horizontal dimensions. Furthermore, none of these packages may weigh more than *Mm* each. This paragraph does not apply to stockers and AMHS transport equipment.

5.4.2 *Recommendations* — Equipment suppliers and device manufacturers might also consider carrier stocker size, move-in timing, and move-in path during stocker and facility design. Equipment that conforms to these limits may still be too large to fit into standard truck trailers or aircraft cargo bays.

5.5 *Maintenance Access*

5.5.1 *Requirements* — To avoid interfering with carrier transport systems, equipment must not require regularly scheduled maintenance from the front. This requirement does not apply to maintenance performed on user interfaces, cart-docking interfaces, load ports, carrier buffers, and load locks.

5.5.2 *Recommendations* — It is recommended that as little regularly scheduled maintenance as possible be required from the side.

5.6 *Width vs. Depth*

5.6.1 *Recommendations* — In general, to minimize the number of bays required in a fab, it is recommended that equipment be designed to minimize width rather than depth.

5.7 *Linked Equipment*

5.7.1 *Recommendations* — To make linked equipment (such as cluster tools or steppers with litho tracks) jointly space efficient, it is recommended that they be designed to minimize the cost footprint of the entire system as a whole.

6 Related Documents

6.1 *SEMI Standards*

SEMI E6 — Facilities Interface Specifications Guideline and Format

SEMI E26.1 — Radial Cluster Tool Footprint 300 mm Standard

SEMI E35 — Cost of Ownership for Semiconductor Manufacturing Equipment Metrics

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

SEMI S2 — Safety Guidelines for Semiconductor Manufacturing Equipment

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

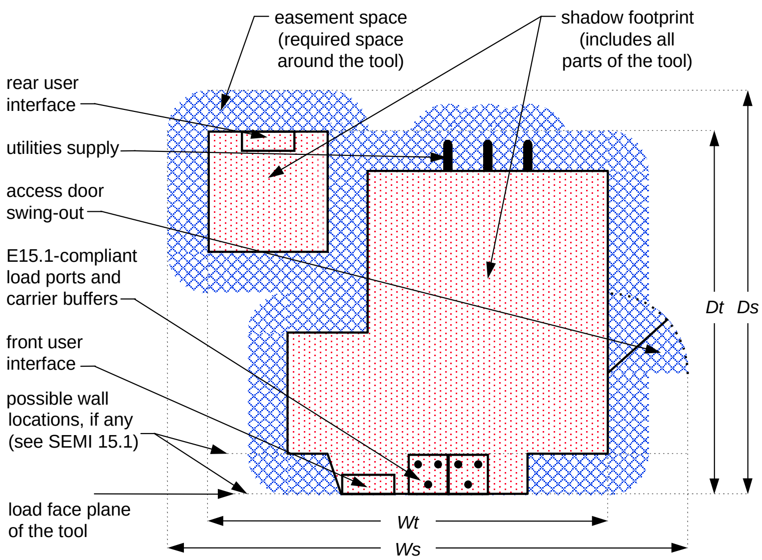

Figure 1
Equipment Footprint Dimensions

Table 1 Equipment Footprint, Height, and Weight Dimensions

Symbol Used	*Value Specified*	*Dimension Description*
H	3.5 m (11 ft. 5 in.) maximum	height of equipment in the main fab
Hs	2 m (6 ft. 6 in.) maximum	height of equipment in the sub-fab
M	1500 kg/m^2 (2.1 lbm./in.^{2}) maximum	mass of equipment divided by its shadow footprint
Mm	6000 kg (13227 lbm.) maximum	mass of equipment move-in packages
Mt	1000 kg (2204 lbm.) maximum	mass of equipment on any 0.6 m by 0.6 m (2 ft. by 2 ft.) floor tile
X	2.2 m (7 ft. 2 in.) maximum	Length (perpendicular to Y) of equipment move-in packages destined for the main fab
Xs	2 m (6 ft. 6 in.) maximum	Length (perpendicular to Ys) of equipment move-in packages destined for the sub-fab
Y	2.8 m (9 ft. 2 in.) maximum	Length (perpendicular to X) of equipment move-in packages destined for the main fab
Ys	1.7 m (5 ft. 6 in.) maximum	Length (perpendicular to Xs) of equipment move-in packages destined for the sub-fab
Z	2.8 m (9 ft. 2 in.) maximum	Height of equipment move-in packages destined for the main fab
Zs	2 m (6 ft. 6 in.) maximum	Height of equipment move-in packages destined for the sub-fab

RELATED INFORMATION 1
APPLICATION NOTES

NOTICE: This related information is not an official part of SEMI E72 but was approved for publication by full letter ballot procedures.

R1-1 The maximum height of equipment in the main fab was set so that the equipment could be installed in existing fabs with ceilings just above the equipment height of 3.5 m (11 ft. 5 in) or in fabs with ceiling heights of 3.66 m (12 ft. 0 in.) where more clearance is provided for such things as parts of some overhead carrier transport systems, fire sprinkler systems at the ceiling, and/or extra room for installation of equipment.

R1-2 The maximum height of equipment in the sub-fab was set so that no part of the equipment (other than connections to the main fab area) sticks up into the piping and duct-work immediately under the waffle slab. In those cases where a part of the equipment must be taller than 2 m (6 ft. 6 in.), it is recommended that it not be taller than 2.5 m (8 ft. 2 in.) to stay under the waffle slab.

R1-3 If equipment must have easement space on the side, it is recommended that they be designed in mirror-image configurations with easement space needed on only one side or the other, so that half of the total easement space on the sides can be deleted. However, it is recommended that the resulting increase in equipment cost, complexity, and spare parts inventory be taken into account.

R1-4 Equipment that conforms to the limits given in this standard may be too large or heavy to fit into buildings that were originally designed for equipment that processes smaller wafers.

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 or equipment mentioned herein. These standards are subject to change without notice.

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SEMI E73-0301
SPECIFICATION FOR VACUUM PUMP INTERFACES - DRY PUMPS

This specification was technically approved by the Global Physical Interfaces & Carriers Committee and is the direct responsibility of the Japanese Physical Interfaces & Carriers Committee. Current edition approved by the Japanese Regional Standards Committee on December 1, 2000. Initially available at www.semi.org January 2001; to be published March 2001. Originally published June 1998; previously published February 1999.

1 Purpose

1.1 This standard specifies the physical and electrical interfaces for dry pump (DRP) type vacuum pumps. Standardization of pump interfaces will allow for interchangeability of pumps. Device manufacturers use this standard when procuring processing equipment to specify to the equipment supplier the interface required for interchangeability of pumps. This document is also used by semiconductor processing equipment suppliers to specify standardized interfaces to pump suppliers.

2 Scope

2.1 This standard applies to vacuum pumps supplied with 300 mm semiconductor processing equipment.

2.2 The standard specifies the mechanical and electrical interfaces for dry pumps including the following.

- Mechanical connectors
- Control signals and connector
- Power supply and connector

2.3 Figure 1 shows the scope of the standardized interface.

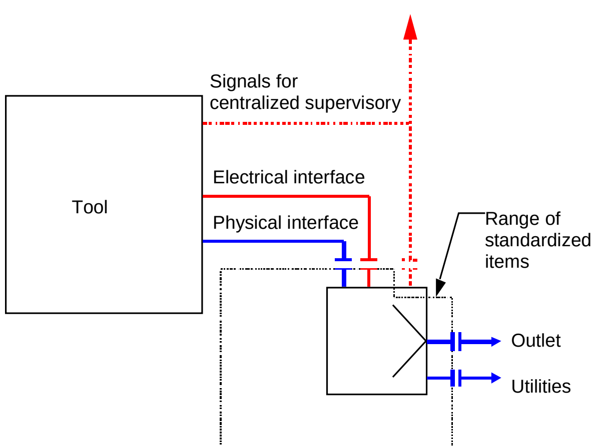

Figure 1
Scope of Standardized Interface

2.4 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 limitations prior to use.

3 Limitations

3.1 This guide is not intended to dictate how to build a vacuum pump but to specify interfaces that will allow for interchangeabilty of individual pumps.

3.2 This standard does not include specifications for sensor-bus compliant interfaces.

3.3 This standard is not intended to address design issues related to safety considerations and containment issues which are addressed elsewhere in the SEMI guidelines.

3.4 International, national, and local codes, laws, and regulations should be consulted to ensure that the equipment meets regulatory requirements in each location of use.

4 Referenced Standards

NOTE 1: As listed or revised, all documents cited shall be the latest publications of adopted standards.

4.1 *SEMI Documents*

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

4.2 *ISO Documents*[1]

ISO 7-1 — Pipe threads where pressure-tight joints are made on the threads - Part 1: Dimensions, tolerances and designation

ISO 1609 — Vacuum Technology - Flange dimensions

ISO 2861-1 — Vacuum technology - Quick-release couplings - Dimensions - Part 1: Clamped type

5 Terminology

5.1 *dry pump (DRP)* — Dry pumps are a type of mechanical vacuum pump. Dry pumps can work at

1 International Organization for Standardization, C.P. 56 CH-1211 Geneva 20, Switzerland

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atmospheric pressure. They are called dry pumps because no liquid sealing materials are used on any surface contacted by gases. Hereafter, the term “DRP” is substituted for “dry pump”.

5.2 *pump alarm* — A cautionary signal that the pump has stopped.

5.3 *pump warning* — A state of an abnormal or extraordinary event during pump operation which means there is a probability the pump will stop.

5.4 *vacuum pump* — A pumping apparatus which exhausts gas or air from an enclosed space to achieve a desired degree of vacuum.

6 Requirements

6.1 *Mechanical Interfaces* — Table 1 specifies the required DRP connector type and size by flange/port.

Table 1 Mechanical Connectors

No.	*Items*		*Connector Type*	*Connector Size*	*Referenced Standard*	*Remarks*
1	Inlet flange	Nominal bore 50 mm or less	ISO KF flange	≤ 50 mm Connector dimensions should be based on the referenced standard	ISO 2861-1	A port flange which connects the pump to a process tool to evacuate gases.
		Nominal bore over 63 mm size	ISO clamped flange	≥ 63 mm Connector dimensions should be based on the referenced standard	ISO 1609	
2	Outlet flange		ISO KF flange	Connector dimensions should be based on the referenced standard	ISO 2861-1	A port flange which connects the pump to the facility evacuation system.
3	Duct port (Option)		Not specified	50 mm or 100 mm diameter port		Port to connect duct for evacuating flames inside the pump.
4	Purge gas port		Compression type*	1/4" Connector		A connection port used to supply inert gas, typically N_2, to the pump. The purge gas protects the inside of the pump from corrosion due to process gases.
5	Cooling water port		ISO taper pipe thread (female on pump side)	1/4" or 3/8"	ISO 7-1	A connection port to supply water used to keep the pump cool.

* For example Swagelock®

6.2 *Electrical Interfaces*

6.2.1 *Control Signals*

6.2.1.1 Table 2 specifies the required DRP control signals. Table 3 and Figure 2 specify the required response time for DRP control signals. Table 4 specifies the required power and contacts for DPR control signals. Tables 5 and 6 and Figure 3 specify the required connector and pin assignments for DRP control signals.

Table 2 I/O Signals

No.	*Signal Name*	*Direction*	*Type*		*Remarks*
1	Start (Run)/Stop	Input signal to Pump	Alternate	Pump runs when closed	
2	Start (Run)/Stop	Output signal from Pump	Alternate	Close on pump start	Running status signals When input power is OFF, output status signals should become open (normally open).
3	Remote/Local	Output signal from Pump	Alternate	Close during remote operation	
4	Pump Warning	Output signal from Pump	Alternate	Open at warning	
5	Pump Alarm	Output signal from Pump	Alternate	Open at alarm	

Table 3 Response Time for Signals

No.	*Items*	*Acceptable Response Time*	*Remarks*
1	Input Power ON	Under 10 seconds After input power turns on	Objects: All status signals shall be ready.
2	Control Signals	Under 2 seconds After receiving a signal	See Figure 2 Objects: a) Start signal (input) ->> Start status (output) b) Stop signal (input) ->>Stop status (output)

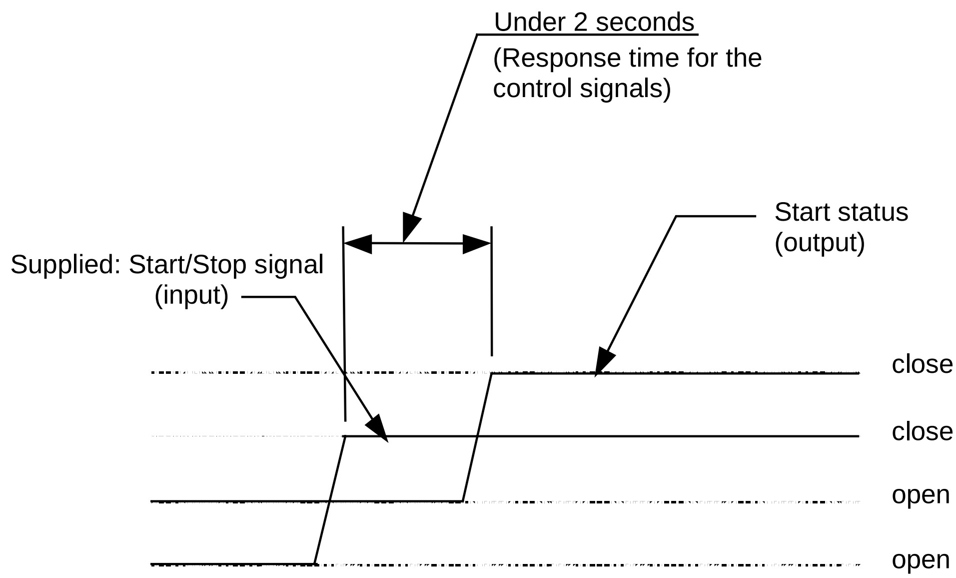

Figure 2
Example of Response Time for Start Signal and Start Status

Table 4 Signal Power and Contacts

No.	*Items*	*Power*		*Remarks*
1	Signal power supply	Input signals to DRP (Control signal)	Input signals shall be driven by the DC power supply in DRP.	Example: See Figure 4. a) Photocoupler Input. b) Relay Input.
		Output signals from DRP (Running status signal)	Output signals shall be driven by DC power supply in tools.	Example: See Figure 5. a) To photocoupler unit. b) To relay unit. c) To TTL unit.
2	Signal power supply voltage	Signal power supply voltage is between 5 V_{DC} and 24 V_{DC}		
3	Acceptable range of signal power supply voltage	Acceptable voltage range is 4 V_{DC} minimum, and 30 V_{DC} maximum.		
4	Running status signal contact	Dry contact or open collector	Acceptable current 100 mA maximum.	

Table 5 Control Signal Connector (pump side)

No.	*Items*	*Connector Type*	*Referenced Standard*	*Pin Assignments*	*Remarks*
1	Control and running status signals	15 pin D sub-miniature Female receptacle		See Table 6 and Figure 3	See Related Documents for an example of the specifications for this connector type.

