equipment), and it must be open from above to facilitate automatic carrier delivery from an overhead transport system.

6.9.3 In Option 3 (with no allowance for automatic carrier deliver from an overhead transport system), the top of the carrier must be ≤H2 (2900 for exposure equipment), clearance above the reticle must be C3.

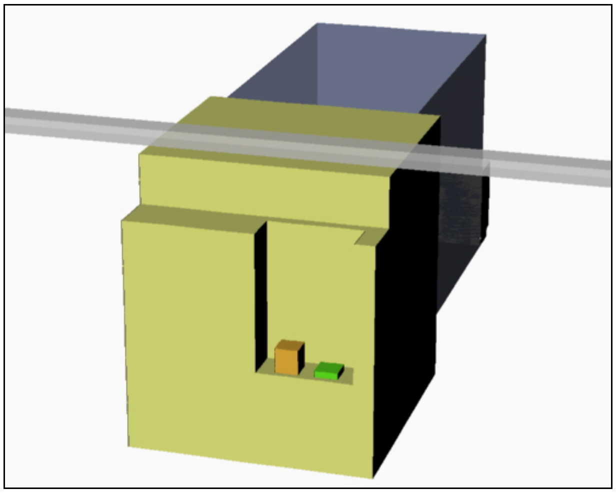
6.9.4 Additional load ports used for manual loading/unloading can be located below the primary load port in each of the three options.

6.9.5 Equipment suppliers and users should note that SEMI S8 requirements might restrict such implementations of manual load ports.

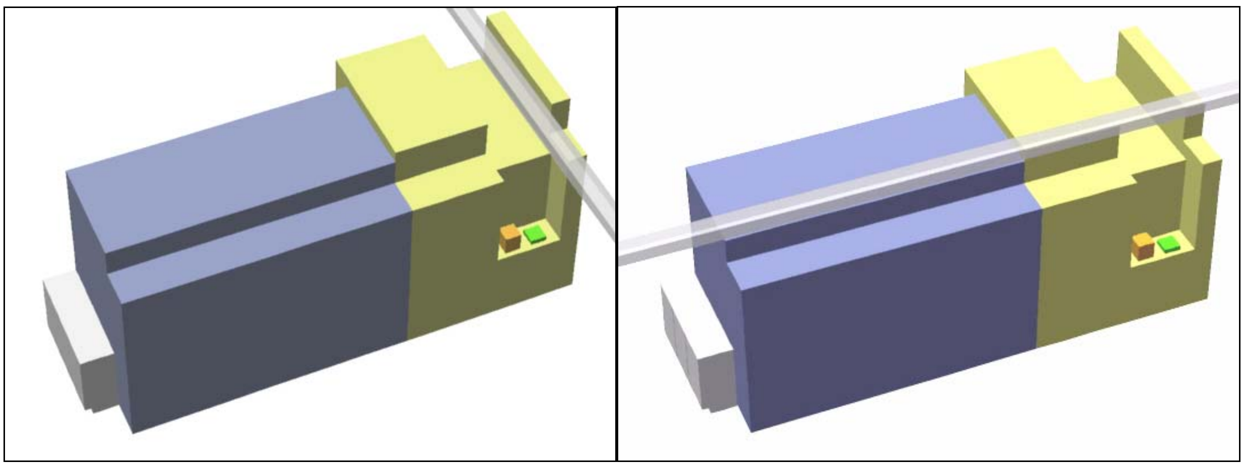
Table 1 Dimensional Requirements for Reticle Load Ports

Dimension	*Application*	*Value, mm (in.)*	*Notes*
C1	minimum	75 (3.0)	Clearance to left and right of RSP.
C2	minimum	50 (2.0)	Radial clearance around RSP.
C3	minimum	150 (5.91)	
D	maximum	250 (9.8)	Load face plane to facial reference plane.
D1	minimum	196 (7.72)	Facial reference plane to OHT easement.
H	range	minimum 890 (35.0) maximum 2690 (106)	Port height: lithography exposure equipment.
		925 ± 35 (36.4 ± 1.4)	Reticle stockers and inspection equipment.
H1	maximum	60 (2.36)	Loading obstruction height at load port.
H2	maximum	2900 (114.2)	OHT easement height: exposure equipment.
		2600 (102.4)	Reticle stockers and inspection equipment (recommended for exposure equipment).
H6	maximum	3200 (126)	Side OHT easement height (see Figure 2b).
R	minimum	10 (0.4) required 15 (0.6) recommended for ergonomic reasons	Load port lead-in capability (correction of RSP misalignment in any horizontal direction).
S	minimum	290 (11.4) [358 (14.1)]	Spacing of adjacent load ports.

[#1] In Table 1 and in the figures of this document, numbers in [square brackets] are specific to the RSP200 (if different from the RSP150 and MRSP150).

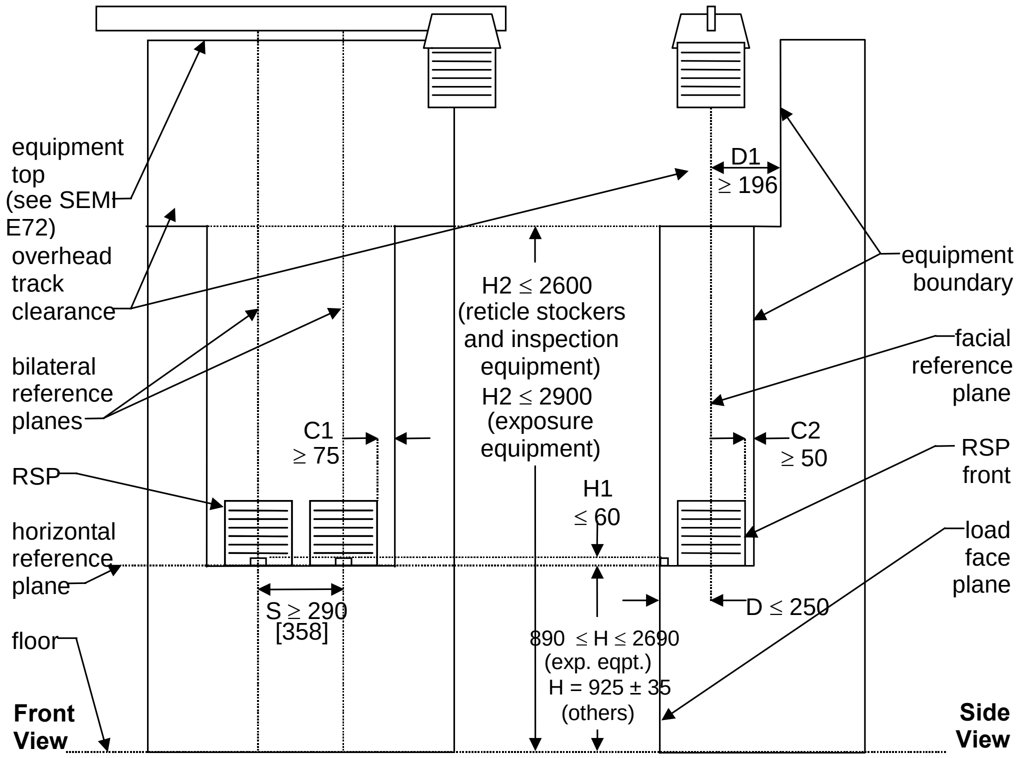


a. Exposure Equipment with RSP Load Ports on Rear

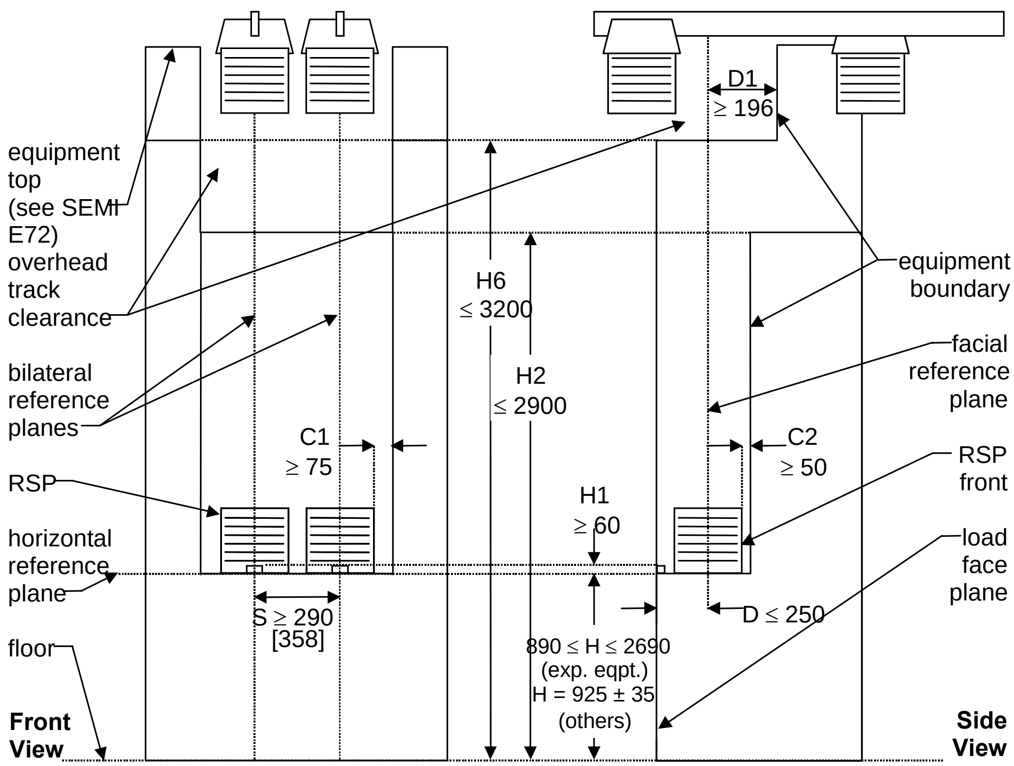


b. Exposure Equipment with RSP Load Ports on One Side, and an Optional View of a 90° OHV Track Orientation.

Figure 1
Easement for Overhead Transport



a. Reticle Stockers, Inspection Equipment, and Exposure Equipment with Load Ports on the Rear



