

Use to multiply the $MTBF_p$ estimate to obtain an upper bound at the given confidence level (time censored or failure censored data).

	CONFIDENCE LEVEL						
# FAILS *r*	60%	70%	80%	85%	90%	95%	97.5%
1	1.958	2.804	4.481	6.153	9.491	19.496	39.498
2	1.453	1.823	2.426	2.927	3.761	5.628	8.257
3	1.313	1.568	1.954	2.255	2.722	3.669	4.849
4	1.246	1.447	1.742	1.962	2.293	2.928	3.670
5	1.205	1.376	1.618	1.795	2.055	2.538	3.080
6	1.179	1.328	1.537	1.687	1.904	2.296	2.725
7	1.159	1.294	1.479	1.610	1.797	2.131	2.487
8	1.144	1.267	1.435	1.552	1.718	2.010	2.316
9	1.133	1.247	1.400	1.507	1.657	1.917	2.187
10	1.123	1.230	1.372	1.470	1.607	1.843	2.085
12	1.108	1.203	1.329	1.414	1.533	1.733	1.935
15	1.093	1.176	1.284	1.357	1.456	1.622	1.787
20	1.077	1.147	1.237	1.296	1.377	1.509	1.637
30	1.060	1.115	1.185	1.231	1.291	1.389	1.482
50	1.044	1.085	1.137	1.170	1.214	1.283	1.347
100	1.029	1.058	1.093	1.115	1.144	1.189	1.229
500	1.012	1.025	1.039	1.049	1.060	1.078	1.094

Table A1-3 1-Sided Lower Confidence Bound Factors for the $MTBF_p$ (Failure Censored Data)

Use for failure censored data to multiply the $MTBF_p$ estimate to obtain a lower bound at the given confidence level. Failure censored data means the test or observation period lasts as long as needed to obtain a preset number of failures.

	CONFIDENCE LEVEL						
# FAILS *r*	60%	70%	80%	85%	90%	95%	97.5%
1	1.091	0.831	0.621	0.527	0.434	0.334	0.271
2	0.989	0.820	0.668	0.593	0.514	0.422	0.359
3	0.966	0.830	0.701	0.635	0.564	0.477	0.415
4	0.958	0.840	0.725	0.665	0.599	0.516	0.456
5	0.955	0.849	0.744	0.688	0.626	0.546	0.488
6	0.954	0.856	0.759	0.706	0.647	0.571	0.514
7	0.953	0.863	0.771	0.721	0.665	0.591	0.536
8	0.954	0.869	0.782	0.734	0.680	0.608	0.555
9	0.954	0.874	0.791	0.745	0.693	0.623	0.571
10	0.955	0.878	0.799	0.755	0.704	0.637	0.585
12	0.956	0.886	0.812	0.771	0.723	0.659	0.610
15	0.958	0.895	0.828	0.790	0.745	0.685	0.639
20	0.961	0.906	0.846	0.812	0.772	0.717	0.674
30	0.966	0.920	0.870	0.841	0.806	0.759	0.720
50	0.971	0.935	0.896	0.872	0.844	0.804	0.772
100	0.978	0.952	0.923	0.906	0.885	0.855	0.830
500	0.989	0.978	0.964	0.956	0.945	0.930	0.918

Table A1-4 Test Length Guide

Use to determine the test time needed to demonstrate a desired $MTBF_p$ at a given confidence level if *r* failures occur. Multiply the desired $MTBF_p$ by the *k* factor corresponding to *r* and the confidence level.

	k FACTOR FOR GIVEN CONFIDENCE LEVELS					
# FAILS *r*	50%	60%	75%	80%	90%	95%
0	0.693	0.916	1.39	1.61	2.30	3.00
1	1.68	2.02	2.69	2.99	3.89	4.74
2	2.67	3.11	3.92	4.28	5.32	6.30
3	3.67	4.18	5.11	5.52	6.68	7.75
4	4.67	5.24	6.27	6.72	7.99	9.15
5	5.67	6.29	7.42	7.90	9.28	10.51
6	6.67	7.35	8.56	9.07	10.53	11.84
7	7.67	8.38	9.68	10.23	11.77	13.15
8	8.67	9.43	10.80	11.38	13.00	14.43
9	9.67	10.48	11.91	12.52	14.21	15.70
10	10.67	11.52	13.02	13.65	15.40	16.96
15	15.67	16.69	18.48	19.23	21.29	23.10
20	20.68	21.84	23.88	24.73	29.06	30.89