Table 6 Pin Assignment for Control Signal Connector

No.	*Pin No.*	*Signal item (polarity)*	*Remarks*
1	1	DRP start input (+)	
2	2	(MBP start input) (+)	An upper pump, such as mechanical booster pump (MBP), to be used with dry pump systems.
3	3	DRP start/stop status (+)	
4	4	(MBP start/stop status) (+)	An upper pump, such as mechanical booster pump (MBP), to be used with dry pump systems.
5	5	Warning status (+)	
6	6	Alarm status (+)	
7	7	Remote/Local status (+)	
8	8		
9	9	DRP start input (-)	
10	10	(MBP start input) (-)	An upper pump, such as mechanical booster pump (MBP), to be used with dry pump systems.
11	11	DRP start/stop status (-)	
12	12	(MBP start/stop status) (-)	An upper pump, such as mechanical booster pump (MBP), to be used with dry pump systems.
13	13	Warning status (-)	
14	14	Alarm status (-)	
15	15	Remote/Local status (-)	
16	-		

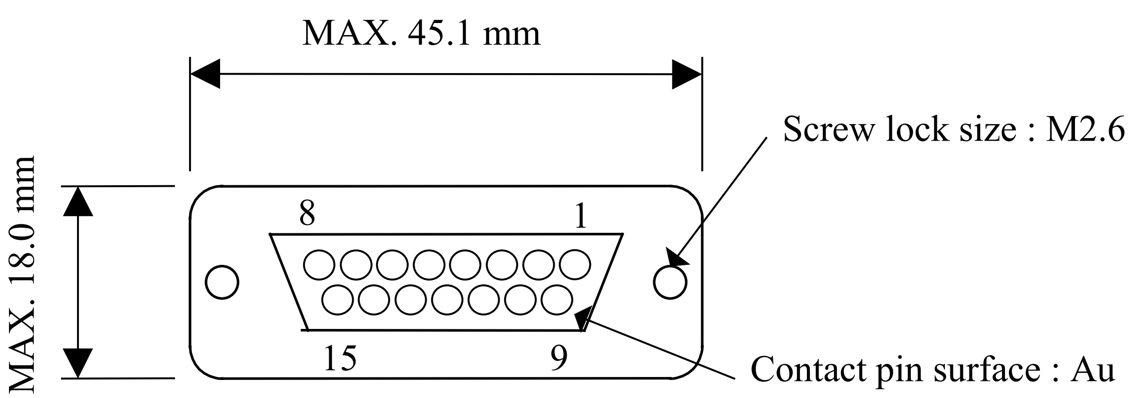

Figure 3
15 pin D Sub-Miniature Female Receptacle

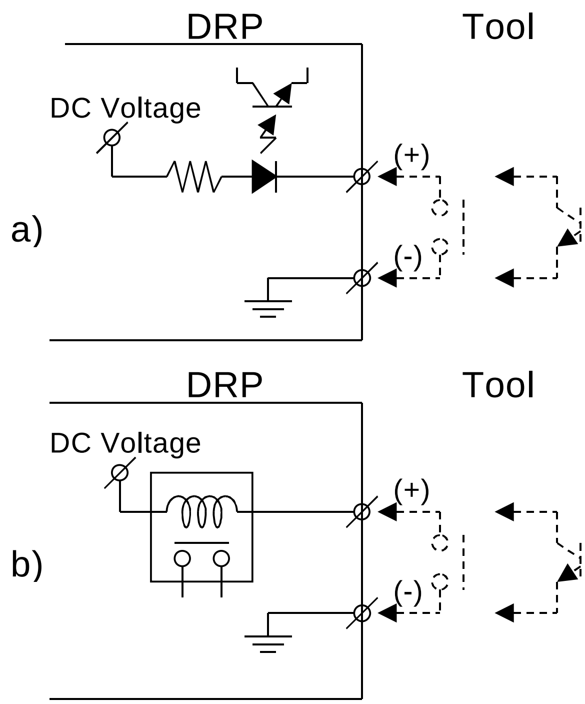

Figure 4
Schematic Example of DRP Input Signals

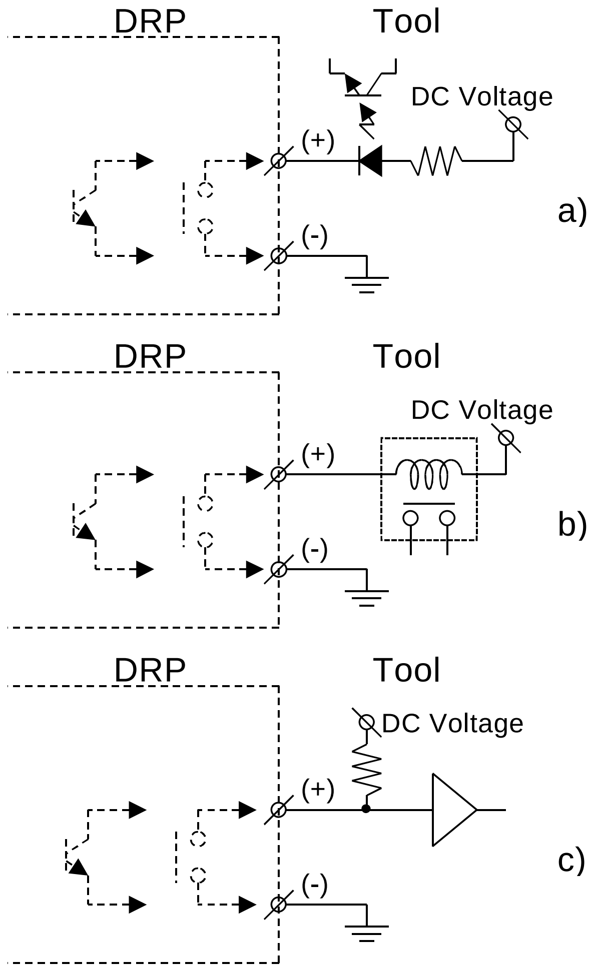

Figure 5
Schematic Example of DRP Output Signals

6.3 *Incoming Power Supply*

6.3.1 Tables 7 and 8 specify the required DRP incoming AC power supply connector and pin assignments.

Table 7 Incoming AC Power Supply Connector (Pump Side)

No.	*Items*	*Connector Type*	*Referenced Standard*	*Pin Assignments*	*Remarks*
1	Three phase: $200V_{AC} – 230V_{AC} \pm 10\%$ 50/60 Hz	Receptacle (male)	SEMI S2	See Table 8	

Table 8 Pin Assignment for Incoming Power Supply Connector

No.	*Pin No.*	*Item*		*Remarks*
1	1 or A	R	AC 3 phase	U
2	2 or B	S		V
3	3 or C	T		W
4	maximum or last pin number in the connector	Earth/Ground		When using a connector that has a special grounding pin not included in the standard pin arrangement, the last pin becomes a blank pin. (See Related Documents for an example of specification for this connector.)

7 Related Documents

NOTE 2: As listed or revised, all documents cited shall be the latest publications of adopted standards.

7.1 *DIN Standard*[2]

DIN VDE 0627 — Connectors and plug-and socket devices; for rated voltages up to 1000 V a.c., up to 1200 V d.c. and rated currents up to 500 A for each pole

7.2 *Military Standard*[3]

MIL-PRF-24308 — General Specification for Connectors, Electric, Rectangular, Non-Environmental, Miniature, Polarized Shell, Rack and Panel

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 or equipment mentioned herein. These standards are subject to change without notice.

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2 Deutsches Institut für Normung e.V., Beuth Verlag GmbH Burggrafenstrasse 4-10, D-10787 Berlin, Germany

3 Military Standards, Naval Publication and Form Center, 5801 Tabor Avenue, Philadelphia, PA 19120

RELATED INFORMATION 1
APPLICATION NOTES

NOTE: This related information is not an official part of SEMI E73 and is not intended to modify or supercede the official standard. This related information is optional and contains information that is not required to conform to this standard.

NOTE 1: While this standard was developed to specify vacuum pumps installed with 300 mm equipment, the standard should also be applied to vacuum pumps installed with 200 mm equipment.

NOTE 2: Signal items for centralized supervisory diagnostics and maintenance could not be standardized, because they are not consistent or technically well-established. Additional work is required for standardization of these signals.

NOTE 3: In order to save space and reduce cost, the connector for the control and running status signals should be the minimum size required for the number of pins specified in the standard. If additional signal connections are required, another connector should be added to the pump.

NOTE 4: Utilizing a 200 VAC system (range: 200 to 230 VAC) rather than a 400 VAC system (range: 380 to 480 VAC) can lower costs associated with manufacturing and purchasing pumps. To help minimize pump costs, this standard incorporates AC supply voltages in the range of 200 to 230 VAC. Many 400 VAC systems are now in use and may be more widespread in the future. However, standardizing on supply voltage of 200 VAC can reduce pump costs now without complications as long as pump manufactures accommodate customers requesting 400 VAC units.

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 or equipment mentioned herein. These standards are subject to change without notice.

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SEMI E74-0301
SPECIFICATION FOR VACUUM PUMP INTERFACES - TURBOMOLECULAR PUMPS

This specification was technically approved by the Global Physical Interfaces & Carriers Committee and is the direct responsibility of the Japanese Physical Interfaces & Carriers Committee. Current edition approved by the Japanese Regional Standards Committee on December 1, 2000. Initially available at www.semi.org January 2001; to be published March 2001. Originally published June 1998; previously published February 1999.

1 Purpose

1.1 This standard specifies the physical and electrical interfaces for turbomolecular pump (TMP) type vacuum pumps. Standardization of pump interfaces will allow for interchangeability of pumps. Device manufacturers use this standard when procuring processing equipment to specify to the equipment supplier the interface required for interchangeability of pumps. This document is also used by semiconductor processing equipment suppliers to specify standardized interfaces to pump suppliers.

2 Scope

2.1 This standard applies to vacuum pumps supplied with 300 mm semiconductor processing equipment.

2.2 The standard specifies the mechanical and electrical interfaces for turbomolecular pumps, including the following:

- Mechanical connectors and locations
- Control signals and connector
- Power supply and connector

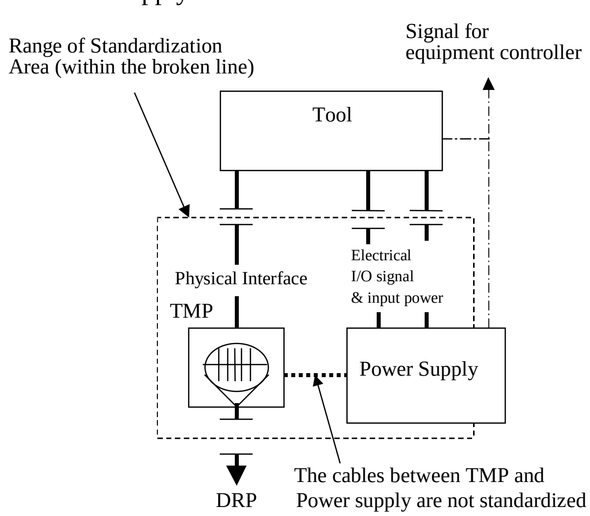


Figure 1
Scope of Standardized Interface

2.3 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 limitations prior to use.

3 Limitations

3.1 This standard is not intended to dictate how to build a vacuum pump, but to specify interfaces that will allow for interchangeability of individual pumps.

3.2 This standard does not include specifications for sensor-bus compliant interfaces.

3.3 This standard is not intended to address design issues related to safety considerations and containment issues which are addressed elsewhere in the SEMI guidelines.

3.4 International, national and local codes, regulations and laws should be consulted to ensure that the equipment meets regulatory requirements in each location of use.

3.5 This standard does not apply to turbomolecular pumps less than 300 l/s or greater than 3000 l/s. Pumps less than 300 l/s are too small and pumps greater than 3000 l/s pumps are not commonly used.

3.6 Double flow turbomechanical pumps are excepted from this standard, because their shapes and structures are different from turbomolecular pumps to be applied this standard.

4 Referenced Standards

4.1 *SEMI Standard*

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

4.2 *ISO Documents*[1]

ISO 7-1 — Pipe threads where pressure-tight joints are made on the threads - Part 1: Dimensions, tolerances and designation

1 International Organization for Standardization, C.P. 56 CH-1211 Geneva 20, Switzerland

ISO 1609 — Vacuum Technology - Flange dimensions

ISO 2861-1 — Vacuum technology - Quick-release couplings - Dimensions - Part 1: Clamped type

NOTE 1: As listed or revised, all documents cited shall be the latest publications of adopted standards.

5 Terminology

5.1 *pump alarm* — A cautionary signal that the pump has stopped or is to be stopped.

5.2 *pump warning* — A state of an abnormal or extraordinary event during pump operation which means there is a probability the pump will stop.

5.3 *turbomolecular pump (TMP)* — Equipment used to create a high vacuum. Rapidly rotating blades force molecules to the bottom for removal by a mechanical pump.

5.4 *Vacuum Pump* — A pumping apparatus which exhausts gas or air from an enclosed space to achieve a desired degree of vacuum.

6 Requirements

6.1 *Mechanical Interfaces*

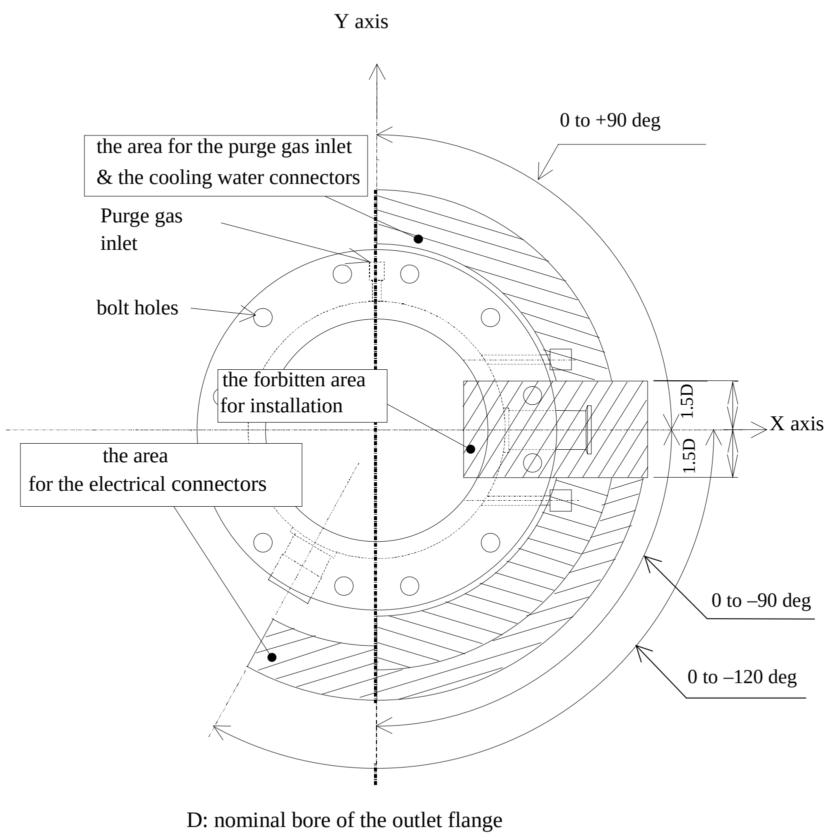
6.1.1 Table 1 specifies the required TMP connector type and size by flange/port. Axial orientation and position of the connectors are specified in Table 2 and Figure 2. Port and connector positions shall be at the periphery of the pump. Put inlet port on the *z*-axis and the outlet port on the *x*-axis. Other connector locations are specified by the angle between the *x*-axis and the center of the connector.

Table 1 Mechanical Connectors

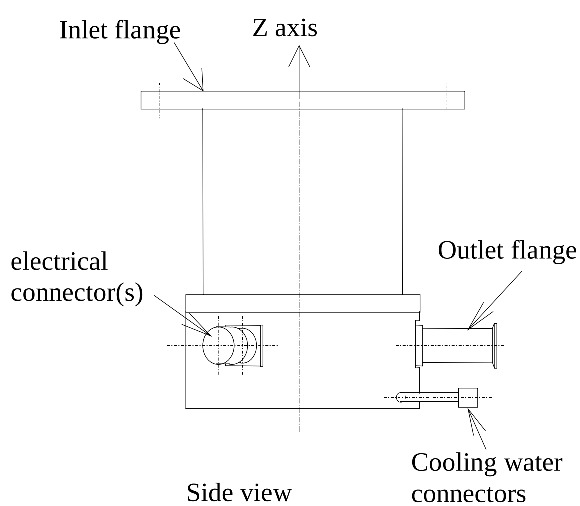
No.	*Items*	*Connector Type*	*Connector Size*	*Referenced Standard*	*Remarks*
1	Inlet flange	ISO bolted flange	Connector dimensions should be based on the referenced standard	ISO 1609	A port flange which connects the pump to a process tool to evacuate gases.
2	Outlet flange	ISO KF flange	Connector dimensions should be based on the referenced standard	ISO 2861-1	A port flange which connects the pump to the DRP (Dry Pump).
3	Purge gas port	ISO KF flange	Size 10 or 16 connector	ISO 2861-1	A connection port used to supply inert gas, typically N_2, to the pump. The purge gas protects the inside of the pump from corrosion due to process gases.
4	Cooling water port	ISO taper pipe thread (female on pump side)	1/4" or 3/8"	ISO 7/1	A connection port to supply water used to keep the pump cool.