b. Exposure Equipment with Load Ports on One Side

Figure 2
Reticle Load Port Requirements

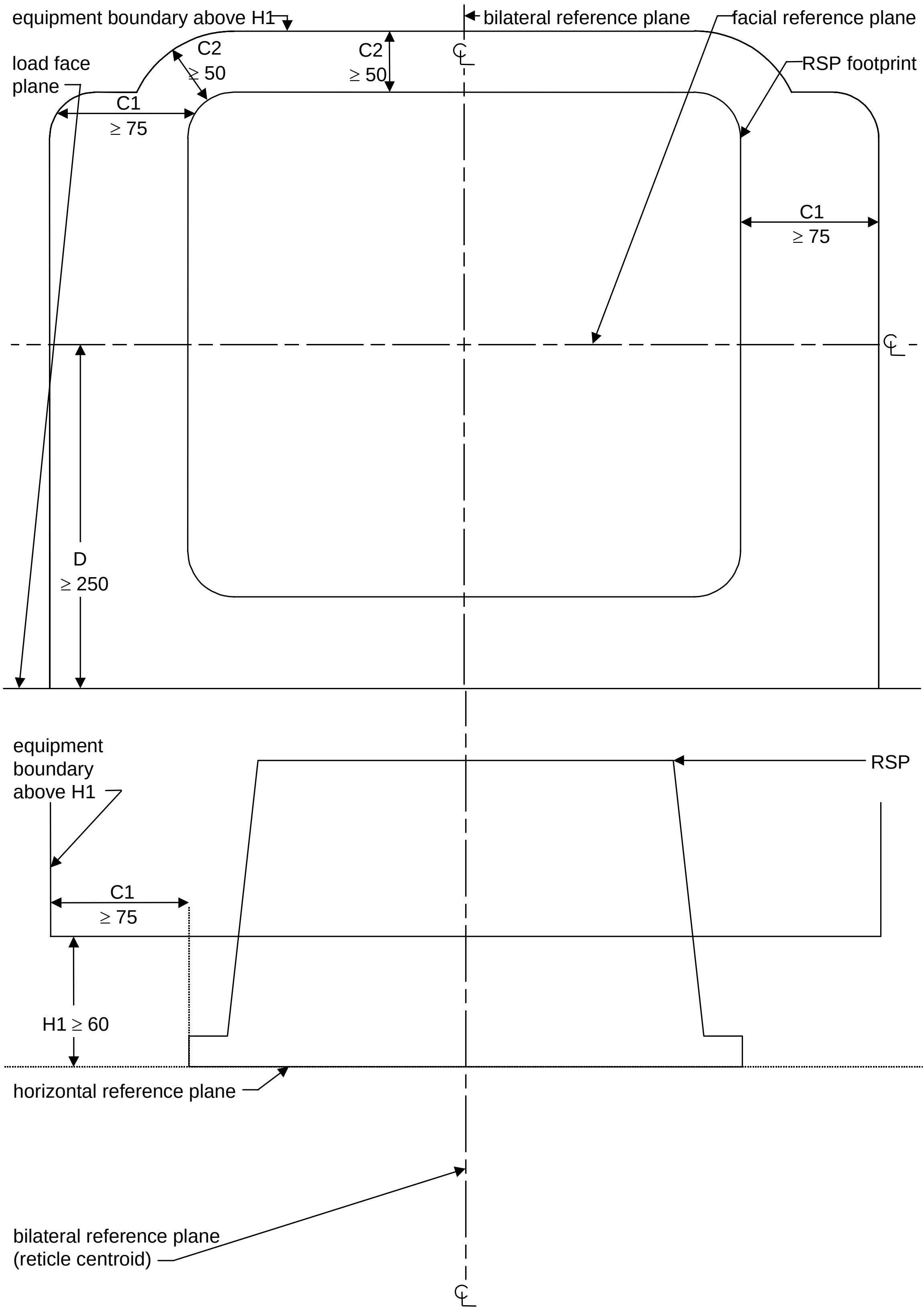


Figure 3
Exclusion Volumes at Horizontal Reference Plane of Reticle Load Port

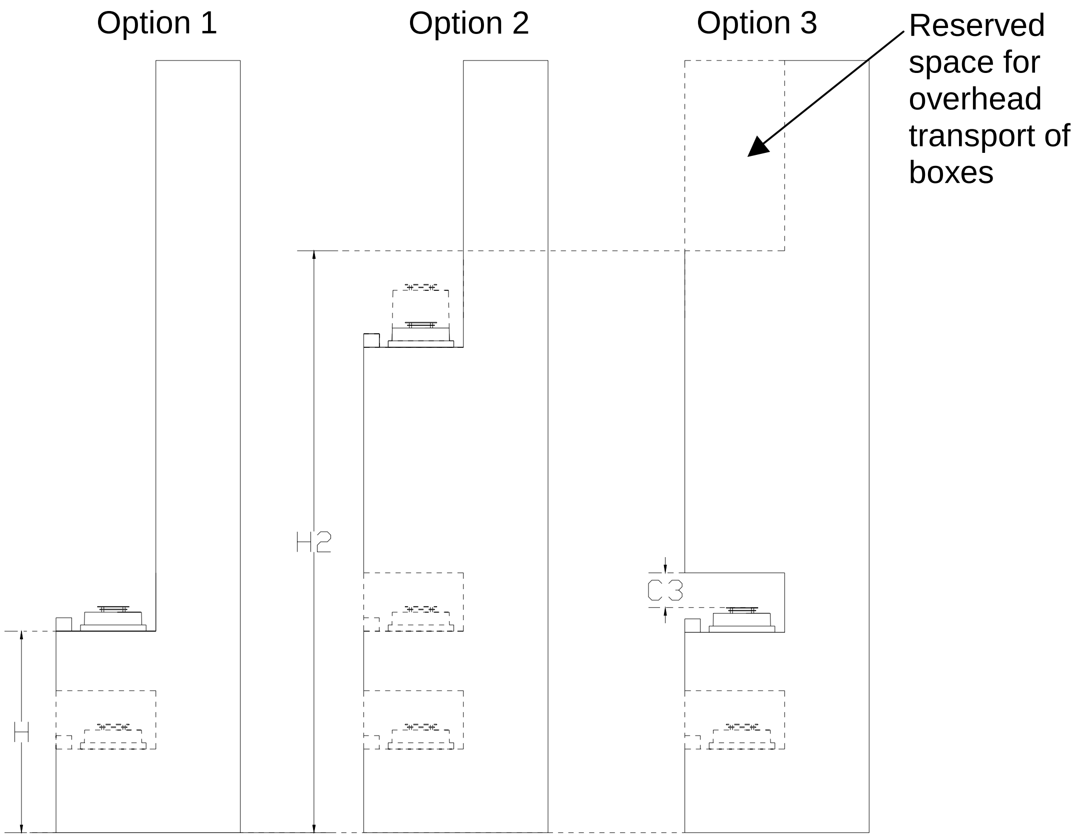


Figure 4
Reticle Load Port Options

RELATED INFORMATION 1
APPLICATION NOTES

NOTICE: This related information is not an official part of SEMI E117 and was derived from current industry knowledge. This related information is to be approved for publication by full letter ballot procedure.

NOTICE: This related information is not meant to modify or supersede SEMI E117 in any way. Rather, these notes are provided primarily as a source of information to aid in the application of the standard. As such, they are to be considered as reference material only. The standard should be referred to in all cases.

R1-1 Application Notes

R1-1.1 *Compliance with This Standard* — It is the device makers' expectation that suppliers of production equipment are ultimately responsible for ensuring that their equipment (as installed in the device makers' facility) complies with this standard. This expectation is the same whether the reticle load port is developed internally by the equipment supplier or is purchased from a third party source. In either case, the production equipment supplier is responsible for understanding all of the requirements contained in this standard. Full compliance with this standard can only be determined after the reticle load port is integrated with the equipment and can be directly affected by production equipment design features (such as user interfaces and light towers).

R1-1.2 To prevent interference between transport systems on the same or adjacent load ports, it is recommended that floor-based transport vehicles and over-head hoist vehicles not exceed clearances C1 and C2 when picking up or placing a RSP on the load port.

SEMI E118-1104^E
SPECIFICATION FOR WAFER ID READER COMMUNICATION INTERFACE — THE WAFER ID READER FUNCTIONAL STANDARD: CONCEPTS, BEHAVIOR AND SERVICE

This specification was technically approved by the Global Information and Control Committee and is the direct responsibility of the Japan Information and Control Committee. Current edition approved by the Japan Regional Standards Committee on July 19, 2002. Initially available at www.semi.org October 2002; to be published November 2002.

E This standard was editorially modified in February 2005 to correct errors in Figure R2-1.

NOTICE: The designation of SEMI E118 was updated during the 1104 publishing cycle to reflect revisions to SEMI E118.1.

1 Purpose

1.1 The purpose of the Wafer ID Reader Functional Standard is to provide a common specification for concepts, behavior, and services (functions) provided by a Wafer ID Reader to an upstream controller.

1.2 A standard interface will increase interchange-ability of Wafer ID Readers so that users and equipment suppliers have a wider range of choices.

2 Scope

2.1 The Wafer ID Reader Functional Standard addresses the functional requirements for a generic Wafer ID Reader interface with an upstream controller.

2.2 The specification includes required behavior and required communications for a Wafer ID Reader.

2.3 This specification does not require, define, or prohibit asynchronous messages sent by the Wafer ID Reader.

2.4 This specification intents to read the Wafer ID specified by SEMI Standard and accessed in the equipment where the wafers transfer in / out is executed with a carrier unit.

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 This standard does not define the specific protocol to be used for the Wafer ID Reader. Supplements to this standard are required to describe how the functions of the Wafer ID Reader are implemented for specific protocols.

4 Referenced Standards

4.1 *SEMI Standards*

SEMI E15 — Specification for Tool Load Port

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

SEMI E39 — Object Services Standard: Concepts, Behavior, and Services

SEMI E47.1 — Provisional Mechanical Specification for Boxes and Pods Used to Transport and Store 300 mm Wafers

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

SEMI E87 — Specification for Carrier Management (CMS)

SEMI E90 — Specification for Substrate Tracking

SEMI E99 — The Carrier ID Reader/Writer Functional Standard: Specification of Concepts, Behaviors, and Services

SEMI E101 — Provisional Guide for EFEM Functional Structure Model

SEMI T7 — Specification for Back Surface Marking of Double-Side Polished Wafers With a Two-Dimensional Matrix Code Symbol

4.2 *ISO/IEC Standard*[1]

ISO/IEC 16022 — International Symbology Specification – Data Matrix

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

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

5 Terminology

5.1 *Abbreviations and Acronyms*

5.1.1 *FOUP* — Front Opening Unified Pod

5.1.2 *WIDR* —Wafer ID Reader

5.2 *Definitions*

5.2.1 *attribute* — information about or associated with some entity or object.

5.2.2 *carrier* — any cassette, box, pod, or boat that contains wafers.

5.2.3 *cassette* — an open structure that holds one or more substrates [SEMI E44].

5.2.4 *controller* — a system that provides control (performs required operations when certain conditions occur or when interpreting and acting upon instructions) and communicates with a higher level manager. Controllers exist at all levels within a factory. Examples of controllers include the Multiple Wafer ID Reader Controller, the Equipment Controller.

5.2.5 *data matrix code symbol* — a two-dimensional array of square cells arranged in contiguous rows and columns. In certain ECC200 symbols, data regions are separated by alignment patterns. The data region is surrounded by a finder pattern [ISO/IEC 16022].

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

5.2.7 *fundamental requirements* — the requirements for information and behavior that must be satisfied for compliance to a standard. Fundamental requirements apply to specific areas of application, objects, or services.

NOTE 1: All portions of the Wafer ID Reader specification are considered to be fundamental requirements unless explicitly described as optional. See also optional requirement.

5.2.8 *load port* — the interface location on a tool where wafer carriers are delivered. It is possible that wafers are not removed from, or inserted into, the carrier at this location.

5.2.9 *message interleaving* — the practice of sending a new message request before receiving the reply to an earlier request.

5.2.10 *Multiple Wafer ID Reader controller* — a unit controlling the Reader function of one or multiple ID Reader Heads, communicates the command/data with the equipment controller or the equivalent controller such as equipment controller.

5.2.11 *optional capability* — a specification that is not required for an implementation to be compliant to a standard. See also fundamental requirement.

5.2.12 *reader head* — a structured portion which functions to detect the ID code. The ID reader unifying a head function inside its body can be placed as a head. The ID reader not unifying a head function will be located separately from the head.

5.2.13 *substrate handler* — a physical subsystem which transfers substrates between the carriers and the process part of the equipment.

5.2.14 *upstream controller* — a controller that directs the Wafer ID Reader through the communication interface.

5.2.15 *Wafer ID* — an identifier for a wafer. A value that uniquely identifies a given wafer in a factory. The identifier may be represented physically with LASER technologies, etc.

5.2.16 *Wafer ID mark* — a physical structure for storing Wafer ID and other information.

5.2.17 *Wafer ID Reader* — a unit (subsystem) that detects and decodes data from the Wafer ID mark, and that communicates with the upstream controller. Wafer ID Reader may be composed of Multiple Wafer ID Reader controller and reader heads.

5.3 *Data Types*

5.3.1 *enumerated* — may take on one of a limited set of possible values. These values may be given logical names, but they may be represented by any single-item data type.

5.3.2 *form* — type of data: positive integer, unsigned integer, integer, floating point (float), enumerated, boolean, text, formatted text, structure, list, ordered list.

5.3.3 *integer* — may take on the value of any negative or unsigned integer. Messaging protocol may impose a limit on the range of possible values.