Table 2 Connector Locations

No.	*Items*	*Connector Location*	*Connector Angle (degrees)*	*Remarks*
1	Inlet flange	*z*-axis		Flange bolt holes shall be symmetrically located at equal distance from the center line of the outlet flange.
2	Outlet flange	transverse	0°	
3	Purge gas port	transverse	- 90° to + 90°	The forbidden area shall be symmetrically located at equal distances from the center of the outlet flange. Distance from the *x*-axis shall be more than 1.5 times the nominal bore of the outlet flange.
4	Cooling water port	transverse	- 90° to + 90°	
5	Electrical connections	transverse	0° to -120°	
6	Other ports	transverse	- 90° to + 90°	



Top view



Side view

Figure 2
Connector Locations

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6.2 *Electrical Interfaces*

6.2.1 *Control Signals*

6.2.1.1 Table 3.1 specifies the required TMP control signals. In cases where TMP are backed up by battery or regeneration power while input power failure, the status of output signals follows Table 3.2. Table 4 and Figure 3 specify the required response time for TMP control signals. Table 5 specifies the required power and contacts for TMP control signals. Tables 6 and 7 and Figure 4 specify the required connector and pin assignments for TMP control signals.

Table 3.1 I/O Signals

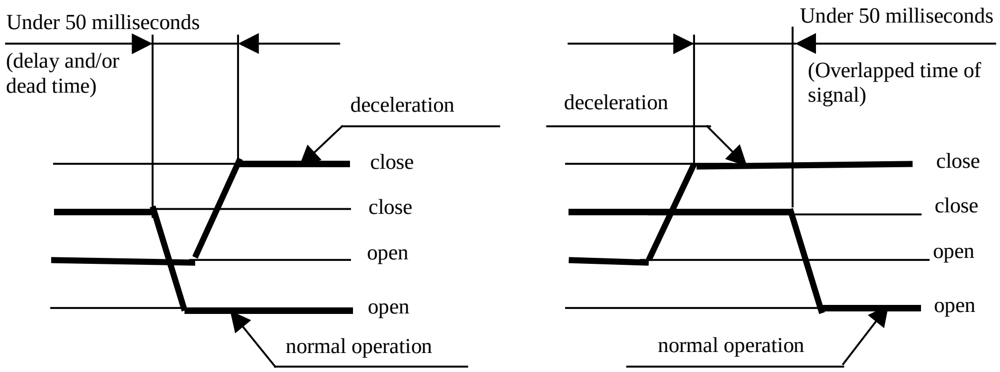
No.	*Signal Name*	*Direction*	*Type*		*Remarks*
1	Start (Run)/Stop	Input signal to Pump	Alternate	Pump runs when closed	
2	Acceleration	Output signal from Pump	Alternate	Close during acceleration	Running status signals When input power is OFF, output status signals should become open (normally open).
3	Normal operation	Output signal from Pump	Alternate	Close during normal operation	
4	Deceleration	Output signal from Pump	Alternate	Close during deceleration	
5	Remote/Local	Output signal from Pump	Alternate	Close during remote operation	
6	Pump Alarm	Output signal from Pump	Alternate	Open at alarm	

Table 3.2 Status of output signals during back up operation mode

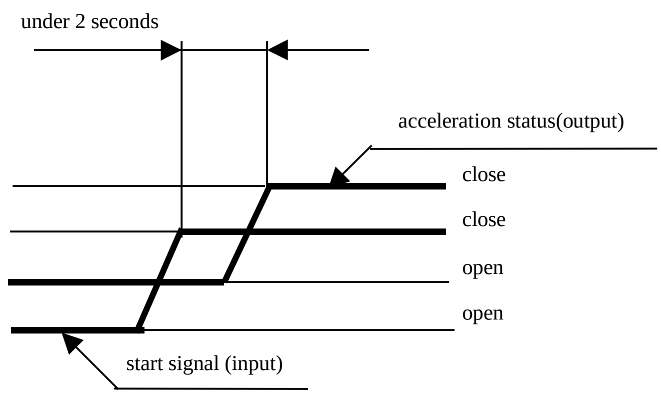
Status of pump	*Signal Name*	*Status of signals*
During back up operation mode	Acceleration	Open
	Normal operation	Open
	Deceleration	Close
	Remote/Local	Close during remote operation
	Pump alarm	Open

Table 4 Response Time and Timing for Signals

No.	*Items*		*Acceptable Response Time*	*Remarks*
1	Response Time	Input Power ON	Under 10 seconds After input power turns on	Objects All status signals shall be ready.
2		Control Signals	Under 2 seconds After receiving a signal	Objects Start signal (input) ->> Acceleration (output) Stop signal (input) ->> Deceleration (output)
3	Timing	Running status signals	Under 50 milliseconds Acceptable delay and/or dead time in a moment of shift of the running status Under 50 milliseconds Acceptable overlapped time in a moment of shift of the running status	Objects (Example) Normal ->> Deceleration The running status signals of alarm and remote/local can be overlapped with other signals.



Timing for the running status signals



Response Time and Timing for Control Signals

Figure 3
Response Time and Timing for Control Signals

Table 5 Signal Power and Contacts

No.	*Items*	*Power*		*Remarks*
1	Signal power supply	Input signals to TMP (Control signal)	Input signals shall be driven by DC power supply in TMP.	Example: See Figure 5. a) Photocoupler Input. b) Relay Input.
		Output signals from TMP (Running status signal)	Output signals shall be driven by DC power supply in tools.	Example: See Figure 6. a) To photocoupler unit. b) To relay unit. c) To TTL unit.
2	Signal power supply voltage	Signal power supply voltage is between 5 V_{DC} and 24 V_{DC}		
3	Acceptable range of signal power supply voltage	Acceptable voltage range is 4 V_{DC} minimum and 30 V_{DC} maximum.		
4	Running status signal contact	Dry contact or open collector	Acceptable current 100 mA maximum.	

Table 6 Control Signal Connector (Pump Side)

No.	*Items*	*Connector Type*	*Referenced Standard*	*Pin Assignments*	*Remarks*
1	Control and running status signals	15 pin D sub-miniature Female receptacle		See Table 7 and Figure 4	(See Related Documents for an example of the specification for this connector type.)

Table 7 Pin Assignment for Control Signal Connector

No.	*Pin No.*	*Signal item (polarity)*	*Remarks*
1	1	Start/Stop input (+)	
2	2		
3	3	Acceleration status (+)	
4	4	Normal status (+)	
5	5	Deceleration status (+)	
6	6	Alarm status (+)	
7	7	Remote/Local status (+)	
8	8		
9	9	Start/Stop input (-)	
10	10		
11	11	Acceleration status (-)	
12	12	Normal status (-)	
13	13	Deceleration status (-)	
14	14	Alarm status (-)	
15	15	Remote/Local status (-)	

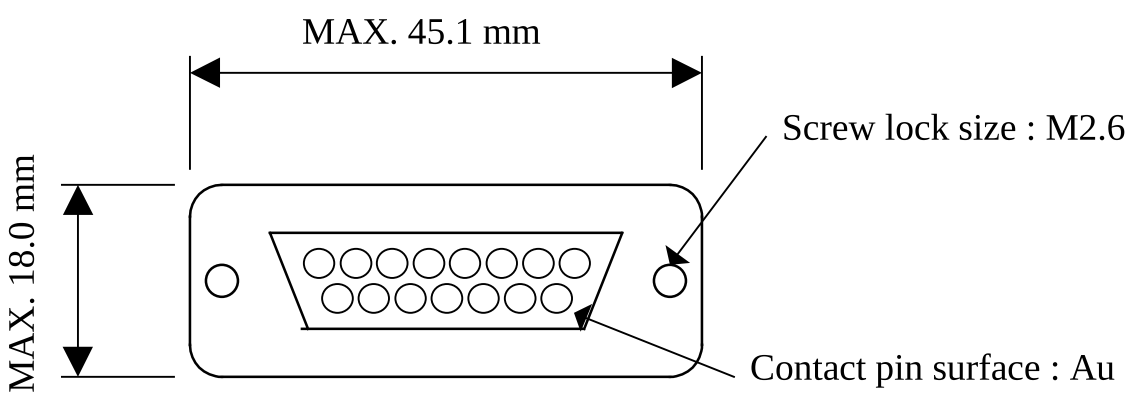


Figure 4
15 pin D sub-Miniature Female Receptacle

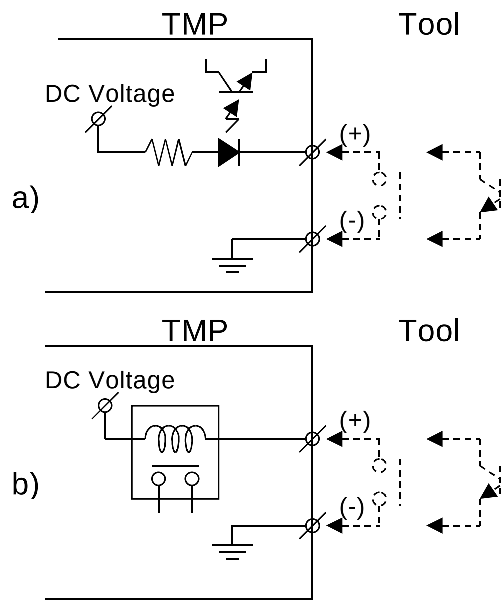


Figure 5
Schematic Example of TMP Input Signals

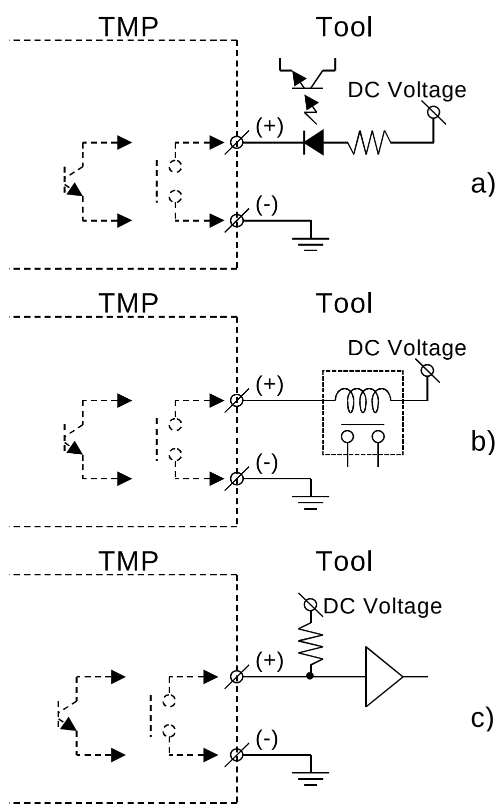


Figure 6
Schematic Example of TMP Output Signals

6.3 *Incoming Power Supply*

6.3.1 Table 8 and Table 9 specify the required TMP incoming AC power supply connector and pin assignments.

Table 8 Incoming AC Power Supply Connector (pump side)

No.	*Items*	*Connector Type*	*Referenced Standard*	*Pin Assignments*	*Remarks*
1	Single phase, $200V_{AC} - 230V_{AC}$ ± 10% 50/60 Hz	Receptacle (male)	SEMI S2	See Table 9	

Table 9 Pin Assignment for Incoming Power Supply Connector

No.	*Pin No.*	*Item*		*Remarks*
1	1 or A	Hot	AC single phase	
2	2 or B	Cold		
3	maximum or last pin number in the connector	Earth/Ground		When using a connector that has a special grounding pin not included in the standard pin arrangement, the last pin becomes a blank pin. (See Related Documents for an example of specification for this connector.)

7 Related Documents

NOTE 2: All documents cited will be the latest published versions.

7.1 *DIN Standard*[2]

DIN VDE 0627 — Connectors and plug-and-socket devices; for rated voltages to 1000 V_{AC}, up to 1200 V_{DC}, and rated currents up to 500 A for each pole

7.2 *Military Standard*[3]

MIL-PRF-24308 — General Specification for Connectors, Electric, Rectangular, Non-Environmental, Miniature, Polarized Shell, Rack, and Panel

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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2 Deutsches Institut für Normung e.V., Beuth Verlag GmbH Burggrafenstrasse 4-10, D-10787 Berlin, Germany

3 Military Standards, Naval Publication and Form Center, 5801 Tabor Avenue, Philadelphia, PA 19120

RELATED INFORMATION 1
APPLICATION NOTES

NOTE: This related information is not an official part of SEMI E74 and is not intended to modify or supercede the official standard. This related information is optional and contains information that is not required to conform to this standard.

NOTE 1: While this standard was developed to specify vacuum pumps installed with 300 mm equipment, the standard should also be applied to vacuum pumps installed with 200 mm equipment.

NOTE 2: ICF flange is available on request for inlet flange.

NOTE 3: In order to save space and reduce cost, the connector for the control and running status signals should be a minimum size required for the number of pins specified in the standard. If the additional signal connections are required another connector should be added to the pump.

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SEMI E76-0299
GUIDE FOR 300 mm PROCESS EQUIPMENT POINTS OF CONNECTION TO FACILITY SERVICES

This Guide was technically approved by the Global Facilities Committee and is the direct responsibility of the North American Facilities Committee. Current edition approved by the North American Regional Standards Committee on August 15, 1998. Initially available at www.semi.org January 1999; to be published February 1999. Originally published September 1998.

This document replaces E76-0998 in its entirety.

1 Purpose

1.1 Factory design variations make it difficult for equipment manufacturers to predict or agree on consistent points of connection for hookup of equipment to facility services. Similarly, device manufacturers cannot easily pre-facilitate their factories for equipment because the connections on the equipment are not consistently located. Standardization of connection locations and utilizing pre-facilitation strategies decreases the cost of and time required for equipment installation.

1.2 This document is a guide for 300 mm equipment manufacturers to define the positioning of the equipment points of connection (EPOC), required on semiconductor processing equipment for hookup to facility utility services. The document identifies locations for the EPOC's and provides EPOC consistency recommendations that should allow for efficient equipment installation. In addition, this document defines strategies to support the device manufacturer's ability to pre-facilitate the utility point of connection (UPOC). Recommendations for supplier-provided EPOC documentation are also included.

2 Scope

2.1 This guide addresses three areas that are necessary to improve the efficiency of and reduce the duration of equipment installations.

a) Recommendations for EPOC location, grouping, consistency and reduction to increase confidence in the accuracy and repeatability of EPOC's, and reduce the amount of work required to hookup equipment. As a result, device manufacturers can employ standard pre-facilitation strategies and increase the efficiency of equipment installation.

b) Pre-facilitation recommendations that provide the ability for UPOC's to be efficiently and accurately installed prior to equipment delivery, thus allowing immediate hook-up of the equipment upon arrival in the wafer fab. This includes recommendations for jigs, templates, mating pedestal bases, and associated interface panels.

c) Documentation recommendations to be required by the device manufacturer and provided by the equipment supplier relative to EPOC location, group, consistency, pre-facilitation strategies and hardware. This includes additional documentation recommended to support equipment installations but not directly related to EPOC's.

2.2 This guide applies to 300 mm semiconductor processing equipment and any supplier-provided support equipment for installation into new factories.

2.3 The following groups of utilities are covered in this guide.

- Electrical Power
- Data communications
- Exhaust and other process effluents
- Process fluids (liquids and gases)
- Support equipment interconnects

2.4 The primary focus for this guide is hookup of semiconductor processing equipment including but not limited to the following equipment types.

- Etch equipment (Dry and Wet)
- Film deposition equipment (CVD, PVD and Plating)
- Thermal equipment
- Surface prep and clean
- Photolithography equipment (Stepper and Tracks)
- Chemical Mechanical Polishing equipment
- Ion Implant equipment
- Metrology equipment

3 Limitations

3.1 This standard does not apply to assembly and test equipment.

3.2 International, national, and local codes, regulations and laws should be consulted to ensure that the equipment meets regulatory requirements in each location.

3.3 This guide is not intended to address design issues related to safety. Safety issues are addressed in other SEMI standards (See SEMI S2).

4 Referenced Documents

4.1 *SEMI documents*

SEMI E6 — Facilities Interface Specifications Guideline and Format

SEMI S2 — Safety Guideline for Semiconductor Manufacturing Equipment

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

5 Terminology

5.1 *bottom feed* — Equipment utility supply lines enter the equipment from its underside typically through the floor.