5.3.4 *structure* — a specific set of items, of possibly mixed data types, in a specified arrangement.

5.3.5 *text* — a character string. Messaging protocol may impose restrictions, such as length or ASCII representation.

5.3.6 *unsigned integer* — may take on the value of any positive integer or zero. Messaging protocol may impose a limit on the range of possible values.

6 Conventions

6.1 *State Model Methodology*

6.1.1 This document uses the Harel state chart convention for describing dynamic operation of defined objects. The outline of this convention is described in an attachment of SEMI E30. The official definition of this convention is described in “State Charts: A Visual Formalism for Complex Systems” written by D. Harel in Science of Computer Programming 8, 1987[2].

6.1.2 Transition tables are provided in conjunction with the state diagrams to explicitly describe the nature of each state transition. A transition table contains columns for Transition number, Previous State, Trigger, New State, Actions, and Comments. The “trigger” (column 3) for the transition occurs while in the “previous” state. The “actions” (column 5) includes a combination of:

- Actions taken upon exit of the previous state.
- Actions taken upon entry of the new state.
- Actions taken which are most closely associated with the transition.

6.1.2.1 No differentiation is made between these cases.

6.2 *Object Notation*

6.2.1 The object models in Related Information 2 use the Object Modeling Technique (OMT) developed by Rumbaugh, James, et al, in Object-Oriented Modeling and Design[3]. An overview of this notation is provided in SEMI E39, Object Services Standard: Concepts, Behavior, and Services.

Num	*Previous State*	*Trigger*	*New State*	*Actions*	*Comments*

6.3 *Service Message Representation*

6.3.1 Services are functions or methods that may be provided by either the equipment or the host. A service message may be either a request message, which always requires a response, or a notification message, that does not require a response.

6.3.2 *Service Definition*

6.3.2.1 A service definition table defines the specific set of messages for a given service resource, as shown in the following table:

Message Service Name	*Type*	*Description*

Type can be either “N” = Notification or “R” = Request & Response.

6.3.2.2 Notification type messages are initiated by the service provider (e.g., the equipment) and the provider does not expect to get a response from the service user. Request messages are initiated by a service user (e.g., the host). Request messages ask for data or an activity from the provider. Request messages expect a specific response message (no presumption on the message content).

6.3.3 *Service Parameter Dictionary*

6.3.3.1 A service parameter dictionary table defines the description, format and its possible value for parameters used by services, as shown in the following table:

2 Elsevier Science, P.O. Box 945, New York, NY 10159-0945, http://www.elsevier.nl/homepage/browse.htt

3 James Rumbaugh, Michael Blaha, William Premerlani, Frederick Eddy, William Lorensen, Object-Oriented Modeling and Design, Englewood Cliffs, New Jersey: Prentice-Hall, 1991.

Parameter Name	*Description*	*Format: Possible Value*

6.3.3.2 A row is provided in the table for each parameter of a service.

6.3.4 *Service Message Definition*

6.3.5 A service message definition table defines the parameters used in a service, as shown in the following table:

Parameter	*Req/Ind*	*Rsp/Cnf*	*Comment*

6.3.5.1 The columns labeled REQ/IND and RSP/CNF link the parameters to the direction of the message. The message sent by the initiator is called the “Request”. The receiver terms this message the “Indication” or the request. The receiver may then send a “Response” which the original sender terms the “Confirmation”.

6.3.5.2 The following codes appear in the REQ/IND and RSP/CNF columns and are used in the definition of the parameters (e.g., how each parameter is used in each direction):

Code	*Description*
M	Mandatory Parameter — Must be given a valid value.
C	Conditional Parameter — May be defined in some circumstances and undefined in others. Whether a value is given may be completely optional or may depend on the value of the other parameter.
U	User-Defined Parameter.
-	The parameter is not used.
=	(For response only.) Indicates that the value of this parameter in the response must match that in the primary (if defined).

7 Overview

7.1 The Wafer ID Reader Model defines the behavior and services (functions). The Wafer ID Reader is a small intelligent system, typically used as a subsystem within equipment.

7.1.1 The primary functionality of the Wafer ID Reader is to read the identifier of the wafer (Wafer ID).

7.1.2 The acronym WIDR is used to refer to the Wafer ID Reader.

7.1.3 An object model for the WIDR is provided in Related Information 2 – Object Model.

7.2 *Number of Heads*

7.2.1 A WIDR provides one or more ID reader heads and is connected to an upstream controller by a single interface. This allows the upstream controller to control either one head or multiple heads using the same interface specification.

7.2.2 *Single Head Configuration*

7.2.2.1 In the case of a single head, the head may be presented as an integrated part of the WIDR.

7.2.3 *Multiple Head Configuration*

7.2.3.1 In the case of multiple heads, some services are logically performed by the WIDR, and the individual heads logically perform others. The individual heads are numbered sequentially and may be referenced individually by the upstream controller. Note that the upstream controller does not communicate directly with the heads. All communications are between the upstream controller and the WIDR unit.

7.2.3.2 In the multi-head case, the WIDR shall allow independent control of the heads. Multiple transactions invoking services performed by the individual heads may be open at the same time. For example, when a read command is sent to one head, the host can send additional commands such as a read command and a status confirmation command to another head before the first head sends the response to the first command.

7.3 *Upstream Controller*

7.3.1 The WIDR provides certain services when requested by the upstream controller. The upstream controller sends a message requesting the specified service, and the WIDR sends a message with the response.

7.3.2 This standard assumes that an upstream controller initiates each service message to the WIDR, and the WIDR sends its response to the upstream controller. The upstream controller must watch the response time to monitor the communication timeout. This standard will define the recommended method for handling exceptions caused by timeouts.

7.3.3 In addition, some WIDR may provide asynchronous notification to the upstream controller. Examples of this include, but are not limited to, the detection of a fault condition resulting in an alarm. Asynchronous notification is not required for compliance to this standard.

8 Attributes

8.1 An attribute is an item of information about an entity that is maintained and is available by request. There is certain information concerning the WIDR that is of potential interest to the upstream controller, including the manufacturer, the model, and the serial number of the device. This information is considered as attributes of the WIDR and is available on request.

8.2 *WIDR Attribute Definition Table*

8.2.1 Table 1 defines the attributes of the WIDR subsystem.

Table 1 WIDR Attribute Definitions

Attribute Name	*Description*	*Access*	*Reqd*	*Form*
Fundamental				
Configuration	Number of heads.	RO	Y	Text
AlarmStatus	Current WIDR substate of ALARM STATUS.	RO	Y	Enumerated: 0 = NO ALARMS 1 = ALARMS
OperationalStatus	Current WIDR substate of OPERATIONAL.	RO	Y	Enumerated: IDLE BUSY MAINTENANCE
SoftwareRevisionLevel	Revision (version) of software.	RO	Y	Text
Optional				
DateInstalled	Date the subsystem was installed.	RO	N	Protocol dependent.
DeviceType	Identifiers subsystem as a WIDR.	RO	N	WIDR (Text)
HardwareRevisionLevel	Revision number of the hardware.	RO	N	Text
MaintenanceData	Supplier dependent.	RO	N	Text
Manufacturer	The name or identifier of the manufacturer.	RO	N	Protocol dependent.
ModelNumber	The manufacturers model designation.	RO	N	Text
SerialNumber	Subsystem serial number assigned by manufacturer.	RO	N	Protocol dependent.

8.3 *Reader Head Attributes*

8.3.1 Table 2 defines the attributes for the Reader Head.

NOTE 2: In the case of an integrated single head, the attributes in Table 2 are regarded as an extension of Table 1.

8.3.2 In the case of multiple heads, it must be possible to distinguish between the attributes of different heads.

Table 2 Reader Head Attribute Definitions

Attribute Name	*Description*	*Access*	*Reqd*	*Form*
Fundamental				
HeadStatus	The current state.	RO	Y	Enumerated: IDLE BUSY NOT OPERATING
HeadID	Head number 0–31.	RO	Y if multi-head	Text. 2 digits.
Optional				
HeadCondition	The current Maintenance status.	RO	N	Enumerated: No alarms Needs Maintenance Read fault
HeadDateInstalled	Date this head was installed.	RO	N	Protocol dependent.
HeadMaintenance-Data	Supplier dependent.	RO	N	Text

9 State Models

9.1 To facilitate independent control of the individual heads, this section defines two separate state models, one for WIDR subsystem and one to be applied to each of the individual heads.

9.2 *WIDR State Model*

9.2.1 This section defines the state model for the WIDR subsystem. Figure 1 shows the diagram for this model.

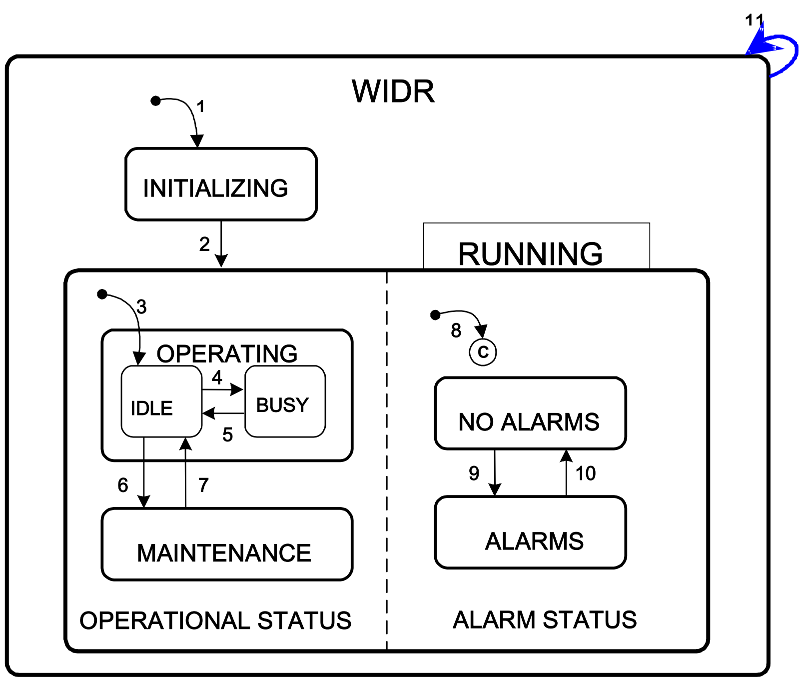


Figure 1
WIDR State Model Diagram

9.2.2 Table 3 defines the states of the WIDR. Definitions are in alphabetical order.

Table 3 WIDR Subsystem State Definitions

State	*Definition*
ALARM STATUS	Shows the presence or absence of alarms.
ALARMS	An alarm condition exists.
BUSY	A service is being performed that affects the state of the hardware.
WIDR	Superstate of WIDR State Model. Always active when WIDR powered on.
IDLE	No service is being performed. All heads are idle.
INITIALIZING	WIDR is performing initialization and self diagnostics. Presence or absence of alarms is initially determined in this state.
NO ALARMS	No alarm conditions exist.
OPERATING	Normal operational states where reading operations can be performed.
OPERATIONAL STATUS	The WIDR is fully capable of performing all services that it supports.
RUNNING	The WIDR is operational and able to communicate.
MAINTENANCE	Internal setup and maintenance activities.

9.2.3 Table 4 defines the transitions of the WIDR State Model.

Table 4 WIDR State Transitions

#	*Previous State*	*Trigger*	*New State*	*Actions*	*Comments*
1	(Any)	Power-up or reset.	INITIALIZING	Initialize hardware and software components.	Default entry on power-up.
2	INITIALIZING	Initialization is complete.	RUNNING	None	The WIDR is now able to communicate.
3	INITIALIZING	Default entry into OPERATING.	IDLE	None	Internal
4	IDLE	A service request to read or perform diagnostics is received.	BUSY	None	
5	BUSY	All service requests that affect the state of the hardware are completed.	IDLE	None	
6	IDLE	A user selects the MAINTENANCE state and all heads are idle.	MAINTENANCE	None	The upstream controller may send a request or the operator may set a switch to select the OPERATING or the MAINTENANCE state. Maintenance and setup activities may now be performed.
7	MAINTENANCE	A user selects the OPERATING state and all heads are idle.	IDLE	None	The upstream controller may send a request or the operator may set a switch to select the OPERATING or the MAINTENANCE state. Normal operating activities may now be performed.
8	INITIALIZING	Default entry into ALARM STATUS.	ALARMS or NO ALARMS	None	
9	NO ALARMS	An alarm condition is detected.	ALARMS	None	

#	Previous State	Trigger	New State	Actions	Comments
10	ALARMS	All alarm conditions have cleared.	NO ALARMS	None	
11	Any	A reset service request is received.	WIDR	None	

9.3 *Read Head State Model*

9.3.1 For a WIDR with multiple heads, this state model shall be provided for each Read Head.

9.3.2 For the single head case, these states are covered in the WIDR state model and no additional state model for the head is required. IDLE and BUSY correspond to substates of the same names in the WIDR state model. If any head is NOT OPERATING, then the active substate of ALARM STATUS in the WIDR state model is ALARMS.

9.3.3 The NOT OPERATING state is not required, if it is not possible to detect alarms related to the head. Note also that some alarm conditions are fatal (so that the head cannot operate with full functionality) while others may not be fatal.

9.3.4 Figure 2 shows the diagram for the Read Head State Model.

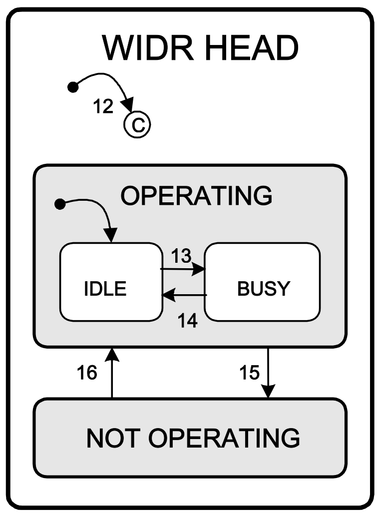


Figure 2
Read Head State Model

9.3.5 Table 5 defines the states for the Read Head.

Table 5 Read Head State Definitions

State	*Definition*
NOT OPERATING	Head is in a non-operational state or has reduced functionality. Maintenance is required.
OPERATING	Head is active and fully functional.
IDLE	Head is not performing a service.
BUSY	Head is performing a service.

9.3.6 Table 6 defines the transitions of the Read Head State Model.

Table 6 Read Head State Transitions

#	Previous State	Trigger	New State	Actions	Comments
12	(unknown)	Initialization on power-up or reset.	Either NOT OPERATING or OPERATING.	None	Default entry on power-up.

#	Previous State	Trigger	New State	Actions	Comments
13	IDLE	Request to perform a service.	BUSY	None	
14	BUSY	Completion of service.	IDLE	None	
15	OPERATING	An alarm condition is detected.	NOT OPERATING	None	
16	NOT OPERATING	Self-Diagnostic Service.	OPERATING	None	All alarm conditions are clear.

10 Alarm Conditions

10.1 An alarm condition exists whenever one or more faults or exceptions that interfere with normal read operations is detected. A maintenance condition exists when the WIDR determines the need for either maintenance (repair) or preventive maintenance activities.

10.2 The WIDR is able to detect and report alarm conditions through its status attributes (when queried by the upstream controller). It may additionally report changes in alarm conditions asynchronously through alarm or event reports.

11 Services

11.1 To be compliant with this standard, the WIDR shall support all services that are indicated as required. In addition, if the WIDR provides other services that have the same or similar functionality as services defined in this document, then compliance to this standard requires they shall satisfy the requirements of the service as defined.

11.2 *List of Services*

11.2.1 Table 7 lists the services defined by this standard and indicates which are optional and which are required.

Table 7 List of Services

Service Name	*Description*
Fundamental Requirements	
GetAttributes	Get specified information about the WIDR.
GetStatus	Get the current status of the WIDR.
ReadWID	Read WID.
Optional Capabilities	
ChangeState	Change to MAINTENANCE state or to OPERATING state.
PerformDiagnostics	Perform diagnostic tests.
Reset	Reset WIDR hardware and software.
SetAttributes	Write specified information.
ReadWIDC	Read WID with 2D Code Read Condition.

11.3 *Parameter Definitions*

11.3.1 Table 8 defines the parameters that are used in one or more services, including individual items within parameter structures. Parameters are listed in alphabetical order.

Table 8 Parameter Definitions

Parameter	*Form*	*Description*
Action	Protocol-specific.	Specifies diagnostic action to perform.
Attribute ID	Text	Attribute identifier. Name of attribute.
Attribute Value	Varies with attribute.	Attribute value.

Parameter	Form	Description
Wafer ID	Text	User data compliances with SEMI Standard.
Head ID	Number 0–31.	Identifies either an individual head (non-zero) or the WIDR subsystem itself (zero).
PM Information	Enumerated: -Normal execution -Maintenance required	Preventive Maintenance Information.
Result Status	Enumerated: -Normal operation -Execution Error -Communication Error -Hardware Error	Result information on the status of the request concerning the service request. *Execution Error*: Cannot Read ID sequence. But equipment is normal. *Communication Error*: syntax error of Message or Message format or Value. *Hardware Error*: ID reader head fault, ID reader head is powered off.
Status	Structure	Information about the status of the WIDR. Consists of PM Information and the current values of the WIDR attributes AlarmStatus, OperationalStatus, and HeadStatus.
2D Code Read Condition	Structure	2D Code Condition for Preventive Maintenance. Cell Size: Number of Pixels in a Cell. Contrast: Contrast Percentage of Dark / Light. Damage Percent: Percentage of Damage Cell. Number Error Bits: Number of the Damage Cell Read Time: Time for Readout. Matrix Style: Normal Mode or Mirror Mode. Matrix Polarity : Dark on Light or Light on Dark.

11.4 *Service Definitions*

11.4.1 This section defines the parameters used for each WIDR service.

11.4.2 *ChangeState*

11.4.2.1 ChangeState is an optional service that requests the WIDR to change its operational substate to MAINTENANCE or to OPERATING. Table 9 defines the parameters used for the ChangeState service.

Table 9 ChangeState Service Definition

Parameter	Req/Ind	Rsp/Conf	Description
StateRequest	M	-	Specifies either MAINTENANCE or OPERATING substate.
Result Status	-	M	Result information on the status of the request.
Status	-	M	Status information.

11.4.3 *Get Attributes*

11.4.3.1 Get Attributes is a required service used to request the attributes of the WIDR.

Table 10 Get Attributes Service Definition

Parameter	Req/Ind	Rsp/Conf	Description
Head ID	M	M	Specifies Head or Subsystem.
(list of) Attribute ID	M	-	Identifiers of one or more attributes.
(list of) Attribute Value	-	M	Attribute Values in order as requested.
Result Status	-	M	Result information on the status of the request.

11.4.4 *Get Status*

11.4.4.1 Get Status is a required service used to get the current status of the WIDR. The upstream controller may request current status at any time.

Table 11 Get Status Service Definition

Parameter	*Req/Ind*	*Rsp/Conf*	*Description*
Head ID	M	M	Specifies Head or Subsystem.
Result Status	-	M	Result information on the status of the request.
Status	-	M	Status information.

11.4.5 *Perform Diagnostics*

11.4.5.1 Perform Diagnostics is an optional service used to request the WIDR perform its internal diagnostics. The supplier shall document the specific diagnostics performed.

Table 12 Perform Diagnostics Service Definition

Parameter	*Req/Ind*	*Rsp/Conf*	*Description*
Head ID	M	M	Specifies Head or Subsystem.
Action	C		Specifies diagnostic action to perform.
Result Status	-	M	Result information on the status of the request.
Status	-	M	Status information.

11.4.6 *Read WID*

11.4.6.1 Read WID is used to request the WID be read by an ID Reader Head. This service is a fundamental requirement.

Table 13 Read WID Service Message Parameter Definition

Parameter	*Req/Ind*	*Rsp/Conf*	*Description*
Head ID	M	M	Specifies Head.
Wafer ID	-	M	Wafer ID.
Result Status	-	M	Result information on the status of the request.
Status	-	M	Status information.

11.4.7 *Reset*

11.4.7.1 Reset is used to re-initialize the WIDR.

Table 14 Reset Service Definition

Parameter	*Req/Ind*	*Rsp/Conf*	*Description*
Result Status	-	M	Result information on the status of the request.

11.4.8 *Set Attributes*

11.4.8.1 Set Attributes is used to set attributes of the WIDR. This is an optional service. Attempts to set attributes with read-only (RO) access shall be denied. Attribute values returned are those as read following the set operation.

Table 15 Set Attributes Service Definition

Parameter	*Req/Ind*	*Rsp/Conf*	*Description*
Head ID	M	M	Specifies Head or Subsystem.
Attribute ID	M	-	AttributeIDs.

Parameter	*Req/Ind*	*Rsp/Conf*	*Description*
Attribute Values	M	-	Attribute Values.
Result Status	-	M	Result information on the status of the request.
Status	-	M	Status information.

11.4.9 Read WIDC is used to read the Wafer ID with the 2D Code Read Condition. This is an optional service.

Table 16 Read WIDC Service Definition

Parameter	*Req/Ind*	*Rsp/Conf*	*Description*
Head ID	M	M	Specifies Head.
Wafer ID	-	M	Wafer ID.
Result Status	-	M	Result information on the status of the request.
Status	-	M	Status information.
2D Code Condition	-	M	2D Code Read Condition.

11.5 *Service Operability*

11.5.1 Some services are performed by the WIDR and others are logically performed by the individual heads. It is expected that the WIDR will support multiple interleaved transactions to the various independent logical units. Table 17 shows which of the various services can be performed by the WIDR when the WIDR and its heads are in various individual states. Note that when in the initializing state after power-up or the reset service, the WIDR may not be able to communicate.

Table 17 Valid Services per State

	Service							
	Set Attributes	*Reset*	*Read WID*	*Perform Diagnostics*	*Get Status*	*Get Attributes*	*ChangeState*	*Read WIDC*
WIDR State								
INITIALIZING								
IDLE	X	X	X	X	X	X	X	X
BUSY						X		
MAINTENANCE	X	X	X	X	X	X	X	X
Head State								
NOT OPERATING						X		
IDLE						X		
BUSY						X		

12 Event Notifications

12.1 Event Notification is an optional capability where the WIDR is able to detect events and report state and status changes independently of a service request from the upstream controller.

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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RELATED INFORMATION 1
SCENARIOS

NOTE: This related information is not an official part of SEMI E118 and was derived from work of the originating task force. This related information was approved for publication by full letter ballot procedures on July 19, 2002.

R1-1 Examples

R1-1.1 This section provides examples of typical scenarios for a WIDR with two read heads.

Table R1-1 Reset Scenario

Controller	*WIDR*			*Head1*		*Head2*	
Msg.	*Msg.*	*Action*	*State*	*Action*	*State*	*Action*	*State*
Reset→		Perform Reset	OPERATING or MAINTENANCE		OPERATING		OPERATING
	←Reset Reply		OPERATING or MAINTENANCE		OPERATING		OPERATING

Table R1-2 Get Status Scenario

Controller	*WIDR*			*Head1*		*Head2*	
Msg.	*Msg.*	*Action*	*State*	*Action*	*State*	*Action*	*State*
Get Status 0→		Determine Status	OPERATING or MAINTENANCE		Any		Any
	←Status Reply		Same		Any		Any

Table R1-3 Scenario for Interleaved Read WID from Both Head

Controller	*WIDR*			*Head1*		*Head2*	
Msg.	*Msg.*	*Action*	*State*	*Action*	*State*	*Action*	*State*
Read WID 01→			OPERATING	Start Read	BUSY		IDLE
Read WID 02→			OPERATING		BUSY	Start Read	BUSY
	←Read WID Reply 01		OPERATING		IDLE		BUSY
	←Read WID Reply 02		OPERATING		IDLE		IDLE

RELATED INFORMATION 2
OBJECT MODEL

NOTE: This related information is not an official part of SEMI E118 and was derived from work of the originating task force. This related information was approved for publication by full letter ballot procedures on July 19, 2002

R2-1 Object Model Notes

R2-1.1 Object models provide a graphic representation of entities. The models in this section use the Object Modeling Technique (OMT) described in Object-Oriented Modeling and Design. Object types are represented by rectangles with one, two, or three sections. The name of the object type is in the first, or only section. Attributes, information about the object, are shown in the second section. Operations or services are shown in a third section. Lines between objects represent relationships.