5.2 *equipment configuration* — Specifically, the arrangement, location, type and quantity of EPOC's needed for installation. Also know as tool configuration.

5.3 *equipment point of connection (EPOC)* — A fitting or other terminal provided with the processing equipment (either external or internal) for utility connection, the equipment end/termination of the hookup. Also know as tool point of connection.

5.4 *external connection* — An external connection is located outside the main frame of equipment.

5.5 *facilities interface specification* — Documentation provided by an equipment supplier that contains the equipment requirements for utilities and installation [SEMI E6].

5.6 *facility services* — Any gas, exhaust, liquid, power, data communications or other material which are supplied to or carried away from the equipment and used in the process. Also referred to as utilities or facilities.

5.7 *footprint* — The total area or floor space consumed by a piece of equipment when viewed perpendicular to the area of reference (e.g., normally, when viewed from directly overhead and considering the floor).

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

5.9 *hookup* — The set of activities and organization required to accept incoming process equipment, move it into place, connect the equipment to all facilities, and test the connections. The connection of all necessary facilities and interconnects required to make the equipment package fully operational.

5.10 *interconnect* — Connections between equipment mainframe and peripheral equipment subsystem equipment [SEMI E6].

5.11 *internal connection* — An internal connection is a utility connection to the equipment which is located internal to the equipment and typically associated with hazardous utilities.

5.12 *interface box* — An enclosure located between the equipment mainframe and facility services typically containing components for pressure regulation and filtration. It functions to consolidate facility service requirements to single points of connection. The interface box can provide location and ability to pre-facilitate equipment hookups in advance of equipment delivery.

5.13 *jig* — A three dimensional fixture, typically a frame that contains equipment installation aides which serve to indicate location and type of connection needed for equipment hook-up.

5.14 *location plane* — The common area on a piece of equipment where EPOC's may be located (e.g., back, side, top, bottom).

5.15 *pedestal* — Structural support element upon which equipment or raised floor rests.

5.16 *pre-facilitation* — The stage in the equipment installation process that follows base build and precedes equipment delivery/equipment hookup. Pre-facilitation brings the various facilities services close to the new equipment location, including new facilities services and structural modifications required to prepare the facility to accept the equipment.

5.17 *pre-facilitation pedestal* — A matching equipment floor mounting surface intended to act as a means to expedite equipment hookup, as well as, save fab floor space by having pre-plumbed connections. Ideally, the pedestal would be installed and facilitated to the UPOC's prior to the equipment arrival.

5.18 *raised floor* — The removable floor system installed above the actual building floor within cleanroom environments to control air flow and allow access for utility routing and connection.

5.19 *seismic bracing* — Structural reinforcement to minimize damage due to earthquakes.

5.20 *single line drop* — A hookup strategy where a piece of processing equipment has only one point of connection per facility service. All manifolding for an individual service is handled with in the equipment.

5.21 *specialty gas* — Non-bulk process gases typically stored in cylinders and used to supply one or more process equipment through specialized manifolds.

5.22 *subfab* — The area below or outside of the cleanroom production area that can be a single or multiple levels and may or may not be clean.

5.23 *support equipment* — Ancillary equipment not part of the main chassis.

5.24 *template* — Provides a dimensional outline of the equipment footprint including overall dimensions, equipment datum point, utility connection/penetration locations, equipment interconnect/penetration locations, maintenance and access spaces, and wafer load/unload stations. It can be made from any cleanroom compatible material.

5.25 *tool* — Any piece of semiconductor fabrication or inspection equipment designed to process wafers. Often used synonymously with equipment in the silicon wafer processing industry.

5.26 *tool accommodation* — A methodology by which semiconductor processing equipment is installed in a cost-effective and timely manner.

5.27 *top feed* — Where utility supply lines enter the equipment from the topside.

5.28 *utility point of connection (UPOC)* — The mating fitting or terminal provided by the facility for interconnection with the EPOC for utility supply, the facility end/termination of the hookup at the equipment.

Table 1. Equipment Point of Connection Location Recommendations

Facility Service / Utility	**Bottom Location Plane Preference**	**Back Location Plane Alternate**	
Gas, Bulk	Bottom	Back (lower)	
Gas, Specialty	Bottom	Back (lower)	Back
Exhaust, Corrosive	Bottom	Back (lower)	Back
Exhaust, Flammable	Bottom	Back (lower)	Back
Exhaust, Solvent	Bottom	Back (lower)	Back
Exhaust, General	Bottom	Back (lower)	Back
Chemical Supply, Inorganic	Bottom	Back (lower)	
Chemical Supply, Organic	Bottom	Back (lower)	
Ultrapure Water	Bottom	Back (lower)	
Cooling Water	Bottom	Back (lower)	
Hot Ultrapure Water	Bottom	Back (lower)	
Drain, Inorganic	Bottom	Bottom	Back (lower)
Drain, Waste Chemical, Organic	Bottom	Bottom	Back (lower)
Power, 100V	Bottom	Back (above wet EPOC)	
Power, 200/400V	Bottom	Back (above wet EPOC)	
Fire Suppression	Bottom	Back	
Ancillary Component Interconnect	Bottom	Back (above wet EPOC)	
Signal Cable	Bottom	Back (above wet EPOC)	
Vacuum Foreline	Bottom	Bottom	Back
Process Vacuum	Bottom	Back	

NOTE: Connections located on the top are not recommended because of possible interference with overhead wafer handling and minienvironment equipment.

Table 2. EPOC Consistency Recommendations

Equipment Delivered Compared to	EPOC Locations	EPOC Types	EPOC Sizes
Supplier-provided Facilities Interface Specification	Should match	Should match	Should match
Similar Equipment (Same Model and Revision) for Same Process Application	Should match	Should match	Should match
Similar Equipment (Same Model and Revision) for Different Process Application	Should match for same utilities. Could match unique utilities to unique locations within the appropriate EPOC group.	Should match	Could match, technical reasons should exist for differences.
Similar Equipment (Different Model) for Same Application	Could match	Could match	Could Match

6 EPOC Recommendations

6.1 *Equipment Point of Connection Locations*

6.1.1 Table 1, EPOC Location Recommendations identifies the locations for the specified facility utility services. The locations noted apply to all equipment types, as listed in the document scope, and all equipment configurations including but not limited to boxed equipment, linked equipment, and cluster equipment.

6.1.2 Bottom Location Plane: Facility services are typically provided from the subfab below the waffle slab. The bottom location of EPOC's allows for straight up routing of supply lines, thus reducing equipment footprint and easing facilitation. The locations of EPOC's need to be readily accessible to facilitate hook-up to the UPOC (i.e., accessible from the back or sides). (See Table 1.)

6.1.3 Back Location Plane: If the bottom location plane option is not utilized for hookup, EPOC's should be on back plane of equipment just above the raised floor. (See Table 1.)

6.2 *Equipment Point of Connection Groups*

6.2.1 Equipment points of connection should be grouped together by service type to ensure ease of hookup and qualification of the equipment. The following groups should be considered during the configuration of the equipment.

a) Electrical Power Connections — Includes but is not limited to connections for main electrical utility power supply.

b) Data Communications Connections — Includes but is not limited to factory systems, automated material handling system, and support equipment communication cables and interface connectors.

c) Gas Delivery System Connections — Includes but is not limited to fittings for bulk and specialty gas lines.

d) Liquid Delivery System Connections — Includes but is not limited to fittings for liquid chemical, slurry, ultra pure water, process cooling water, temperature control unit fluids, and industrial water lines.

e) Equipment Effluent Connections — Includes but is not limited to fittings for exhaust, drain, and vacuum lines.

f) Life and Safety System Connections — Includes but is not limited to fire protection, leak detection, emergency machine off (EMO), and hazard warning systems.

6.2.2 A hierarchy should be adhered to when locating these groups of connections on equipment. Data communication wiring should be routed separately from power wiring and connections. Radio frequency (RF) interconnects should be routed and grouped separately. All electrical and electronic wiring should be away from and above water and drain lines.

6.3 *Equipment Point of Connection Consistency*

6.3.1 This section provides key elements to ensure the required consistency of the equipment points of connection. Connection locations on the equipment should be consistent with those defined in the Facilities Interface Specification and should not deviate from equipment to equipment of a specific model and revision. EPOC tolerances need to be +/- 6.35 mm (+/- 1/4 inch) in all directions as measured from the supplier defined equipment datum point. Tighter tolerances should be considered for inflexible or difficult to move hookups such as large diameter (over 2 inch) exhaust or water lines. Connector sizes and types should match exactly.

6.3.2 Table 2 - EPOC Consistency Recommendations identify equipment variations and levels of consistency required for equipment points of connection location, connector type and size.

6.3.3 In Table 2, the term “Should Match” identifies areas that have traditionally been the most costly and where significant gains can be made in achieving installation efficiency . The term “Could Match” identifies areas where modest gains can be made in installation efficiency .

6.4 *Equipment Point of Connection Reduction*

6.4.1 The number of connection points to the equipment should be kept to a minimum. The EPOC’s located on wafer processing equipment should follow a strategy commonly referred to as single line drops, where there is only one point of connection per service per piece of equipment. Where feasible, distribution of a particular facility (e.g., chilled water, waste drains for the same type of chemicals) should be distributed through internal manifolding. Internal equipment manifolding should be configured to allow for configurable equipment sub-systems like process chambers and gas panels. In addition to manifolding, all other interface box functions should be configured on-board the equipment this includes any required shut-off valves, regulators, filters, QC sample valves and pressure indicators.

6.5 *Equipment Point of Connection Interface Panel*

6.5.1 Once EPOC locations and groupings have been defined and standardized for purposes of consistency, the supplier could utilize an interface panel concept for simplifying equipment hook-up. The interface panel should consist of a physical panel that becomes part of the permanent equipment installation. All EPOC’s should be comprehended in the layout of the interface panel using the recommendations for location, grouping, and consistency as discussed in Sections 6.1, 6.2, and 6.3. The supplier should design a standard interface panel layout that supports a given equipment type and all associated revisions.

6.5.2 Common connector technologies, types, and sizes should be utilized along with provisions for containment of hazardous materials. Typically, hazardous production material connections are contained within the equipment

6.5.3 Spacing of multiple gas and liquid connections on the interface panel should provide sufficient access and spacing for installation and maintenance for multiple lines (i.e., orbital weld head, wrench, and test fittings).

7 Pre-facilitation Recommendations

7.1 The pre-facilitation strategy should provide the device manufacturer with the ability to efficiently and accurately install UPOC’s prior to equipment delivery, allowing immediate hook-up of the equipment upon arrival to the fab. The equipment supplier should provide a template and/or jig, as well as a EPOC interface panel (if applicable) or pre-facilitation pedestal prior to the equipment delivery as part of a strategy to support accurate pre-facilitation of utility points of connection. In situations where a pedestal is being utilized (see Section 7.4), the pedestal can serve as an aide to pre-facilitation. The supplier and device manufacturer should discuss and agree on the chosen strategy.

7.2 Templates: The template provides a two-dimensional guide that projects EPOC locations to a two-dimensional surface, typically the floor. This would allow the device manufacturer to open popouts, core holes, etc., and pre-facilitate to a point close to, but not necessarily including, the UPOC. See Figure 1 for a representative example of a Template.

7.3 Jigs: The jig provides a guide that locates the -EPOC’s in three-dimensional space. This would allow the device manufacturer to pre-facilitate to the UPOC’s or at least prefabricate the facility lines and UPOC’s such that final hookup could be accomplished immediately after setting the equipment. See Figure 2 for a representative example of a Jig.

7.4 Pre-facilitation Pedestal: Application notes and three representative examples of using pedestals to support pre-facilitation are included in the related information section at the end of this document.

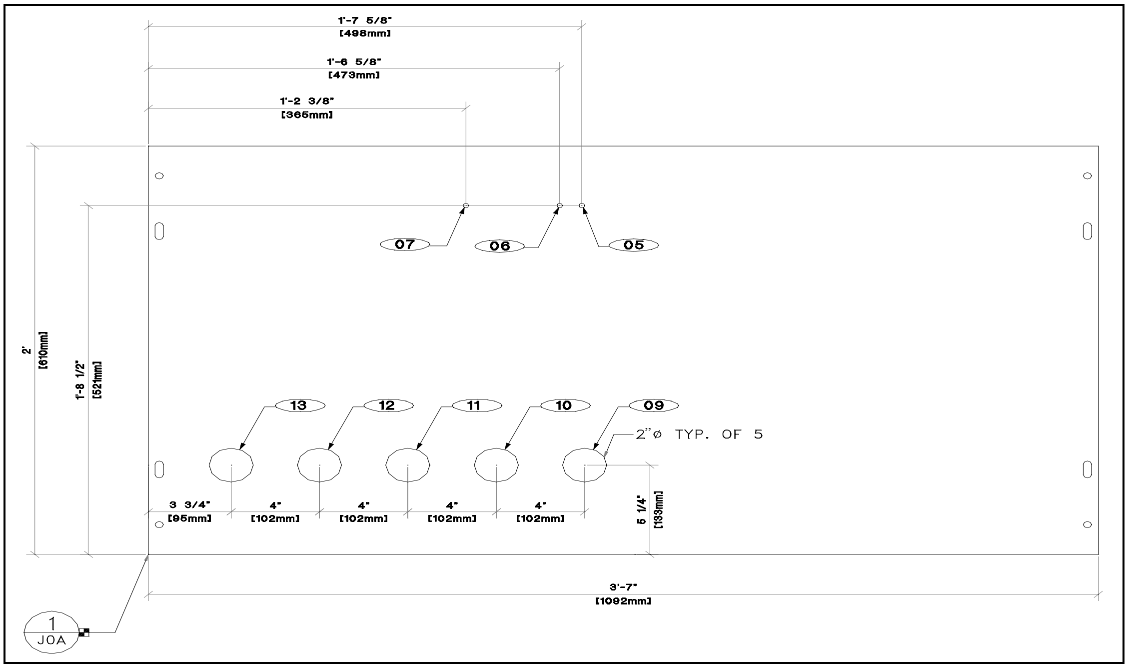


Figure 1
Template Example

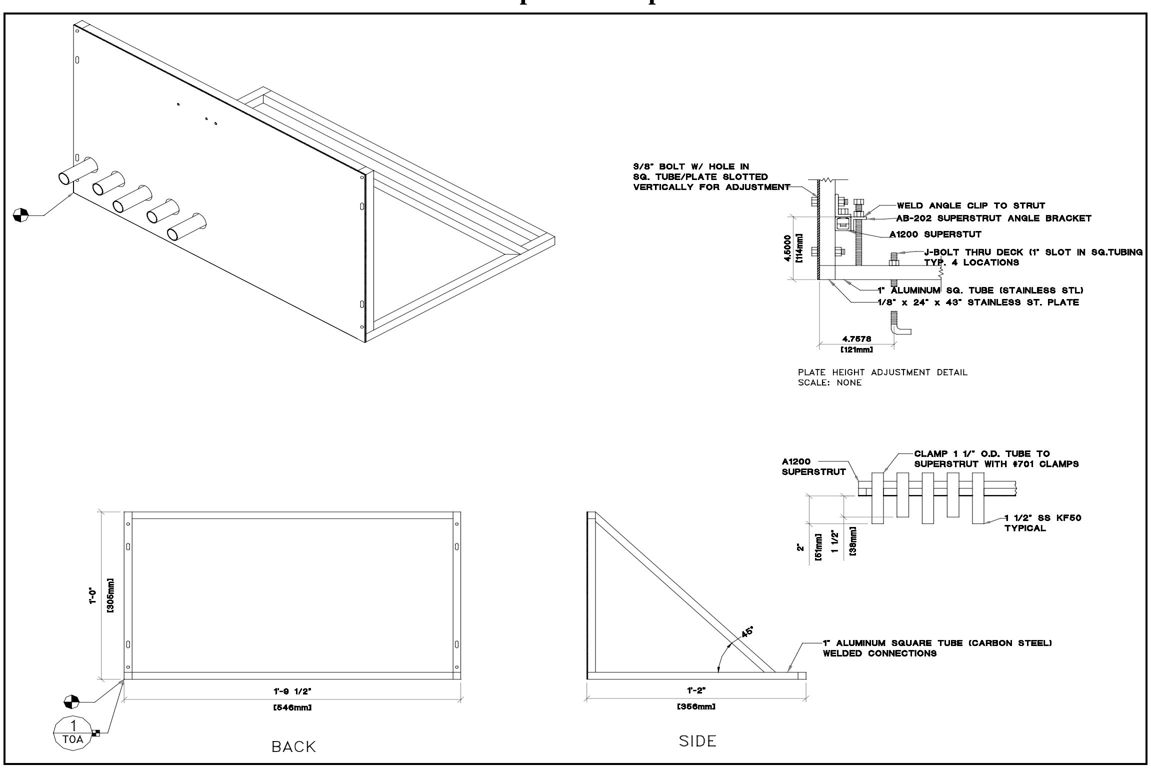


Figure 2
Jig Example

8 Documentation Recommendations

8.1 Equipment suppliers should provide the following documentation concerning equipment point of connections and/or template, jig, and pre-facilitation pedestal to the device manufacturers. The device manufacturer should provide to the supplier, the dates the documentation is required if it is not already specified in this guide.

a) All documentation should be supplied prior to the equipment delivery to the device manufacturer (as deemed appropriate by both the device manufacturer and supplier) and includes a minimum of two sets per piece of equipment .

b) Text and step-by-step procedures should be written in a concise, coherent manner enabling the device manufacturers to achieve and sustain all system performance goals.

c) All drawing documentation provided electronically should be in a format which is compatible with standard computer aided design (CAD) software used by device manufacturers. The CAD format should be compatible with common CAD systems, to include but not limited to, .DWG, .DXF, .DXB, .PS, and .WMF file extensions.

d) The documentation should match the revision of the equipment delivered.

8.2 The equipment supplier should notify the device manufacturer within 30 days of any equipment configuration changes which have an impact on the facility or installation requirements. These changes include, but are not limited to, equipment dimensions, equipment elevation, and equipment points of connection. There should be no changes made within 3 weeks of equipment shipment.

8.3 *EPOC Documentation*

8.3.1 Equipment requirements for utilities and installation should be provided by the equipment supplier. Included EPOC documentation should contain but not be limited to the following information.

a) Floor space requirements (footprint).

b) EPOC matrix indicating service, size/type of connection, location plane, and x,y,z dimensions relative to equipment datum point.

c) Two dimensional drawings showing the equipment points of connection that specify the protrusion depths.

8.3.2 For interface panels, the equipment supplier should provide documentation that includes clear instruction for assembly and positioning the interface panel, a key that clearly identifies which EPOC's are included, and appropriate design drawings such that the device manufacturer can include the interface panel in their respective construction designs.

8.3.3 The following documentation is also required to support the equipment installation activity but is not directly related to the EPOC.

a) Equipment elevation drawings representing all sides of the equipment.

b) Air conditioning and ventilation requirements (acceptable temperature and humidity ranges, exhaust plumbing, etc.).

c) Vibration requirements (acceptable amplitude and frequency).

d) Electrical requirements (voltage, current, wattage, number of phases, power quality, supply voltage wave form requirements, etc.).

e) Vacuum amounts, gases (grade and flow), chilled water flow and other environmental requirements including plumbing requirements (type, size, etc.) for each.

f) A section detailing the procedures to be followed during equipment unpacking and inspection.

g) A section detailing step-by-step set-up procedures that will specifically outline machine assembly and installation on the factory floor.

8.4 *Template, Jig, or Pre-facilitation Pedestal Documentation.*

8.4.1 For templates, jigs, and pre-facilitation pedestals, the equipment supplier should provide documentation that includes clear instruction for assembly, clear instruction for aligning the template, jig, or pre-facilitation pedestal relative to the equipment datum point, and a key that clearly identifies which EPOC's are included. The documentation should also clearly indicate which pieces of equipment (model and revision number) that are supported by a specific template, jig, or pre-facilitation pedestal.

8.4.2 For pre-facilitation pedestals, the equipment supplier should also provide appropriate design drawings and information such that the device manufacturer can include the pedestal design in their respective construction designs. In addition, the supplier should provide applicable documentation required for structural certification.

9 Related Documents

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

9.1 *SEMI Standards*

SEMI E49 — Guide for Standard Performance, Practices, and Sub-Assembly for High Purity Piping Systems and Final Assembly for Semiconductor Manufacturing Equipment

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

SEMI E49.2 — Guide for High Purity Deionized Water and Chemical Distribution Systems in Semiconductor Manufacturing Equipment

SEMI E49.3 — Guide for Ultrahigh Purity Deionized Water and Chemical Distribution Systems in Semiconductor Manufacturing Equipment

SEMI E49.4 — Guide for High Purity Solvent Distribution Systems in Semiconductor Manufacturing Equipment

SEMI E49.5 — Guide for Ultrahigh Purity Solvent Distribution Systems in Semiconductor Manufacturing Equipment

SEMI E49.6 — Guide for Subsystem Assembly and Testing Procedures — Stainless Steel Systems

SEMI E49.7 — Guide for Subsystem Assembly and Testing Procedures — Polymer Systems

SEMI E49.8 — Guide for High Purity Gas Distribution Systems in Semiconductor Manufacturing Equipment

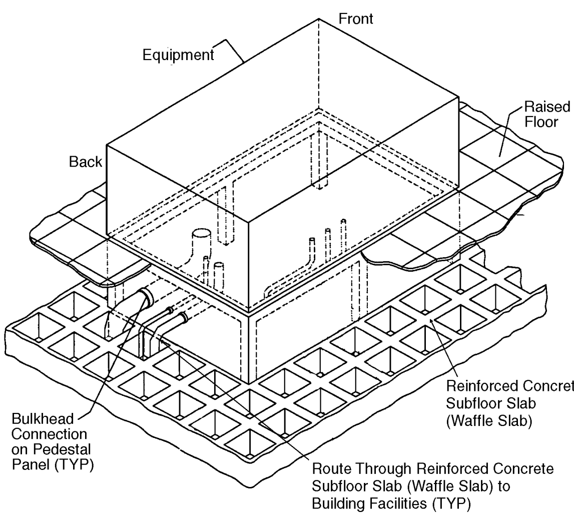
SEMI E49.9 — Guide for Ultrahigh Purity Gas Distribution Systems in Semiconductor Manufacturing Equipment

SEMI E51 — Guide for Typical Facilities Services and Termination Matrix

SEMI S8 — Safety Guidelines for Ergonomics/Human Factors Engineering of Semiconductor Manufacturing Equipment.

RELATED INFORMATION 1 Pre-facilitation Pedestal Application Notes

NOTE: This related information was balloted, but is not an official part of SEMI E76 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.



NOTE: This is only a representative example, a pre-facilitation pedestal can be of an open frame or enclosed box design. Due to bay design and pass thru hole locations a pedestal leg may sometimes become located over an opening thus, a design that allows flexible leg or foot locations should be incorporated.

Figure R1-1
Pre-facilitation Pedestal Example

R1-1. Pre-facilitation Pedestal

R1-1.1 A pedestal provides a permanent base or frame to support the equipment and could be considered an extension of the equipment mainframe In addition, the pedestal could emulate a docking station concept whereby all utilities points of connection could be located and installed prior to equipment delivery. Once the equipment is set on this pre-facilitation pedestal, hookup is relatively quick and easy. When a pre-facilitation pedestal is used, both the device manufacturer and supplier should agree who is responsible for coordinating space utilization within the pedestal.

R1-1.2 When pre-facilitation pedestals are used, the physical location of the EPOC's and corresponding UPOC's can be determined by utilizing templates, jigs, and/or EPOC interface panels in conjunction with the pedestal. The facility utility lines can be prefabricated and installed to the UPOC's prior to setting the equipment on the pre-facilitation pedestal. See Figure R1-1 for a representative example of a Pre-facilitation Pedestal.

R1-1.3 The pre-facilitation pedestal should be provided by the equipment supplier and standardized for a equipment type. In addition, the equipment supplier is responsible for providing the engineering and design of the pre-facilitation pedestal (with input from the device manufacturer as required). Installation of hardware within the pedestal should be done during manufacturing or during pre-facilitation. The following pedestal features (as required by the equipment supplier and end user) are the responsibility of the pre-facilitation pedestal supplier.

a) Vibration isolation, leveling, seismic reinforcing, and load distribution point loading.
b) Connection points from the pedestal to the facility which can be from any plane but should take into consideration potential interference with adjacent tools.
c) Routing of the plumbing and harnesses within the pedestal.
d) Containment of gases and liquids within the pedestal, including possible HPM.
e) Support equipment interconnects within the pedestal

R1-1.4 To use the pre-facilitation pedestal, the distance from the highest point on the waffle slab to the bottom of equipment (typically the top of the raised floor) should be equal to or greater than 0.6 meters (2 feet).

R1-1.5 The pre-facilitation pedestal is recommended for use when these conditions apply.

a) connections located on the bottom of the equipment,
b) maintenance access to the bottom of the equipment as required,
c) repair and spilled liquids access is required underneath the equipment,
d) pedestal is required as an appropriate structural base to set the equipment on,

e) large footprint and/or multiple module for equipment,

f) large number of connections required for the equipment (more than 10), and

g) peripheral components for the equipment (pumps, RF generators, chiggers, etc.) are typically located beneath the equipment in a subfab area.

R1-1.6 The pre-facilitation pedestal is not recommended for use when these conditions apply.

a) small table mounted equipment,

b) no more than one connection on the bottom of the equipment,

c) other connections located on back, top, or side,

d) no maintenance, repair, or spill clean up access requirements beneath equipment,

e) few connections required (less than 10), and

f) few if any peripheral components required or located below equipment in subfab area.

R1-1.7 These conditions are only recommendations and dialog between the supplier and device manufacturer is recommended to determine if a pre-facilitation pedestal is necessary or beneficial for a specific application.

R1-1.8 The Figure R1-2 shows the facility utility lines running up through the waffle slab directly underneath the equipment. The UPOC - EPOC connections occurs at the EPOC interface panel which is located on the top plane of the pre-facilitation pedestal. This concept is preferred by device manufacturers as the number of connections are minimized, no additional space is required on the sides or in back of the equipment for routing, and the HPM lines can be pre-facilitation to the UPOC without additional connections or special double containment requirements.

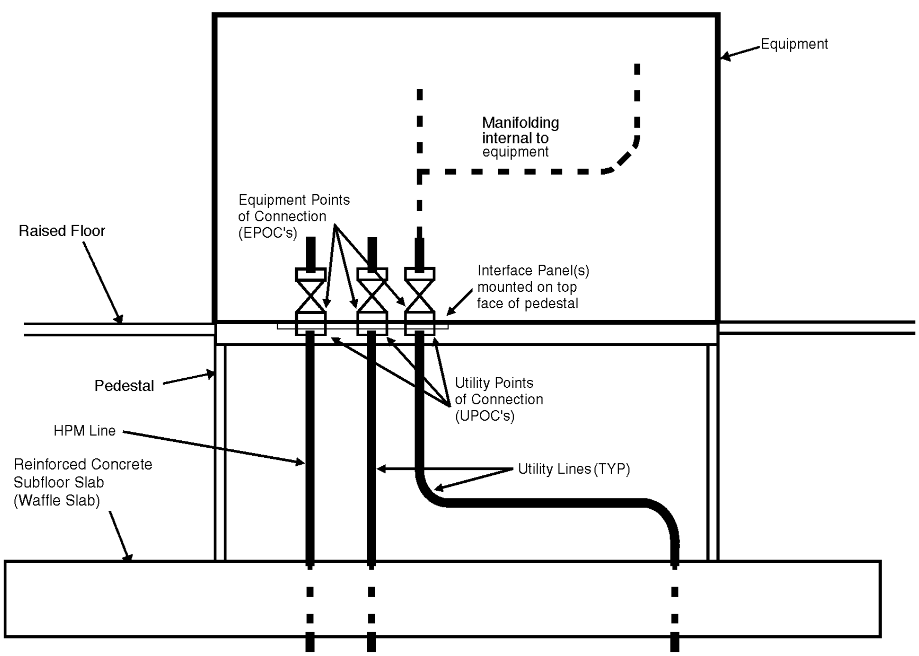


Figure R1-2
Pre-facilitation Pedestal with Top Mounted Interface Panel

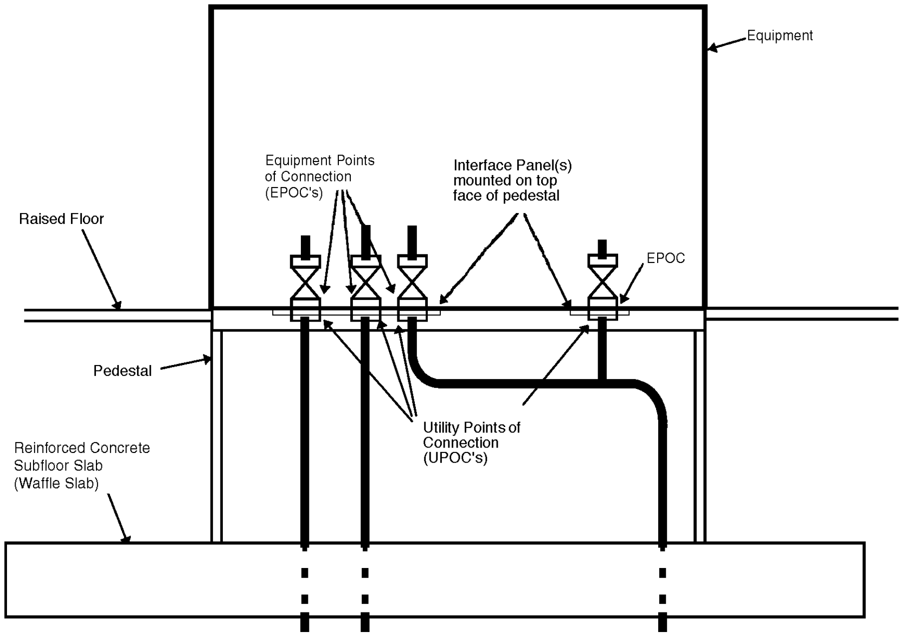


Figure R1-3
Pre-facilitation Pedestal with Multiple Top Mounted Interface Panels

R1-1.9 The Figure R1-3 also shows the facility line running through the waffle slab directly underneath the equipment. In addition, this example depicts situations where there is a physical requirement to manifold connections underneath the equipment. The same advantages as Example #1 apply with the exception of minimizing the number of connections to the equipment.

R1-1.10 The Figure R1-4 shows the facility utility lines running up through the waffle slab to the side/back of the pre-facilitation pedestal and connecting to the EPOC interface panel mounted on the side/back of the pre-facilitation pedestal. In this example a short section of line is required to complete the connection from the EPOC interface panel to the connection within the equipment itself. This short section of line should be prefabricated such that final hookup to the equipment can be accomplished quickly once the equipment is set. It is important to note that this option requires careful consideration on how to accommodate HPM lines. It is generally undesirable to have additional connections in HPM lines or to design the pre-facilitation pedestal itself to provide secondary containment. In this example, the equipment supplier is responsible for the volume in the pre-facilitation pedestal to route and manifold the plumbing as required

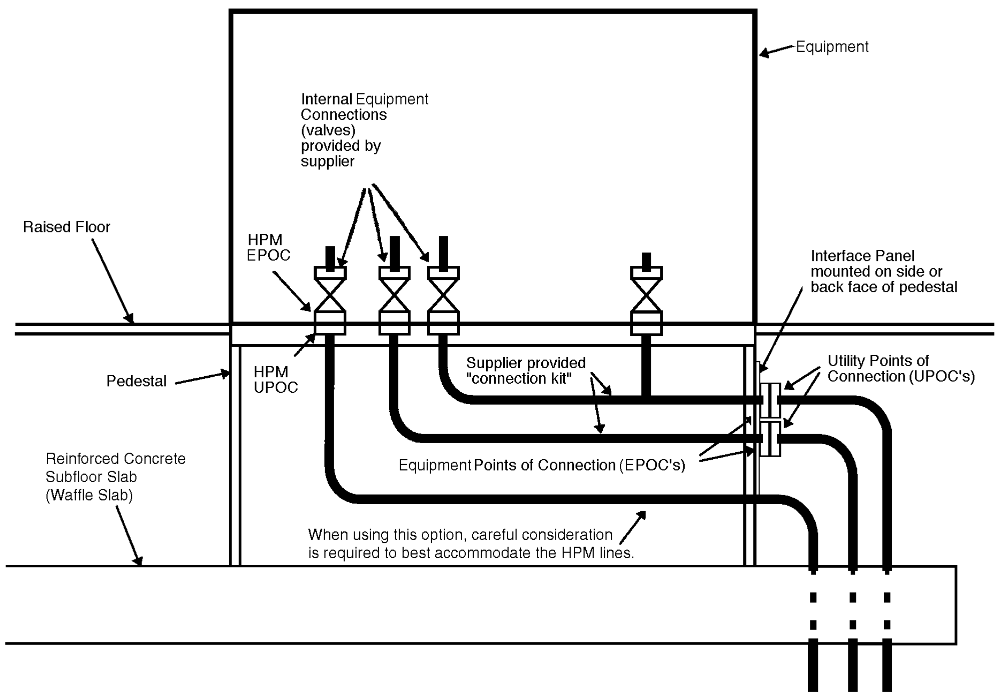


Figure R1-4
Pre-facilitation Pedestal with Side/Back Mounted Interface Panels

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SEMI E77-1104

TEST METHOD FOR CALCULATION OF CONVERSION FACTORS FOR A MASS FLOW CONTROLLER USING SURROGATE GASES

This test method was technically approved by the Global Gases Committee and is the direct responsibility of the North American Gases 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 September 1998.