R2-1.2 Three models are shown for purposes of illustration. The general multi-head case is shown first with only the required attributes and services. Next, the full model for the multi-head case is shown with all attributes and services defined in this standard. Finally, the full model for the integrated single-head case is shown.

R2-1.3 Note that the Upstream Controller sends all service requests to the WIDR controller, including services shown for the individual heads. Services shown on these models for WIDR are those with a Head ID service parameter value of zero while services shown for the Head are those with a Head ID service parameter value between one and thirty-one.

R2-2 Fundamental Requirements Example Object Models

R2-2.1 The object model in Figure R2-1 shows objects for the general (multi-head) WIDR satisfying fundamental requirements only. It shows the WIDR subsystem as made up of one or more heads. It also illustrates the required attributes and services provided by the WIDR and its relationships with its upstream controller and with its heads.

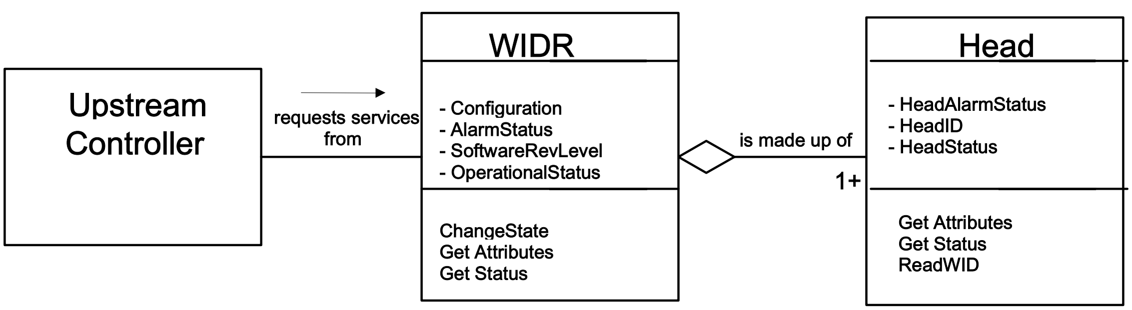

Figure R2-1
Object Model for Fundamental Requirements

R2-3 Full Capabilities

R2-3.1 Figure R2-2 shows the object model for a WIDR with full capabilities, so that all optional attributes and services are supported.

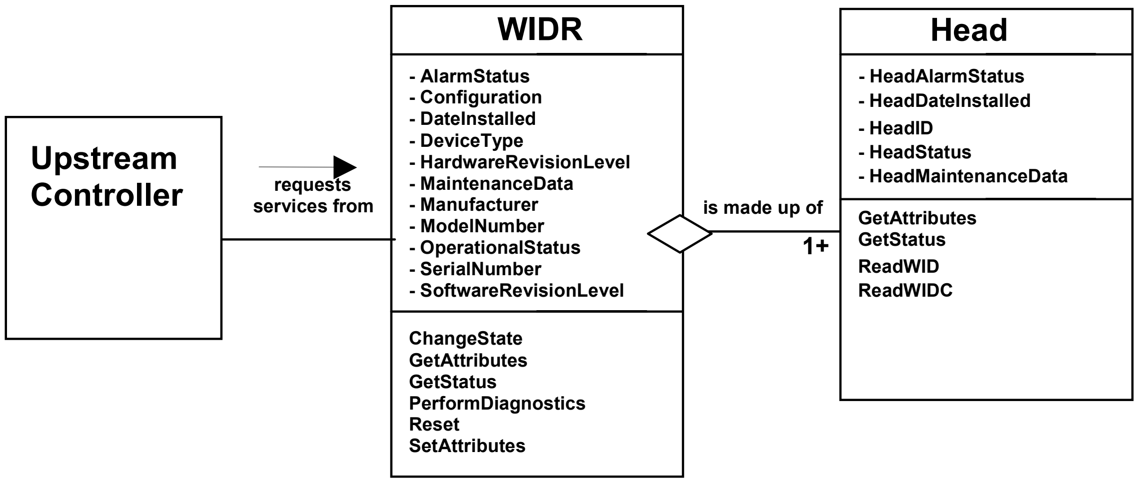

Figure R2-2
Object Model for Full Capabilities

R2-4 Integrated Model

R2-4.1 Figure R2-3 shows the object model for a WIDR with full capabilities and a single integrated head. The head is not shown as a separate component in this case, and the head attributes and services have become part of the WIDR subsystem itself.

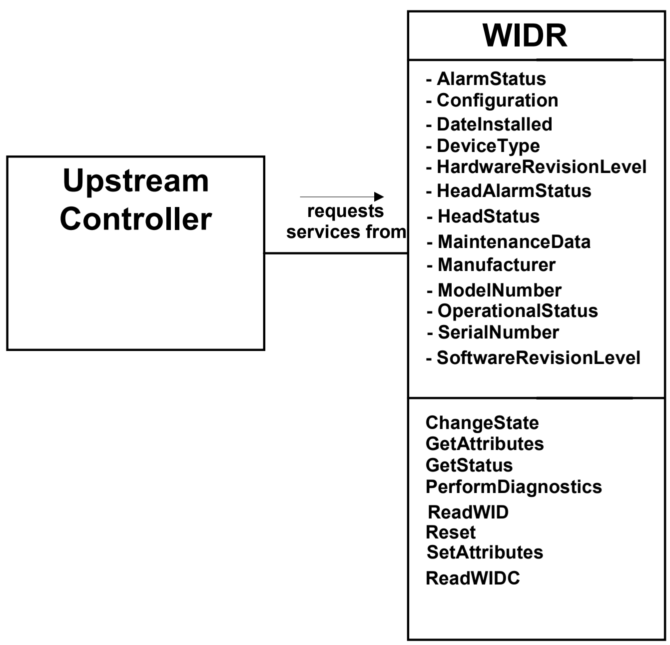

Figure R2-3
Integrated Model with Full Capabilities

RELATED INFORMATION 3
APPLICATION NOTES

NOTE: This related information is not an official part of SEMI E118 and was derived from work of the originating task force. This related information was approved for publication by full letter balot procedures on July 19, 2002.

R3-1 Combined State Model

R3-1.1 Figure R3-1 shows the combined state model for the WIDR unit with nn heads, from HEAD01 TO HEADnn. The WIDR is considered as IDLE when and only when it is in OPERATING and all of its heads are IDLE.

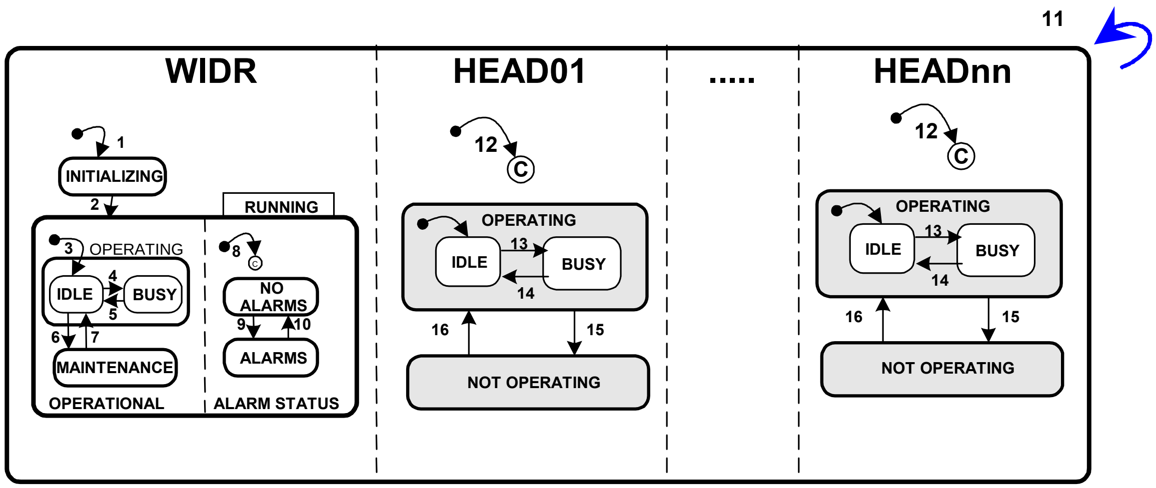

Figure R3-1
Combined State Model

SEMI E118.1-1104
SPECIFICATION FOR SECS-I AND SECS-II PROTOCOL FOR WAFER ID READER COMMUNICATION INTERFACE STANDARDS

This specification was technically approved by the Global Information and Control Committee and is the direct responsibility of the Japanese Information and Control Committee. Current edition approved by the Japanese Regional Standards Committee on July 23, 2004. Initially available at www.semi.org September 2004; to be published November 2004. Originally published March 2003; last published March 2004.

1 Purpose

1.1 This document maps the services and data of the Wafer ID Reader (WIDR) standard to SECS-II streams and functions and data definitions.

2 Scope

2.1 This document applies to all implementations of WIDR that use the SECS-II message protocol (SEMI E5).

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

3 Referenced Standards

3.1 *SEMI Standards*

SEMI E4 — SEMI Equipment Communications Standard 1 Message Transfer (SECS-I)

SEMI E5 — SEMI Equipment Communications Standard 2 Message Content (SECS-II)

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

4 Terminology

4.1 *Abbreviations and Acronyms*

4.1.1 *SECS* — SEMI Equipment Communications Standard

4.1.2 *WIDR* — Wafer ID Reader

5 Physical Requirements

5.1 The WIDR using the SECS-I protocol shall use a 9-pin female connector.

6 Service Message Mapping

6.1 Table 1 shows the specific SECS-II streams and functions that shall be used for SECS-II implementations of the service messages defined in SEMI E118.

6.2 Request and notification messages are mapped to primary (odd-numbered) SECS-II functions and response messages are mapped to secondary (even-numbered) SECS-II functions.

6.3 In some cases, a common set of parameters allows more than one service to be mapped to the same stream and function, with an additional SECS-II data item used to differentiate between the two services.

Table 1 Services Mapped to SECS-II Messages

Message Name	*Stream,Function*	*SECS-II Name*
ChangeState	S18,F13/F14	Subsystem Command Request/Acknowlege
Get Attributes	S18,F1/F2	Read Attribute Request/Data
Get Status	S18,F13/F14	Subsystem Command Request/Acknowledge
Perform Diagnostics	S18,F13/F14	Subsystem Command Request/Acknowledge
Read WID	S18,F9/F10	Read ID Request/Data
Reset	S18,F13/F14	Subsystem Command Request/Acknowledge
Set Attributes	S18,F3/F4	Write Attribute Request/Acknowledge
Read WIDC	S18,F15/F16	Read 2D Code Condition Request/Data

7 Service Parameter to Data Item Mapping

7.1 Table 2 shows the mapping between message parameters defined by WIDR and data items defined by SECS-II. For parameters specified in the definitions of a WIDR service, either the parameters themselves, or individual elements of complex parameters, map to a specific data item.