1 Purpose

1.1 The purpose of this test method is to quantify a nominal average conversion factor from one gas to another for an MFC and to quantify the conversion factor as function of flow for an MFC.

2 Scope

2.1 This procedure describes a method to determine the MFC conversion factor and function between two gases.

2.2 This document provides a common basis for communication between manufacturers and users.

2.3 The intent of this document is not to suggest any specific testing program, but to specify the test method to be used when testing for parameters covered by this method. Reference operating conditions represent the environmental conditions where the "best" performance can be expected.

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 It is not practical to evaluate performance under all possible combinations of operating conditions. This test procedure should be applied under laboratory (reference) conditions; its intent is to collect sufficient data to form a judgment of the field performance of the MFC being tested.

3.1.1 The results from this test represent the performance of the specific device tested (i.e., make, model, full scale flow and operating conditions). The results may not apply to devices of different manufacture, model, full scale flow or under different operating conditions.

3.2 This procedure does not apply to pressure based MFC.

4 Referenced Standard

4.1 None.

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

5 Terminology

5.1 *Abbreviations & Acronyms*

5.1.1 *CF (gasA/gasB)* — conversion factor from Gas A to Gas B.

5.1.2 *D.U.T.*— device under test

5.1.3 *kPa* — kiloPascal

5.1.4 *MFC* — mass flow controller

5.1.5 *psia* — pounds per square inch absolute

5.1.6 *sccm* — standard cubic centimeters per minute

5.1.7 *slm* — standard liters per minute

5.1.8 *%F.S.* — percent full scale

5.2 *Definitions*

5.2.1 *actual flow* — the flow rate as determined by the flow standard used in the test procedure.

5.2.2 *conversion factor* — the ratio of the mass flow-rate of Gas A flowing through an MFC for a given setpoint to the mass flow rate of Gas B flowing through the same MFC and setpoint.

5.2.3 *conversion function* — a relationship that describes the flow dependency of the conversion factor. The conversion function is graphically determined.

5.2.4 *indicated flow* — the flow rate as determined by the output of the D.U.T.

5.2.5 *mean* — the sum of a group of measurements divided by the number of measurements; average.

5.2.6 *measured value* — the actual flow through a D.U.T., expressed in sccm or slm.

5.2.7 *measured value, average* — the sum of all readings (both upscale and downscale) for all cycles, at a single setpoint, divided by the number of these readings.

5.2.8 *nameplate gas* — the gas intended to be controlled by the MFC in operation.

5.2.9 *range* — the algebraic difference between the maximum and minimum values.

5.2.10 *setpoint* — the input signal provided to achieve a desired flow, reported as sccm, slm, or percent full scale.

5.2.11 *span* — the full scale range of the D.U.T.

5.2.12 *surrogate gas* — the gas substituted for the nameplate gas during the calibration process.

5.2.13 *zero drift* — the undesired change in electrical output (i.e., indicated flow), at a no-flow condition, over a specified time period, reported in sccm or slm.

5.2.14 *zero offset* — the deviation from zero at a "no-flow" condition reported in sccm, slm, or mV.

6 Summary of Test Method

6.1 Gas flow and setpoint data are collected for two gases. This data is reduced to quantify the relationship between the flow measurement by the MFC on one gas to another gas.

6.2 This method allows the user to determine the conversion factor between two gases for the MFC and to determine the onset of errors in the MFC calibration due to the conversion factor/function effects.

7 Interferences

7.1 The accuracy rating of the measuring equipment shall be superior to that of the D.U.T. Preferably the measuring equipment will have an accuracy that is four times better than the D.U.T. Calibration equipment must have a valid calibration certificate.

7.2 Take care when using test instruments with a specified accuracy expressed in percent of full scale.

7.3 Installation effects on the flow should be minimized. Monitor pressure upstream of the D.U.T. to ensure that flow variations due to pressure are minimized.

7.4 Verify electrical signals directly at the D.U.T. connector to ensure that the signals at the D.U.T. and standard agree with the signals at the data recording equipment.

7.5 Certain gases will contaminate the D.U.T. This test should be considered a destructive test in such cases.

7.6 All electrical measurements should be read on devices with at least 4.5 digits of resolution. These devices must have valid calibration certifications.

7.7 The device mounting position must be in accordance with the manufacturer's specifications.

8 Apparatus (See Figure 1.)

8.1 *Flow Standard* — A device or system that accurately measures the flow and reports the actual flow.

8.2 *Data Acquisition System* — The system that measures the electrical signals from the device under test. The data acquisition system may also read the signals from the flow standard, record test data and control the test sequence.

8.3 *Temperature Probe* — A device to measure the temperature of the flowing gas.

8.4 *Three-Way Valve* — A special valve to switch the system from one gas source to another.

8.5 *Manual Isolation Valves* — Valves that will positively shut off the gas line.

8.6 *Pressure Regulator* — A device that regulates gas pressure to a set value.

8.7 *Pressure Transducer* — An instrument to measure the gas pressure and report it as an electrical signal.

9 Materials

9.1 *Clean, Dry* N_2 — With 99.999% minimum purity, to be used for purging.

9.2 Test Gas "A"

9.3 Test Gas "B"

10 Safety Precautions

10.1 This test method may involve hazardous materials, operations, and equipment. This test method does not purport to address the safety considerations associated with its use. It is the responsibility of the user to establish appropriate safety and health practices and to determine the applicability of regulatory limitations before using this method.

10.2 Follow the manufacturer's specifications and instructions for installation and operation whenever possible. Note any exceptions in the test report.

11 Test Specimen

11.1 Allow all components in the test apparatus to warm up following the manufacturer's specification.

11.2 Take necessary steps when switching gases to ensure that only the desired gas is in the D.U.T. and flow standard at the time the test is performed.

12 Preparation of Apparatus

12.1 Locate the D.U.T. in the test environment to stabilize temperature for 24 hours prior to warm up.

12.2 The reference operating conditions shall be as follows:

12.2.1 *Ambient Temperature* — 23 ± 2°C

12.2.2 *Gas Temperature* — Same as ambient. In the case of a condensible gas, the gas temperature should be maintained as a gradient, with highest temperature at the outlet end of the test set up, and slightly reduced temperatures back to the source. This will ensure that condensing vapors do not accumulate in the test set up. Gradient should simulate actual process parameters where the MFC will be installed.

12.2.3 *Ambient Pressure* — 101.3 kPa (+ 4.7 or – 15.3 kPa)

12.2.4 *Gas Pressure, Inlet* — 172 ± 34 kPa unless the gas is not capable of delivering this pressure, then normal fab operating conditions should be observed.

12.2.5 *Gas Pressure, Outlet* — < 80 kPa

12.2.6 *Relative Humidity* — 40% ± 5%, non-condensing (suggestion: record if outside this range)

12.2.7 *Magnetic Field* — ≤ 50 μT

12.2.8 *Electromagnetic Field* — ≤ 100 μV/m

12.2.9 *Vibration* — ≤ 0.5 m/s at 50 to 200 Hz

12.3 Following the conditioning period (See Section 12.1), warm up the device according to manufacturer's specifications.

12.4 Perform an adequate nitrogen purge to ensure all previous gases and moisture have been removed from the system. Prior to corrosive gas testing, a cyclic pump and purge operation is recommended, alternately backfilling with nitrogen, and evacuating the test manifold.

12.5 Leak check the manifold, using available methodologies to verify the test system leak integrity. Introduce the test gas at a sufficient rate and time to ensure the test apparatus is completely filled with the test gas and only the test gas.

12.6 Record the zero offset with line pressure inside the MFC to best simulate normal operating conditions. Line pressure during testing is to be 170.30 kPa (24.7 psia) unless safety practices for the gas under test dictate that a lower line pressure be used.

NOTE 1: In addition, if this test is performed on hazardous gases, bleeding off gas pressure to obtain atmospheric pressure inside the MFC may not be easy to do.

12.7 Command 100%, and establish flow, then close the downstream isolation valve; then close the upstream isolation valve (see Figure 1).

12.8 With both isolation valves closed, and a 100% setpoint wait until the pressure drop across the MFC is dissipated, ensuring a "no flow" condition through the MFC. Dissipation of the pressure across the MFC is indicated when the indicated flow drops to a steady state value near zero.

12.9 After the electrical output signal has stabilized for at least three minutes, record the MFC zero offset in Table 1.

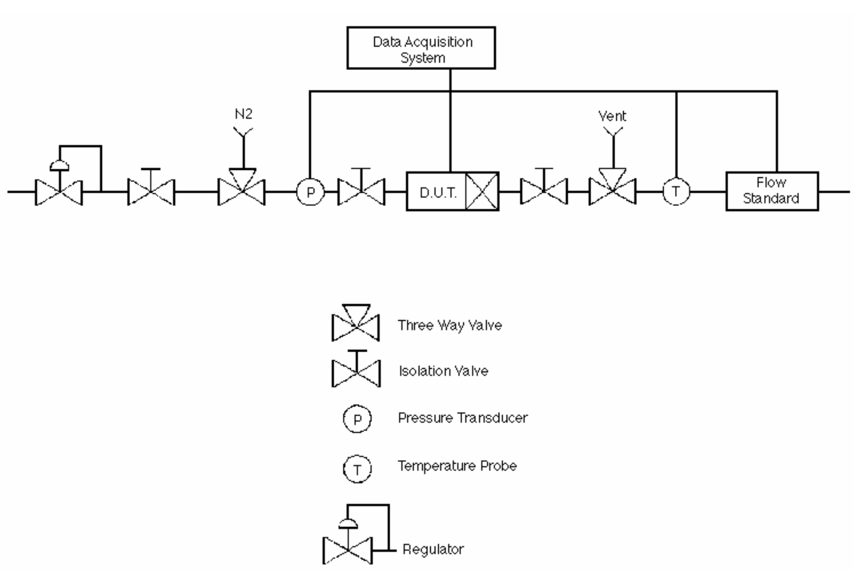

Figure 1
Mass Flow Controller Test Fixture

Table 1 Indicated and Actual Flow vs. Setpoint

MFC Mfg/Model/Serial # ____________________________________
Name Plate Gas/Range ____________________________________
Test Gas ____________________________________
Temp ___________ Bar ___________ Date ___________
Factory Calibration Gas ____________________________________

Column A *D.U.T. Setpoint* *Indication in % F.S.*	*Column B* *D.U.T. Flow* *Indication in % F.S.*	*Column C* *Flow Standard* *Raw Data*
0%[#1]		0
50		
60		
70		
80		
90		
100		
90		
80		
70		
60		
50		
40		
30		
10		
0%	__________________	0
10		
20		
30		
40		0
50		
60		
70		
80		
90		
100		
90		
80		
70		
60		
50		
40		
30		
10		
0%	__________________	0
10		
20		
30		
40		

Column A *D.U.T. Setpoint* *Indication in % F.S.*	*Column B* *D.U.T. Flow* *Indication in % F.S.*	*Column C* *Flow Standard* *Raw Data*
50		
60		
70		
80		
90		
100		
90		
80		
70		
60		
50		
40		
30		
10		
0%		0
10		
20		
30		
40		
50		
60		
70		
80		
90		
100		
90		
80		
70		
60		
50		
40		
30		
10		
0%		0
10		
20		
30		
40		0
50		
60		
70		
80		
90		
100		
90		
80		

Column A *D.U.T. Setpoint* *Indication in % F.S.*	*Column B* *D.U.T. Flow* *Indication in % F.S.*	*Column C* *Flow Standard* *Raw Data*
70		
60		
50		
40		
30		
10		
0%	________________	0
10		
20		
30		
40		
0%	________________	

[#1] 0%; the MFC is not controlling gas flow in this state but rather is in a no-flow condition during which MFC zero offset is to be recorded.

12.10 Set the D.U.T. output to zero per the manufacturer's procedure. This may entail automatic re-zeroing of the device, or may require an adjustment by the operator.

12.11 Record the adjusted zero reading in Table 1.

12.12 The reference supply conditions used shall be the reference values specified by the manufacturer. For those instances when a range of values is specified rather than a reference value, the midpoint of the range shall be taken to be the reference value.

12.13 The power supply must be sufficiently rated for the device under test. In addition, the following supply conditions and tolerances shall apply reference voltage:

12.13.1 *AC Supply* — ± 1%

12.13.2 *DC Supply* — ± 0.1%

12.13.3 *Reference Frequency* — ± 0.1 Hz

12.13.4 *Harmonic Distortion of AC Supply* — ≤ 1%

12.13.5 *Ripple of DC Supply* — ≤ 0.1% rms

13 Procedure

13.1 For the gas of interest, collect flow data for five cycles of 11 different setpoints. The setpoints are 100%, 90%, 80%, 70%, 60%, 50%, 40%, 30%, 20%, 10%, and 0% of full scale. Begin collecting data at the 50% level then 60%, 70% and so on. Record the data on the form in Table 1.

13.1.1 When a non-zero setpoint is given, allow the MFC to stabilize at the desired setpoint by observing the reading on the flow standard. Record the data once the MFC has stabilized at the current setpoint.

NOTE 2: If, during data acquisition at a nominal setpoint, the instrument fails to stabilize, the D.U.T. is not stable enough for the test to proceed.

13.1.2 When a zero setpoint is given, perform the procedure described in Sections 12.7–12.9 (do not rezero the MFC) to ensure a "no-flow" condition through the MFC and record the zero offset indicated by the MFC's output in Table 1.

13.2 Use Table 1 to record the following:

13.2.1 *Column A* — D.U.T. setpoint (% F.S.)

13.2.2 *Column B* — D.U.T. flow indication (% F.S.)

13.2.3 *Column C* — Raw flow standard reading (sccm)

14 Calculations or Interpretation of Results

14.1 For each test gas, calculate the mean and standard deviation of the corrected flow readings, for common setpoints on the same gas. For example, calculate the mean and standard deviation for all the 0% readings for a given gas, then repeat the calculations for the 10% readings, etc. Record the results on Table 2 in Columns B and C. Plot the result as illustrated in Figure 2.

Table 2 Statistical Performance

MFC Mfg/Model/Serial # ______________________________________
Name Plate Gas/Range ______________________________________
Test Gas ______________________________________
Temp ___________ Bar ___________ Date ___________
Factory Calibration Gas ______________________________________

Column A *D.U.T. Setpoint* *(% F.S.)*	*Column B* *Mean Corrected Standard Flow Reading (SCCM)*	*Column C* *Standard Deviation Flow (SCCM)*
10		
20		
30		
40		
50		
60		
70		
80		
90		
100		

Nameplate Gas/Range ___________ Test Gas ________________ Date _____________
MFG/Serial # _________________ Barometric Pressure _______________
Inlet Pressure _________________ Temperature _____________________

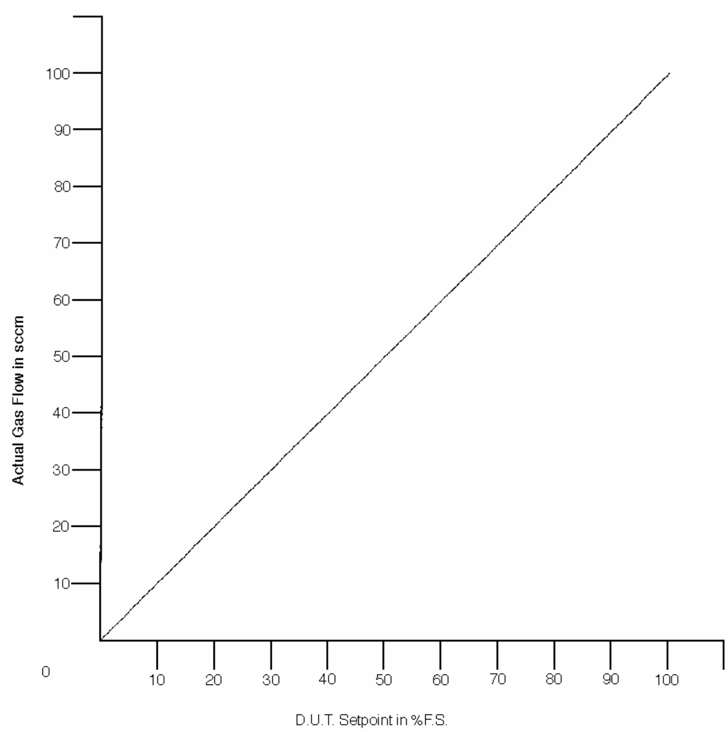

Figure 2
D.U.T. Setpoint vs. Gas Flow

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14.2 *Conversion Factors* — The conversion factor between any Gas A and any Gas B at each setpoint is calculated as follows:

$$\textit{conversion factor } (\textit{Gas A} / \textit{Gas B}) \ @\ X\% \textit{ setpoint} = \frac{\textit{average actual flow @ } X\% \textit{ setpoint on Gas A}}{\textit{average actual flow @ } X\% \textit{ setpoint on Gas B}}$$

where X = setpoint value

14.3 Calculate the conversion factors for the gas tested and record in Table 3.

Table 3 MFC Conversion Factors for Each Setpoint

MFC Mfg/Model/Serial # ____________________________________

Name Plate Gas/Range ____________________________________

Test Gas ____________________________________

Temp ___________ Bar ___________ Date ___________

Factory Calibration Gas ____________________________________

Column A *D.U.T. Setpoint* *(% F.S.)*	*Column B* *CF (Gas A / Gas B)*
100%	
90	
80	
70	
60	
50	
40	
30	
20	
10	

14.4 *Interpretation*

14.4.1 Figure 3 illustrates the conversion factor between two specific gases as a function of setpoint. It may be used to accurately map from one gas to the other and may predict the flow error that will result if the average conversion factor is used.

Nameplate Gas/Range ___________ Test Gas ________________ Date _____________

MFG/Serial # _________________ Barometric Pressure _______________

Inlet Pressure _________________ Temperature _____________________

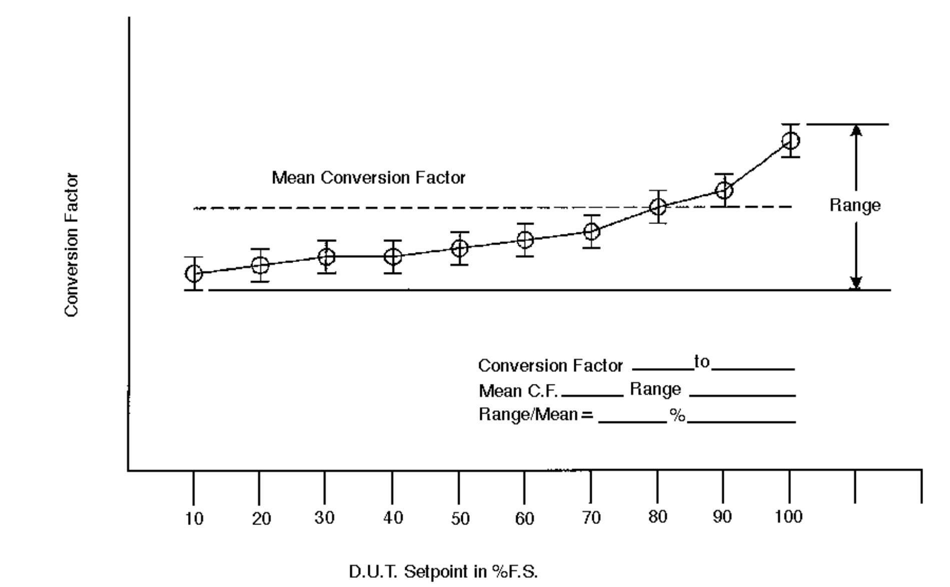

Figure 3
Conversion Factors vs. D.U.T. Setpoint

15 Reporting Results

15.1 *MFC Conversion Factors*

15.1.1 Plot the conversion factor from Gas A to Gas B against the D.U.T. setpoint. Note the mean value and range of values (see Figure 3).

16 Related Documents

16.1 *ANSI Standards*[1]

ANSI C39.5 — Safety Requirements for Electrical and Electronic Measuring and Controlling Instrumentation

ANSI C42.100 — Dictionary of Electrical and Electronics Terms

ANSI MC4.1 — Dynamic Response Testing of Process Control Instrumentation

16.2 *IEC Standard*[2]

IEC 546 — Methods of Evaluating the Performance of Controllers with Analogue Signals for Use in Industrial Process Control

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

2 International Electrotechnical Commission, 3, rue de Varembé, Case Postale 131, CH-1211 Geneva 20, Switzerland. Telephone: 41.22.919.02.11; Fax: 41.22.919.03.00, Website: www.iec.ch

16.3 *ISA Standard*[3]

ISA S51.1 — Process Instrumentation Terminology

16.4 *MIL-STD*[4]

MIL-STD 45662 — Calibration Systems Requirements

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3 Instrument Society of America, 67 Alexander Drive, Research Triangle Park, NC 27709, USA Telephone: 919.549.8411 Website: www.isa.org

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

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SEMI E78-1102
ELECTROSTATIC COMPATIBILITY - GUIDE TO ASSESS AND CONTROL ELECTROSTATIC DISCHARGE (ESD) AND ELECTROSTATIC ATTRACTION (ESA) FOR EQUIPMENT

This guide 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 August 29, 2002. Initially available at www.semi.org September 2002; to be published November 2002. Originally published September 1998.

1 Purpose

1.1 The purpose of this document is to minimize the negative impact on productivity caused by static charge in semiconductor manufacturing environments. It is a guide for establishing electrostatic compatibility of equipment used in semiconductor manufacturing.

1.2 Electrostatic surface charge causes a number of undesirable effects in semiconductor manufacturing environments. Electrostatic discharge (ESD) damages both products and reticles. ESD events also cause electromagnetic interference (EMI), resulting in equipment malfunctions. Charged wafer and reticle surfaces attract particles (electrostatic attraction or ESA) and increase the defect rate. Charge on products can also result in equipment malfunction or product breakage. Operating problems and additional product defects due to static charge can have a negative impact on the cost of ownership of semiconductor manufacturing equipment (refer to SEMI E35).

1.3 An increasing amount of semiconductor production is done in minienvironments or within the production equipment. The majority of static related problems occur while the product is in its carriers, or being transferred from them, by the production equipment.

1.4 Static control methods can be incorporated in the equipment design to reduce static charge to acceptable levels. This guide will be used primarily by equipment manufacturers during the design of their equipment. There are test methods available (see Sections 6 and 7 of this guide) to demonstrate the effectiveness of the static control methods. The end user will be able to use the same test methods to verify compliance with an equipment purchase specification.

2 Scope

2.1 The scope of this document is limited to methods of measurement and a guide for the maximum recommended level of static charge on:

- Product or reticles,
- Carriers, and
- Parts of the input/exit ports of equipment and minienvironments.

2.2 This document presents a matrix of maximum recommended levels of static charge on products, reticles, carriers, and the input and exit ports of production equipment or minienvironments. The purpose is to:

- Reduce product, reticle, and equipment damage due to ESD,
- Reduce equipment lock-up problems due to ESD events, and
- Reduce the attraction of particles to charged surfaces.

2.3 This document references SEMI E43 and other methods of measuring static charge. Related Information 1 of this document contains a theoretical investigation of electrostatic particle attraction, as well as case histories from users and equipment manufacturers as to the static charge problems encountered and how they were solved. A bibliography of related technical papers is also included. Related Information 2 describes static control methods commonly used in semiconductor manufacturing.

2.4 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 health practices and determine the applicability or regulatory limitations prior to use.

3 Limitations

3.1 *Static Measurements* — Measurements of electrostatic quantities such as charge, electric field, and voltage are difficult to make. The nature of the object (insulator or conductor), its geometry, its surroundings, and the measuring equipment itself, are only a few of the factors affecting the accuracy of an electrostatic measurement.

3.1.1 Similarly, it is difficult to relate the measurement of an electrostatic quantity to its effect on products or equipment. For example, an ESD simulator produces a standardized discharge waveform when a capacitor is discharged at a known voltage. This device is used to establish the ESD damage threshold for semiconductor products, or the effect of ESD on equipment. While the amount of charge transferred is known (q = CV), the maximum current that results is not. There is no guarantee that the same amount of charge would produce the same results if different values of capacitance and voltage were used.

3.2 *Location* — The test methods and maximum recommended levels of static charge on product, reticles, and carriers are meant to be applied at the input/exit ports of production equipment, and when possible within the equipment. This document is not meant to be applied in any way that affects the process within the equipment.

3.3 *Test Methods* — The test methods referenced in this document do not guarantee precise measurements of static charge levels. The maximum static charge levels recommended in this document have large tolerances. (See Section 15.1.)

3.4 *Static Charge Control* — There are a variety of static related issues in a semiconductor manufacturing environment. The issues are complex due to the wide range of electrostatic problems, and device or equipment sensitivities to these problems. This guide contains general recommendations. Users of this document are cautioned that specific static related problems may require or allow different levels of static charge than are recommended in this document.

4 Referenced Standards

4.1 *SEMI Standards*

SEMI E10 — Standard for Definition and Measurement of Equipment Reliability, Availability, and Maintainability (RAM)

SEMI E33 — Specification for Semiconductor Manufacturing Facility Electromagnetic Compatibility

SEMI E35 — Cost of Ownership for Semiconductor Manufacturing Equipment Metrics

SEMI E43 — Guide for Measuring Static Charge on Objects and Surfaces

4.2 *ESD Association Standards and Advisories*[1]

ESD STM5.1 — Sensitivity Testing – Human Body Model (HBM) - Component Level

ESD ADV1.0 — Glossary of Terms

ESD ADV 2.0 — Advisory for Protection and Sensitivity Testing of Electrostatic Discharge Susceptible Items - Handbook

ANSI/ESD STM5.3.1 — Sensitivity Testing - Charged Device Model (CDM) - Component Level

ANSI/ESD STM5.2 — Sensitivity Testing -- Machine Model (MM) - Component Level

4.3 *Other Documents*

IEC/TS 61000-4-2 — Transient Immunity Standard, International Electrotechnical Commission (IEC)[2]

89/336/EEC — European Union Directive on Electromagnetic Compatibility

NOTE 1: As listed or revised, all documents cited shall be the latest publications of adopted standards.

5 Terminology

5.1 *Definitions*

5.1.1 *deposition velocity* — Particle flux to a surface (number of particles deposited per unit area per unit time) divided by the particle concentration adjacent to the surface boundary layer.

5.1.2 *electromagnetic interference (EMI)* — Any electrical signal in the non-ionizing (sub-optical) portion of the electromagnetic spectrum with the potential to cause an undesired response in electronic equipment.

5.1.3 *electrostatic attraction (ESA)* — The force between two or more oppositely charged objects. The result is increased deposition rate of particles onto charged surfaces, or movement of charged materials.

5.1.4 *electrostatic compatibility* — Charge control adequate for interequipment transfer of products, reticles, and carriers without electrostatic problems.

5.1.5 *electrostatic discharge (ESD)* — The rapid spontaneous transfer of electrostatic charge induced by a high electrostatic field.

NOTE 2: Usually the charge flows in a spark between two objects at different electrostatic potentials.

5.1.6 *equipment interrupt* — Any variance from the specifications of equipment operation, whether or not the equipment recovers automatically. Interrupts include, but are not limited to, equipment stoppage, equipment data errors, and physical mishandling of products (reference SEMI E10).

5.1.7 *ESD simulator* — An instrument providing a specified electrostatic discharge current waveform

1 ESD Association, 7900 Turin Road, Rome, NY 13440

2 IEC, 3, rue de Varembe, CH - 1211 Geneva 20 Switzerland

when discharged directly to a product or equipment part.

5.1.8 *input and exit ports* — The locations where product and/or product carriers are placed to allow the equipment to process them, or where they are removed from the equipment after processing.

5.1.9 *minienvironments* — A localized environment created by an enclosure to isolate the product from contamination and people.

5.1.10 *product* — Any unit intended to become a functional semiconductor device.

5.1.11 *sensitivity level 1* — Product, reticles, and equipment are extremely vulnerable to damage and/or problems from static charge.

5.1.12 *sensitivity level 2* — Product, reticles, and equipment are highly vulnerable to damage and/or problems from static charge.

5.1.13 *sensitivity level 3* — Product, reticles, and equipment have nominal vulnerability to damage and/or problems from static charge.

5.1.14 *sensitivity level 4* — Product, reticles, and equipment have negligible vulnerability to damage and/or problems from static charge.

5.2 *Description of Terms Specific to this Standard*

5.2.1 *carrier* — A device for holding wafers, dies, packaged integrated circuits, or reticles for various processing steps in semiconductor manufacturing.

6 Requirements

6.1 *Measurement Methods and Instrumentation* — No single method of testing for static charge can determine a "safe" level. The amount of static charge, the distribution of static charge on an object, and the nature of the static discharge will all interact to determine if the charge level is safe. It will be difficult to determine levels that ***guarantee*** static related problems are totally eliminated. The goal of this guide is to assist the user in identifying static charge levels likely to cause problems in process equipment. This guide should provide the user with enough insight to define a test methodology for each static problem and understand its limitations.

6.2 *ESD Damage*

6.2.1 When considering direct ESD damage to an object (product, reticle, or equipment), the important parameter is the current accompanying the charge transfer to or from the object. Under a fixed set of test parameters, the damaging amount of current due to the charge transfer to or from the object can be determined. Established test methods exist for determining the threshold of damage to a particular object. ESD simulators of various types are used for this purpose. Refer to EOS/ESD Association Standards listed in Section 4 for further information concerning device testing.

6.2.2 The end user should determine what is damaging current level due to charge transfer to product or reticles that will be handled in a particular piece of production equipment.

6.2.3 In the context of production equipment, it appears important to know the charge on the product, its carriers, and any other objects that might directly contact the product. Charge is measured in coulombs, or more conveniently in nanocoulombs (10^{-9} coulombs) for this purpose. The measurement is made with instrumentation known as a Faraday Cup, as shown in Section 7, Figure 1.

6.2.4 A charged object, like an integrated circuit, is placed in the Faraday Cup and a reading is taken of the charge on it. It will be necessary to obtain an instrument with a large enough "cup" for wafers, cassettes, and other equipment parts. It will also be necessary to get the objects into the cup without altering their charge levels. Further information on making these measurements should be available from the manufacturers of the measuring equipment.

6.2.5 The user should determine with an ESD simulator what levels of ESD cause product, or reticle damage. The equipment manufacturer will need to determine with an ESD simulator what levels of static charge cause equipment damage.

6.2.6 It will be the responsibility of the equipment manufacturer to demonstrate that equipment operation does not generate more than the allowable amount of charge on product, carriers or equipment parts. This is shown in Section 7, Figure 2.