Table 2 Service Parameters to Data Item Mapping

Parameter Name	*SECS-II Data Item*	*Format*	*Values*
Attribute ID	ATTRID	20	Name of attribute
Attribute Value	ATTRVAL	20	
HeadID	TARGETID	20	"00"-"31" Identifies either an individual head ("01"-"31") or the WIDR subsystem itself ("00").
PM Information	STATUS	20	"NE" = Normal execution, "MR" = Maintenance required
Result Status	SSACK	20	"NO" = Normal operation; "EE" = Execution error; "CE" = Communication error; "HE" = Hardware error
StateRequest	CPVAL	20	"OP", "MT"
Status	STATUSLIST	L,4 1. <PMInformation> 2. <AlarmStatus> 3. <OperationalStatus> 4. <HeadStatus>	Current values of PM Information with the corresponding attributes for WIDR and Head (if applicable). See Tables 4 and 5.
Wafer ID	MID	20	
2D Code Read Condition	CONDITIONLIST	L,7 1. <Cell Size> 2. <Contrast> 3. <Damage Percent> 4. <Number Error Bits> 5. <Read Time> 6. <Matrix Style> 7. <Matrix Polarity>	Current values of Cell Size, Contrast, Damage Percent, Number Error Bits, Read Time, Matrix Style, Matrix Polarity with the corresponding attributes for Code Condition. See Table 6. CONDITIONLIST data shall be formatted in the fixed order as in Format column.

NOTE 1: There are also data items used in SECS-II messages that do not map to specific services parameters. Services with the same set of parameters are mapped to the same SECS-II message by adding an additional data item to differentiate between the services. Table 3 contains the SECS-II data items that have not a corresponding WIDR service parameter.

Table 3 Additional Data Requirements Table

SECS-II Data Item	*Function*	*Value*
SSCMD	Used to differentiate between different subsystem commands indicated.	"ChangeState" "GetStatus" "Perform Diagnostics" "Reset"

8 Data

8.1 *WIDR Attributes*

8.1.1 Table 4 specifies the values for the WIDR attribute identifiers and limitations on values.

Table 4 WIDR Attribute Definitions

Attribute Name	*Description*	*Access*	*Format*	*Value*
Fundamental				
"Configuration"	Number of heads.	RO	20	"01"–"31"
"AlarmStatus"	Current WIDR substate of ALARM STATUS.	RO	20	"0" = NO ALARMS "1" = ALARMS
"OperationalStatus"	Current WIDR substate of OPERATIONAL.	RO	20	"IDLE", "BUSY", "MANT"
"SoftwareRevisionLevel"	Revision (version) of software.	RO	20	8 byte maximum
Optional				
"DateInstalled"	Date the subsystem was installed.	RO	20	"YYYYMMDD" format
"DeviceType"	Identifies subsystem as a Wafer ID Reader.	RO	20	"WIDR"
"HardwareRevisionLevel"	Revision number of the hardware.	RO	20	8 byte maximum
"MaintenanceData"	Supplier dependent.	RO	20	80 byte maximum
"Manufacturer"	The name or identifier of the manufacturer.	RO	20	20 byte maximum
"ModelNumber"	The manufacturers model designation.	RO	20	20 byte maximum
"SerialNumber"	Subsystem serial number assigned by manufacturer.	RO	20	20 byte maximum

8.2 *Read Head Attributes*

8.2.1 Table 5 shows the format and values for the Read Head.

Table 5 Read Head Attribute Definitions

Attribute Name	*Description*	*Access*	*Format*	*Value*
Fundamental				
"HeadStatus"	The current state.	RO	20	"IDLE", "BUSY", "NOOP"
"HeadID"	Head number 0–31.	RO	20	2 digits, "00" through "31".
Optional				
"HeadCondition"	The current Maintenance status.	RO	20	Enumerated: "NO" = No alarms "NM" = Needs maintenance "NP" = No power "RW" = Read fault
"HeadDateInstalled"	Date this head was installed.	RO	20	"YYYYMMDD" format
"HeadMaintenanceData"	Supplier dependent.	RO	20	Text

8.3 *2D Code Read Condition Attributes*

8.3.1 Table 6 specifies the values for the 2D Code Read Condition attribute identifiers and limitations on values.

Table 6 2D Code Read Condition Attribute Definitions

Attribute Name	*Description*	*Access*	*Format*	*Value*
Optional				
“CellSize”	Number of Pixels in a Cell	RO	20	“000”–“999”
“Contrast”	Contrast Percentage of Dark / Light	RO	20	“000”–“100”
“Damage Percent”	Percentage of Damage Cell	RO	20	“000”–“100”
“Number Error Bits”	Number of the Damage Cell	RO	20	“000”–“999”
“Read Time”	Time for Readout, in seconds	RO	20	“000”–“120”
“Matrix Style”	Normal Mode or Mirror Mode	RO	20	“NO” = Normal Mode “MR” = Mirror Mode
“Matrix Polarity”	Dark on Light or Light on Dark	RO	20	“DON” = Dark on Light “LON” = Light on Dark

To show that data is not available for an attribute, the attribute value is set to a zero-length string.

Note 1: A zero-length item for an attribute value means that does not exist.

RELATED INFORMATION 1
SCENARIOS

NOTICE: This related information is not an official part of SEMI E118.1 and was derived from the work of the originating task force. This related information was approved for publication by full letter ballot procedures on January 10, 2003.

This section provides examples of typical scenarios for a Wafer ID Reader.

R1-1 Read WID

R1-1.1 The upstream controller sends a Read WID Request message to the WIDR for Head 1. The WIDR Head 1 reads the ID, and the WIDR returns the ID to the upstream controller.

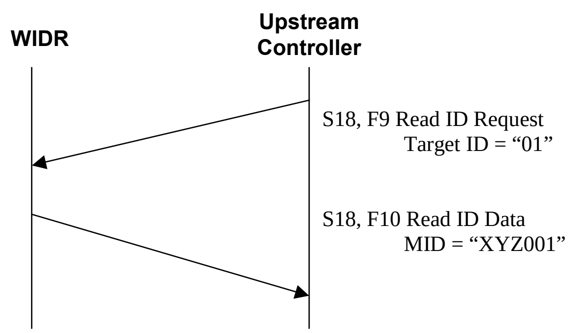

Figure R1-1
Read WID Scenario

R1-2 Read WID

R1-2.1 The upstream controller sends a Read WID Request message to the WIDR for Head 1. The WIDR Head 1 reads the ID, but the WIDR can't read the ID. There isn't the ID on the wafer.

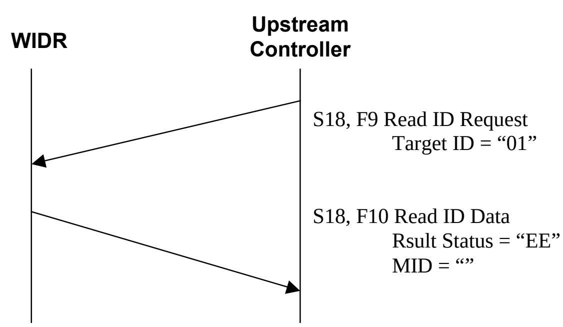

Figure R1-2
Read WID Scenario

SEMI E119-1104
MECHANICAL SPECIFICATION FOR REDUCED-PITCH FRONT-OPENING BOX FOR INTERFACTORY TRANSPORT OF 300 mm WAFERS

This specification was technically approved by the Global Physical Interfaces and Carriers Committee and is the direct responsibility of the North American Physical Interfaces and Carriers Committee. Current edition approved by the North American Regional Standards Committee on August 16, 2004. Initially available at www.semi.org September 2004; to be published November 2004. Originally published November 2002.

1 Purpose

1.1 This standard partially specifies a reduced-pitch front-opening box for interfactory transport of 300 mm wafers (FOBIT). This reduced-pitch box, with a capacity of 25 wafers but with the approximate physical volume of a 13-wafer FOUP, is intended to reduce the cost of transporting wafers between IC manufacturing sites. To leverage current industry 300 mm technology, this reduced-pitch front-opening box is intended to interface with 13-wafer FIMS, as specified in SEMI E62.

2 Scope

2.1 This standard is intended to set an appropriate level of specification that places minimal limits on innovation while ensuring modularity and inter-changeability at all mechanical interfaces. Only the physical interfaces for FOBIT are specified; no materials requirements or micro-contamination limits are given. However, this standard has been written so that both metal and injection-molded plastic FOBITs can be manufactured in conformance with it.

2.2 This standard assumes that the FOBIT is intended for use in the interfactory transportation of wafers. The following boundary conditions were used in the creation of this specification:

- Minimizing the pitch between wafers will reduce the cost of transporting wafers.
- The FOBIT will be used for interfactory transportation of both processed and unprocessed wafers.
- The box will have a 25-wafer capacity.
- Random access of wafers, using edge grip handling devices, is not a requirement for this standard.
- The FOBIT will be compatible with the following 300 mm Standards:
- 13-wafer FIMS Interface (SEMI E62)
- 300 mm Load Port (SEMI E15.1)
- Kinematic Coupling (SEMI E57)
- The FOBIT will not necessarily be compliant with the following 300 mm Standards due to wafer restraint requirements and product applications during transportation:
- 300 mm Front-Opening Unified Pod (SEMI E47.1)
- 300 mm Open Cassette (SEMI E1.9)
- 300 mm Front-Opening Shipping Box (SEMI M31)
- The technical requirements of this standard are written for the transportation of nominal thickness wafers, as defined by SEMI M1.15.

2.3 This reduced-pitch, 25-capacity FOBIT is designed for use with the 13-capacity FIMS interface, as specified in SEMI E62.

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

3 Referenced Standards

3.1 *SEMI Standards*

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

SEMI E15 — Specification for Tool Load Port

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

SEMI E47.1 — Provisional Mechanical Specification for Boxes and Pods Used to Transport and Store 300 mm Wafers

SEMI E57 — Mechanical Specification for Kinematic Couplings Used to Align and Support 300 mm Wafer Carriers

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

SEMI M1.15 — Standard for 300 mm Polished Monocrystalline Silicon Wafers (Notched)

SEMI M31 — Provisional Mechanical Specification for Front-Opening Shipping Box Used to Transport and Ship 300 mm Wafers

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

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

4 Terminology

4.1 *Definitions*

4.1.1 *bilateral datum plane* — a vertical plane that bisects the wafers and that is perpendicular to both the horizontal and facial datum planes (as defined in SEMI E57).

4.1.2 *box* — a protective portable container for a carrier and/or substrate(s).

4.1.3 *carrier* — an open structure that holds one or more substrates.

4.1.4 *carrier bottom domain* — volume (below *z*6 above the horizontal datum plane) that contains the bottom of the carrier (as defined in SEMI E1.9).

4.1.5 *carrier capacity* — the number of substrates that a carrier holds (as defined in SEMI E1.9).

4.1.6 *carrier sensing pads* — surfaces on the bottom of the carrier for triggering optical or mechanical sensors (as defined in SEMI E1.9).

4.1.7 *carrier side domains* — volumes (from *z*6 above the horizontal datum plane to *z*15 above the top nominal wafer seating plane) that contain the mizo teeth or slots that support the wafer and the supporting columns on the sides and rear of the carrier (as defined in SEMI E1.9).

4.1.8 *carrier top domain* — volume (higher than *z*15 above the top wafer) that contains the top of the carrier (as defined in SEMI E1.9).

4.1.9 *facial datum plane* — a vertical plane that bisects the wafers and that is parallel to the front side of the carrier (where wafers are removed or inserted). On tool load ports, it is also parallel to the load face plane specified in SEMI E15 on the side of the tool where the carrier is loaded and unloaded (as defined in SEMI E57).

4.1.10 *front-opening box for interfactory transport (FOBIT)* — a transportation box with a front-opening interface (that mates with a FIMS port that complies with SEMI E62).

4.1.11 *front-opening shipping box (FOSB)* — a shipping box (that complies with SEMI M31) with a front-opening interface.

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

4.1.13 *horizontal datum plane* — a horizontal plane from which projects the kinematic-coupling pins on which the carrier sits. On tool load ports, it is at the load height specified in SEMI E15 and might not be physically realized as a surface (as defined in SEMI E57).