6.3 *Particle Attraction*

6.3.1 Electrostatic attraction (ESA) of particles can occur due to the electrostatic field created by the charge on the surface of an object. Both the field strength and, usually to a lesser degree, the divergence of the field influence the electrostatic contribution to particle deposition velocity. Electrostatic particle deposition velocity also depends on particle size and particle electrical charge. Unfortunately, even under controlled laboratory conditions, accurate measurements of electric field strength, particle size distribution, and, especially, particle charge, are difficult. Of these three parameters, electric field measurements are the most likely to be available.

6.3.2 Measurements of electrostatic field can be made with a commonly available electrostatic fieldmeter. The units of electrostatic field are volts/cm (volts/inch).

Precise measurements will be difficult as the presence of the measuring instrument changes the field characteristics and may overstate the actual level of electrostatic field. This is shown in Section 7, Figure 3. SEMI E43 describes measurement techniques using an electrostatic fieldmeter.

6.3.3 Electrostatic deposition velocity depends only on electric field, particle size and particle charge. However, the concentration of particles deposited on a surface also depends on the particle concentration in the equipment area and the length of the exposure time during which particle deposition occurs. Mechanisms other than electrostatic deposition, such as gravitational settling and diffusion, can also contribute to particle deposition. The concentration of particles deposited by these non-electrostatic mechanisms will also vary with particle concentration in the equipment ambient and exposure time.

6.3.4 Comparisons of the electrostatic deposition velocity with the deposition velocities associated with these other deposition mechanisms is the key for determining threshold values of allowed electrostatic field from the viewpoint of particle deposition. Such comparisons are the basis for estimating the allowed values of electrostatic field presented in Appendix A1-2.2 and Related Information R1-2. Users and equipment manufacturers should determine and agree on ambient particle sizes and concentrations, and product exposure times.

6.4 *Equipment ESD*

6.4.1 Equipment ESD immunity is being addressed in general through a number of international standards including IEC 61000-4-2 and BS EN 61000-6-2 for European CE compliance. Measurements are made using an ESD simulator which is described in these standards.

6.4.2 The ESD simulator is used to create both a direct discharge to the surface of the equipment and an air discharge to a surface 10 cm (4 inches) away from the equipment. The ESD simulator charges a 150 picofarad capacitor (C) to a known voltage (V) and then discharges it to produce a standardized discharge waveform. Knowing the voltage and capacitance involved in this test means the total charge can be calculated by the equation $q = CV$. For example, a 4000 volt discharge (IEC 61000-4-2 test level) transfers a charge, $q = 600$ nanocoulombs.

6.4.3 The value of the capacitor (C) in the ESD simulator is specified in the international standards. It should not be assumed that a different value of capacitance and voltage that produce the same charge transfer of 600 nanocoulombs would have the same affect on a specific piece of equipment. Discharge currents will vary with the impedance of the discharge path and with the voltage. It is, however, impractical to test all possible combinations. For the purposes of this guide, the parameters of the ESD simulator specified in the standards for equipment ESD immunity will be used.

6.4.4 For true ESD immunity, an ESD event in equipment must not disturb either the equipment it occurs in, or another nearby piece of equipment. Charge on product or carriers transferred from one piece of equipment must not disturb the operation of subsequent equipment. It will be a systems issue to make sure that **all** equipment in a facility meets the required ESD immunity standards.

6.4.5 The range of reactions in equipment to an ESD event runs from *transient errors* that are automatically corrected, to *hard errors* that cannot be corrected without manual intervention or damage the equipment. While small numbers of transient errors may be acceptable from the point of view of equipment operation, they may still cause unacceptable product losses.

6.4.6 The user and manufacturer must determine with an ESD simulator what levels of ESD cause equipment interruptions. The user must determine if any of these equipment interruptions caused by ESD are acceptable.

6.4.7 In setting a level to provide ESD immunity for an individual piece of equipment from static charge on products and carriers, the charge on these items should be kept below the levels determined by ESD simulator testing.

6.4.8 The Faraday Cup measurement can be used for this purpose. If equipment has been tested for ESD immunity and passes a 4000 volt test, then total charge on product and carriers leaving this equipment should be kept below 600 nanocoulombs. Any product transferred at this level should not be handled by other equipment with a lower ESD immunity. A possible implementation of this test method is shown in Section 7, Figure 4.

7 Apparatus

7.1 *ESD Damage* — The apparatus for determining the ESD damage thresholds for products will depend on the test methods used. See Section 4 for additional information. For measuring the charge generated on product, reticles, or carriers, the Faraday Cup test method is shown in Figure 1.

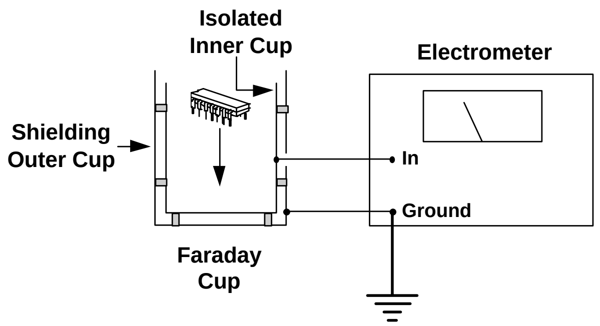

Figure 1
Faraday Cup Charge Measurement

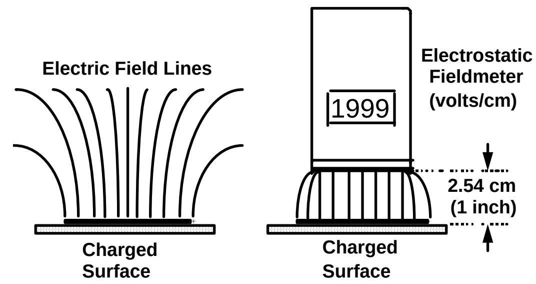

Figure 3
Electrostatic Field Measurement

7.1.1 The relationship between ESD simulator testing for product damage and charge measurements using the Faraday cup is shown in Figure 2.

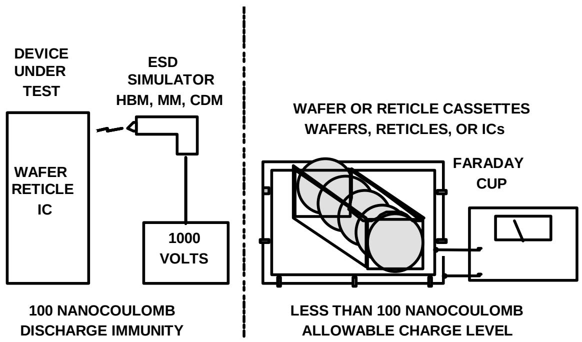

Figure 2
ESD Damage Testing

7.2 The instrument used for making electrostatic field measurements is known as an electrostatic fieldmeter. Instructions concerning its use should be obtained from the instrument manufacturer and SEMI E43. The measurement configuration shown in Figure 3 illustrates the effect of the instrument on the measurement. In most cases the presence of the fieldmeter will increase both the flux from the charged surface and the divergence of the electric field lines. The fieldmeter will generally indicate a higher value of electric field than would be present without the fieldmeter.

7.3 The instrumentation and test methods for determining the ESD sensitivity of equipment are described by IEC 6100-4-2 or other acceptable test methods. The amount of static charge determined by this test method is to be compared with the charge measured on products and carriers with the Faraday Cup test method. Figure 4 illustrates the two methods.

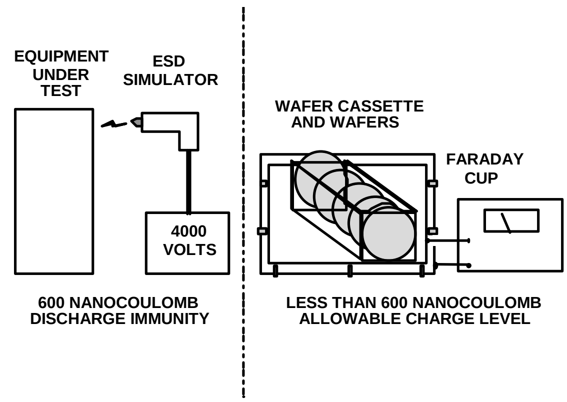

Figure 4
ESD Immunity Testing

8 Safety Precautions

8.1 *Personnel* — Static charges can create safety hazards during some semiconductor production processes. ESA or ESD events that result in the jamming or breakage of product in high speed equipment may create a personnel hazard. ESD events that produce sparks must be prevented in areas that use flammable or explosive chemicals or gases. ESD events to personnel are usually not harmful, but they may result in an unwanted reflex, or “startle” reaction. This reflex may create a personnel hazard, particularly in the vicinity of moving equipment or where caustic chemicals are in use. It may be necessary to use additional static charge control methods, beyond those used inside the equipment, to minimize these personnel hazards.

8.2 *Measurement Safety* — Users should exercise caution while making static charge measurements in the vicinity of moving parts of production equipment, or in areas where static potentials on ungrounded conductors may exceed 30,000 volts. Refer to SEMI E43 for additional measurement safety considerations.

9 Test Specimen

9.1 The user and equipment manufacturer will need to agree on:

- The type(s) of testing to be performed,
- Who will do the testing,
- The number and type of test samples,
- The number of measurements, and
- Acceptable test results.

9.2 The operating history of the equipment prior to, or during testing (e.g., warm-up time, type of carrier, number of products processed, operating speed), and all appropriate environmental conditions (e.g., temperature, humidity, airflow) should be agreed upon and documented.

10 Preparation of Apparatus

10.1 Depending on the type of testing to be done, consult the appropriate testing document for apparatus preparation. See Sections 4 and 16 for additional information.

11 Calibration and Standardization

11.1 Depending on the type of testing to be done, consult the appropriate testing document for apparatus calibration and verification. See Sections 4 and 16 for additional information.

12 Procedures

12.1 Refer to Sections 6 and 7 and the appropriate test methods of Sections 4 and 16.

12.2 *ESD Damage*

12.2.1 Users shall establish product damage thresholds for their products. Measurement methods for integrated circuits are described in the documents contained in Sections 4 and 16. Appropriate measurement methods for ESD damage to wafers, reticles, and other items may be adapted from the instrumentation used in these test methods. Appendix A1-2.1 and Related Information R1-1 contain additional information to select an appropriate sensitivity level to reduce ESD damage.

12.2.2 Measurement of ESD damage thresholds are made in units of nanocoulombs (nC = 10^{-9} coulombs).

12.2.3 The Faraday Cup method is used to determine the static charge levels on products, product carriers and equipment parts. Each item shall be transported to the Faraday cup in a way that does not alter its charge level. Consult the measurement equipment manufacturer's instructions for recommendations on how to achieve this.

12.2.4 Measurements should be made of products, carriers, and materials in the equipment input/exit ports after significant amounts of product have been handled under normal manufacturing conditions. Measurements should be made of products and their carriers after they have undergone normal processing in the equipment under test. Typically five measurements of products and/or carriers should be sufficient to demonstrate compliance with the selected Sensitivity Level.

12.2.5 Measurements should be made on each of three successive days after equipment has stabilized in its normal operating mode (e.g., after two hours).

12.3 *Particle Attraction*

12.3.1 Users should work with equipment manufacturers to determine ambient particle levels and product exposure times during processing. Appendix A1-2.2 and Related Information R1-2 contain information to select an appropriate Sensitivity Level to reduce electrostatic attraction of particles.

12.3.2 Electrostatic field measurements on products, product carriers, and equipment surfaces should be made in at least three different locations on any item. Locations should be separated by approximately three times the distance between the measuring instrument and the measurement location. For most electrostatic fieldmeters measuring at 25.4 mm (1 inch), the measurement locations will be 76.2 mm (3 inches) apart. Refer to SEMI E43 for additional measurement considerations. Measurements of electrostatic field are expressed in volts/cm or volts/inch.

12.3.3 Measurements should be made on products, carriers, and materials in the equipment input/exit ports after significant amounts of product have been handled under normal manufacturing conditions. Measurements should be made of products and their carriers after they have undergone normal processing in the equipment under test. Typically five measurements of products and/or carriers should be sufficient to demonstrate compliance with the selected Sensitivity Level.

12.3.4 Measurements should be made on each of three successive days after equipment has stabilized in its normal operating mode (e.g., after two hours).

12.4 *Equipment ESD*

12.4.1 Equipment manufacturers should determine the effects of ESD on their equipment using an ESD Simulator and the appropriate test methods (IEC 6100-4-2 or others). Users should agree on the types of equipment interrupts that are acceptable (if any). Appendix A1-2.3 and Related Information R1-3 contain additional information to select an appropriate sensitivity level to reduce ESD-related equipment interruptions.

12.4.2 Compliance with the desired Sensitivity Level may be demonstrated using the Faraday Cup method described in Sections 6.4 and 7.3.

12.4.3 Measurements should be made on products, carriers, and materials in the equipment input/exit ports after significant amounts of product have been handled under normal manufacturing conditions. Measurements should be made of products and their carriers after they have undergone normal processing in the equipment under test. Typically, five measurements of products and/or carriers should be sufficient to demonstrate compliance with the selected Sensitivity Level.

12.5 Equipment used in semiconductor manufacturing should meet the following levels shown in Table 1 for protection from problems caused by static charge.

Table 1 Recommended Sensitivity Levels

	Electrostatic Discharge (Nanocoulombs)	*Particle Attraction (Volts/cm)*	*Equipment Malfunction (Nanocoulombs)*
Level 4	100	4000	1200
Level 3	50	400	600
Level 2	10	200	300
Level 1	1	100	150

12.5.1 Sensitivity Level 4 compliance means that products, reticles, and carriers can leave the equipment with up to the recommended amounts of static charge or electrostatic field measured on them according to the test method used. This level essentially states that the equipment is used in a process that has no significant problems handling charged product, nor are there issues associated with contamination or ESD damage.

12.5.2 At levels 1, 2, or 3 a decision should be made as to what is the most serious static charge problem. The Sensitivity Level and test methods are chosen accordingly. The lower the level of static charge allowed, the more static control measures the equipment manufacturer may need to install.

12.5.3 Level 1 may be used primarily by manufacturers of specialized components such as: gallium arsenide semiconductors or magneto-resistive (MR) disk drive read heads; those experiencing significant losses due to contamination; or those using specialized equipment with low immunity to ESD or EMI.

12.6 The levels listed in Table 1 have been determined as the result of analysis of working conditions, or experiments done in operating semiconductor facilities. Justifications for these levels are found in Appendix 1. The actual levels to be used for any piece of production equipment may be decided by agreement between the user and manufacturer of the equipment.

12.7 Other levels may be appropriate under specific equipment conditions and for specific devices.

13 Calculations

13.1 A series of five measurements should be made. The average of the five measurements should not exceed the recommended level.

14 Reporting Results

14.1 Data records should contain the following information:

- Description of equipment under test including model and serial numbers.
- Description of the equipment operating conditions and environment.
- Measurement equipment and last calibration date.
- Description of objects measured and measurement locations.
- Humidity and temperature at measurement location when measurements were made.
- Results of measurements.
- Personnel making the measurements.
- Any other relevant comments.

15 Precision and Accuracy

15.1 *Accuracy of Test Methods* — The test methods referenced in this document do not guarantee precise measurements of static charge levels. Similarly, maximum static charge levels recommended in this document are not stated as precise requirements. Accuracy of approximately ± 20% is acceptable in all measuring instrumentation. At low static charge levels or for more accurate measurements, alternative instrumentation and test methods may need to be used.

16 Related Documents

16.1 *EIA/JEDEC Standards*

EIA/JESD22-A114 — Electrostatic Discharge (ESD) Sensitivity Testing Human Body Model (HBM)

EIA/JESD22-A115 — Electrostatic Discharge (ESD) Sensitivity Testing Machine Model (MM)

JESD22-C101A — Field-Induced Charged-Device Model Test Method for Electrostatic Discharge Withstand Thresholds of Microelectronic Components

16.2 *Other Documents*

EN 50082 — Generic Immunity Standard for CE Compliance, CENELEC European Union

BS EN 61000-6-2 — Electromagnetic compatibility (EMC) - Generic standards - Immunity for industrial environments - British Standards Institution (BSI).[3]

MIL-STD 883C — Notice 8 – Method 3015.7 – Electrostatic Discharge Sensitivity Classification

3 BSI, 389 Chiswick High Road, GB - LONDON W4 4AL