4.1.14 *minienvironment* — a localized environment created by an enclosure to isolate the product from contamination and people.

4.1.15 *nominal wafer centerline* — the line that is defined by the intersection of the two vertical datum planes (facial and bilateral) and that passes through the nominal centers of the seated wafers (which must be horizontal when the carrier is placed on the coupling) (as defined in SEMI E57).

4.1.16 *optical wafer sensing paths* — lines of sight for optically sensing the positions of the wafers. Several horizontal optical wafer sensing paths are present in between the carrier side domains. In addition, two vertical optical wafer sensing paths are created by rectangular exclusion zones in the front of the carrier top and bottom (as defined in SEMI E1.9).

4.1.17 *shipping box* — a protective portable container for a carrier and/or wafer(s) that is used to ship wafers from the wafer suppliers to their customers.

4.1.18 *virtual tracking unit* — an entity (which could be a number of substrates or an individual die or mask group) that the factory floor control system treats as a single unit for tracking purposes (as defined in SEMI E1.9).

4.1.19 *wafer carrier* — any cassette, box, pod, or boat that contains wafers (as defined in SEMI E15).

4.1.20 *wafer extraction volume* — the open space for extracting a wafer from the carrier (as defined in SEMI E1.9).

4.1.21 *wafer pick-up volume* — the space that contains entire bottom of a wafer if the wafer has been pushed to the rear of the carrier (as defined in SEMI E1.9).

4.1.22 *wafer set-down volume* — the open space for inserting and setting down a wafer in the carrier (as defined in SEMI E1.9).

5 Requirements

The FOBIT has the following components and sub-components:

Key:

- Required feature
- ◊ Optional feature

- Door on front
  - Holes for latch keys that lock the door to the FIMS interface when the door is unlatched from the box
  - Holes for registration pins
  - Door presence sensing areas
- Top
  - ◊ Top robotic handling flange (optional)
- Interior
  - Non-removable cassette with supports for 25 wafers
  - Wafer capture mechanism
  - 2 end-effector exclusion zones
- Sides
  - ◊ Ergonomic manual handles (optional)
- Bottom
  - 5 carrier sensing pads
  - Center retaining feature
  - Front retaining feature
  - 4 info pads
  - 2 advancing box sensing pads
  - 3 features that mate with kinematic coupling pins and provide a 10 mm lead-in
  - ◊ 3 features that mate with kinematic coupling pins and provide a 15 mm lead-in (optional)
  - ◊ 2 bottom side rails for use with roller conveyor or forklifts (optional)

5.1 *Kinematic Couplings* — The physical alignment mechanism from the FOBIT to the tool load-port (or a nest on a vehicle or in a stocker) consists of features (not specified in this standard) on the top entity that mate with three or six pins underneath as defined in SEMI E57. The three features that mate with the kinematic coupling pins must provide a lead-in capability that corrects a FOBIT misalignment of up to *r*69 in any horizontal direction.

5.2 *Inner and Outer Radii* — All required concave features may have a radius of up to *r*65 to allow cleaning and to prevent contaminant build-up. All required convex features may also have a radius of up to *r*66 to prevent small contact patches with large stresses that might cause wear and particles. Note that these limits on the radius of all required features are specified as a maximum (not a minimum) to ensure that the required features are not rounded off too much. The lower bound on the radius is up to the FOBIT supplier. Note also that this radius applies to every required feature unless another radius is called out specifically. A required feature is an area on the surface of the FOBIT specified by a dimension (or intersections of dimensions) that has a tolerance and not just a maximum or minimum (such as the edges of the robotic handling flange).

5.3 *Door* — It is recommended that the FOBIT be in a horizontal orientation when it is opened or closed (corresponding to the front side of the cassette where wafers are accessed so the door is perpendicular to the wafers and parallel to the facial datum plane). The door and its frame must be designed to mate with a port that conforms to SEMI E62. Specifically, the FOBIT door and its frame must have surfaces that mate with the seal zones and the reserved spaces for vacuum application (which includes all of the circles bounded by *r*38 except for the holes for the registration pins at the center of each circle) defined in Sections 5.3 and 5.6 of SEMI E62 (which specifies *r*38). These FOBIT door and frame surfaces must be a distance of *y*52 from the facial datum plane and must have a flatness of *y*42. No surface on the FOBIT door may project further from the facial datum plan than the door seal zone and the reserved spaces for vacuum application. The door of the FOBIT must also be designed so that when the FOBIT is pressed against the FIMS port, both latch keys on the port are inserted to their full length. Furthermore, when the latch keys are turned more than 45° toward the position that unlocks the FOBIT door, the latch key holes on the door must be such that the door is not removable from the latch keys.

5.4 *Wafer Capture and Centering* — When the FOBIT is closed, the wafers must be captured in the FOBIT to prevent movement during subsequent handling, including transportation. It should be noted that wafers are typically transported in a vertical orientation and generally require support from a secondary package. It is recommended that this secondary package be designed to allow for easy removal of the FOBIT from the secondary package.

5.5 *Wafer Orientation and Numbering* — The wafers must be horizontal when the FOBIT is placed on the kinematic coupling, and the wafers slots are numbered in increasing order from bottom to top (so the bottom wafer is wafer number 1, the next wafer up is wafer number 2, etc.).

5.6 *Internal Horizontal Dimensions* — Figure 1 shows a cross-section of the horizontal boundaries of the FOBIT side domains (which contain the parts of the FOBIT higher than *z*6 above the horizontal datum plane and lower than *z*15 above the top wafer). In this and following figures, the heaviest lines are used for surfaces that have tolerances (not surfaces that have only maximum or minimum dimensions). Table 1 defines the dimensions shown in this figure.

5.7 *Internal Vertical Dimensions* — Figures 2 through 5 show the vertical dimensions of the internal FOBIT. Note that *z*8 (the height of the bottom nominal wafer-seating plane above the horizontal datum plane) and *z*12 (the distance between adjacent nominal wafer seating planes) are given as absolute distances with no tolerance. This means that the sum of actual height variations in the FOBIT from the kinematic coupling to the supporting features holding each wafer must be contained within the tolerance of *z*10 with no further stack-up at each higher wafer. The method for meeting this requirement is left up to the FOBIT supplier. Table 1 defines all dimensions for Figures 2 through 5.

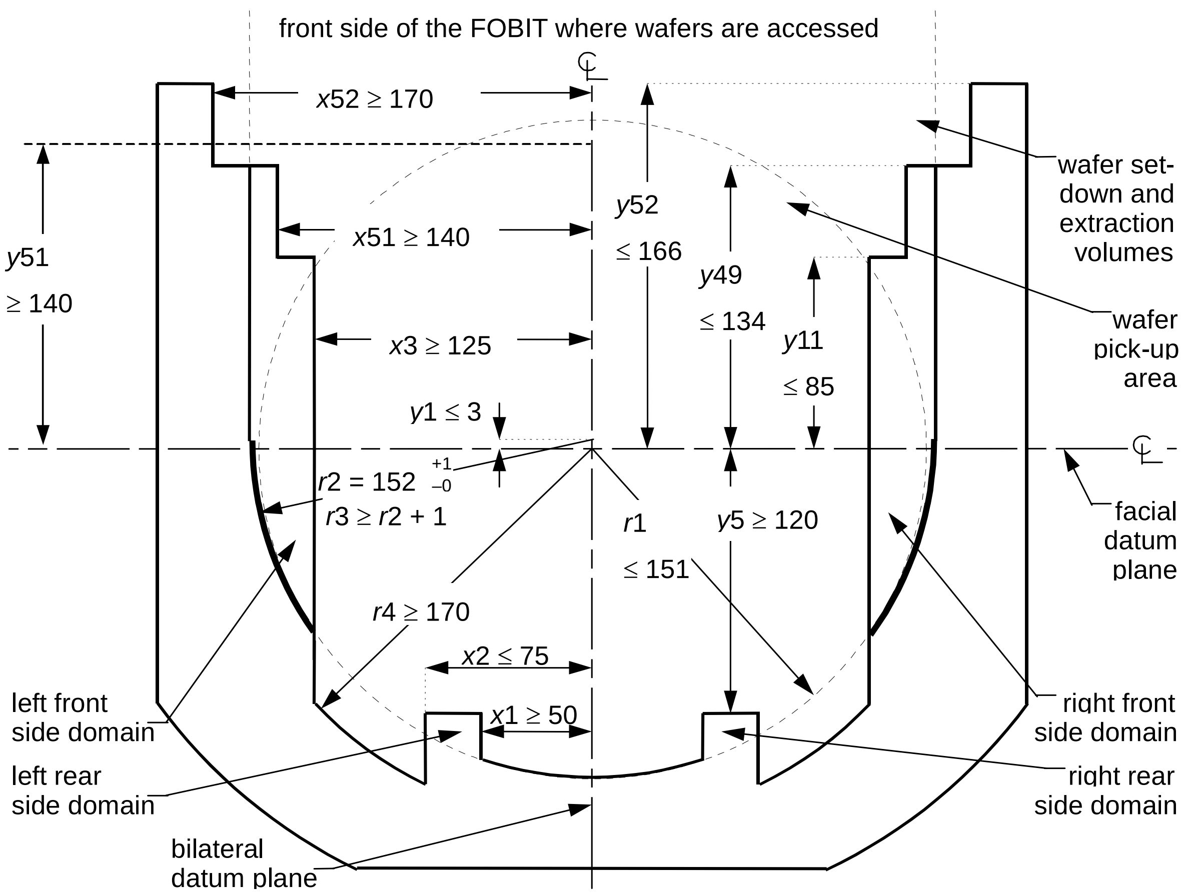

Figure 1
Top View of FOBIT Internal Dimensions

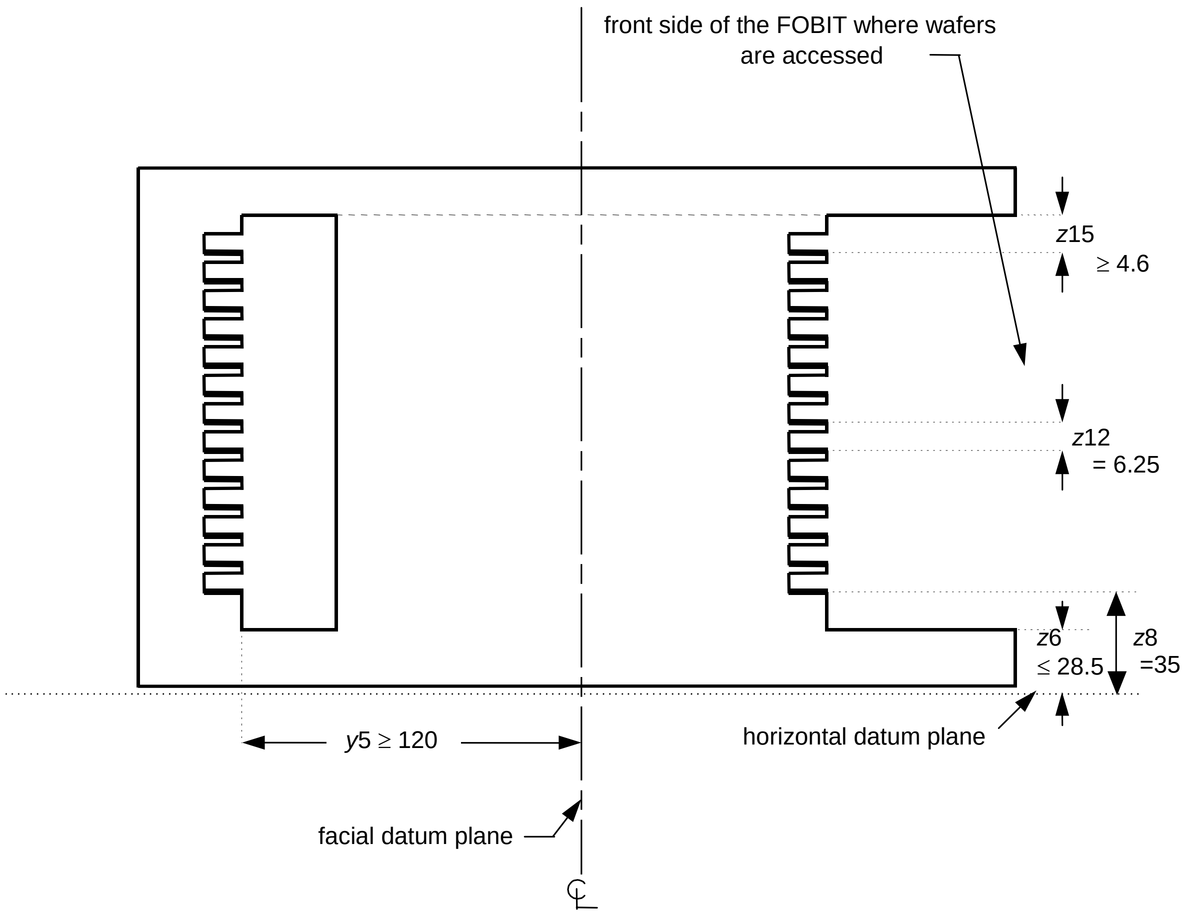

Figure 2
Side View of FOBIT Internal Dimensions

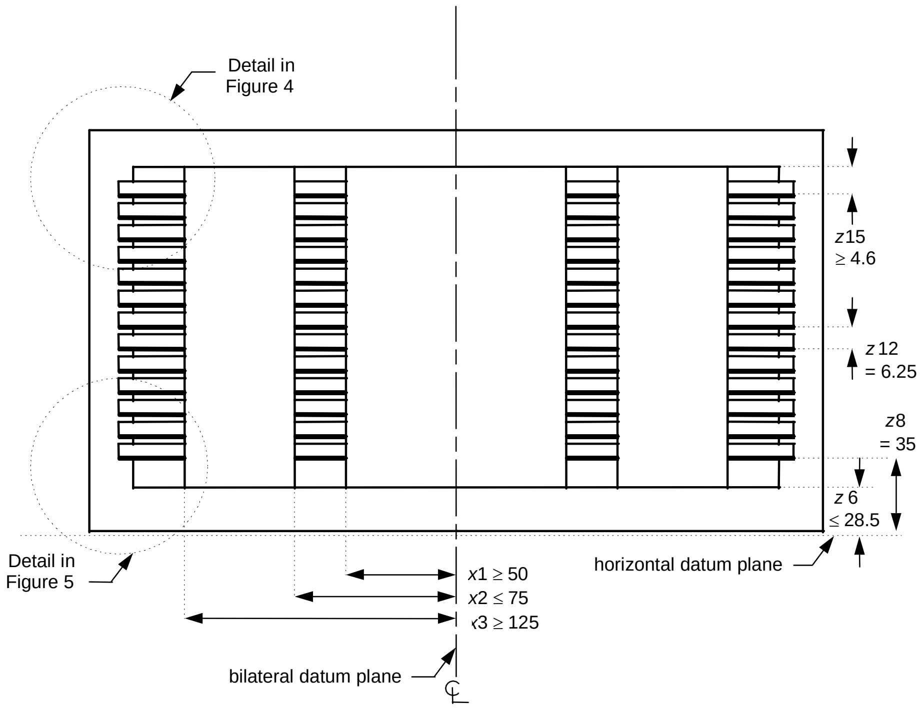

Figure 3
Front View of FOBIT Internal Dimensions

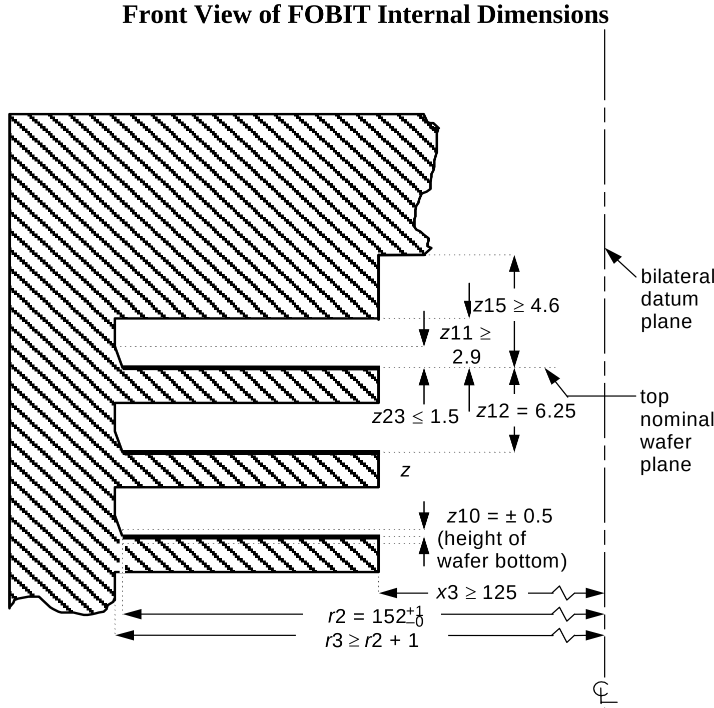

Figure 4
Upper Cross-Section at Facial Datum Plane

5.7.1 *Wafer Set-Down Volume* — The open space for the wafer set-down volume consists of a cylindrical section with radius *r*2 and a main axis parallel to and *y*1 in front of the nominal wafer centerline. The top of this cylindrical section is *z*11 above the nominal wafer-seating plane and its bottom is *z*10 above the nominal wafer-seating plane. The implications for wafer positioning of the tolerance on *r*2 are as follows. The wafers should be placed in the FOBIT within a circle of radius corresponding to the smaller bound on *r*2 to avoid touching the edge of the wafer to the side of the FOBIT. Once the wafer has been placed, the FOBIT must not allow a wafer to move outside of a circle of radius corresponding to the larger bound on *r*2. There are two exceptions to this limit on wafer movement. When the wafer is pushed toward the rear of the FOBIT, the location of the wafer is defined by the wafer pick-up volume (see Section 5.7.3). When the FOBIT is gently tilted forward up to 45°, the wafers may slide forward, but it is recommended that they not extend further than *y*20 from the facial datum plane.

5.7.2 *Wafer Extraction Volume* — The open space for the wafer extraction volume includes a cylindrical section with radius *r*3 and a main axis parallel to and *y*1 in front of the nominal wafer centerline. The top of this cylindrical section is *z*11 above the nominal wafer-seating plane and its bottom is *z*23 above the nominal wafer-seating plane. The wafer extraction volume also includes the extrusion out the front of the FOBIT of this cylindrical section. The implications for wafer extraction of the definition of dimension *r*3 (*r*3 ≥ *r*2 + 1) are as follows; the FOBIT must give an extra 1mm (0.04 in.) of horizontal clearance once the wafer is picked up from wherever it ends up (within the bounds of *r*2) after transport in the FOBIT.

5.7.3 *Wafer Pick-Up Volume* — If a wafer is placed in the wafer set-down volume and is then pushed toward the rear of the FOBIT, then the entire bottom of the wafer must be contained in the wafer pick-up volume. However, if the wafer is not pushed toward the rear of the FOBIT, then the wafer may only be somewhere within the wafer extraction volume. The wafer pick-up volume is defined by a cylindrical section with radius *r*1 and a main axis at the nominal wafer centerline. Its top and bottom are the upper and lower tolerance of *z*10 around the nominal wafer-seating plane.

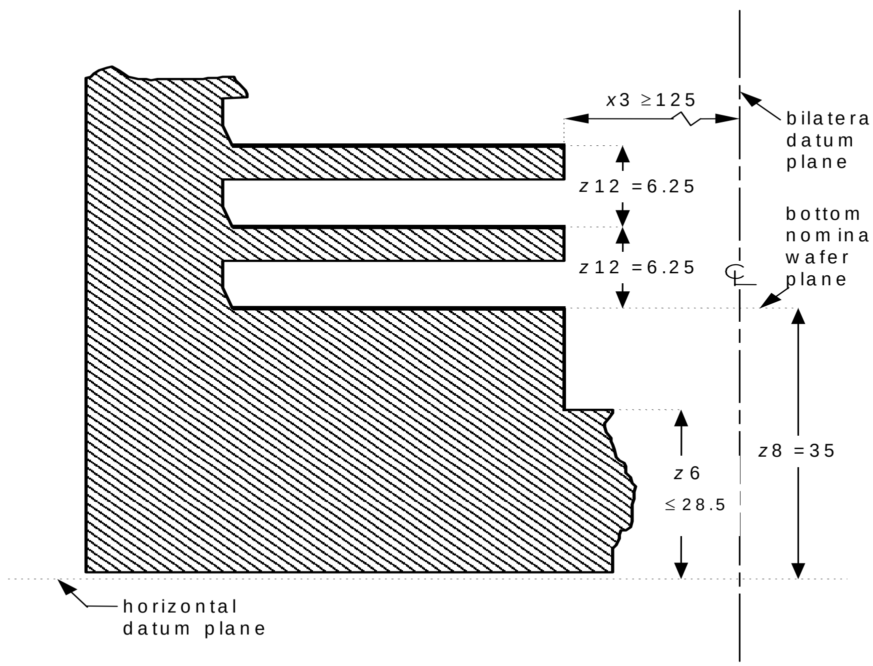

Figure 5
Lower Cross-Section at Facial Datum Plane

Table 1 Internal FOBIT Dimensions (Figures 1–5)

Symbol Used	*Figure Number*	*Value Specified*	*Datum Measured from*	*Boundary or Feature Measured to*
*r*1	1	151 mm (5.94 in.) maximum	nominal wafer centerline	outer edge of wafer pick-up volume
*r*2	1, 4	152 = + 1/– 0 mm (5.98 + 0.04 – 0 in.)	*y*1 in front of nominal wafer centerline	encroachment of FOBIT side domains on wafer set-down volume
*r*3	1, 4	*r*2 + 1 mm (0.04 in.) minimum	*y*1 in front of nominal wafer centerline	encroachment of FOBIT side domains on wafer extraction volume
*r*4	1	170 mm (6.69 in.) minimum	nominal wafer centerline	encroachment of FOBIT on end effector exclusion zone between front and rear FOBIT side domains
*x*1	1, 3	50 mm (1.97 in.) minimum	bilateral datum plane	inside of rear FOBIT side domains
*x*2	1, 3	75 mm (2.95 in.) maximum	bilateral datum plane	outside of rear FOBIT side domains
*x*3	1, 3, 4, 5	125 mm (4.92 in.) minimum	bilateral datum plane	inside of front FOBIT side domains
*x*51	1	140 mm (5.51 in.) minimum	bilateral datum plane	interior of FOBIT sides between *y*11 and *y*49
*x*52	1	170 mm (6.69 in.) minimum	bilateral datum plane	interior of FOBIT sides between *y*49 and *y*52
*y*1	1	3 mm (0.12 in.) maximum	facial datum plane	origin of *r*2 and *r*3 on bilateral datum plane
*y*5	1, 2	120 mm (4.72 in.) minimum	facial datum plane	front of rear FOBIT side domains
*y*11	1	85 mm (3.35 in.) maximum	facial datum plane	interior of FOBIT sides between *x*3 and *x*51
*y*20[#1]	None	158 mm (6.22 in.)	facial datum plane	maximum protrusion of wafers toward the front of the FOBIT
*y*49	1	134 mm (5.28 in.) maximum	facial datum plane	interior of FOBIT sides between *x*51 and *x*52
*y*51	1, 6, 8	140 mm (5.51 in.) minimum	facial datum plane	rear of door
*z*6	2, 3, 5	28.5 mm (1.12 in.) maximum	horizontal datum plane	top of FOBIT bottom domain
*z*8	2, 3, 5	35 mm (1.38 in.)	horizontal datum plane	bottom nominal wafer seating plane
*z*10	4	0 ± 0.5 mm (0.00 ± 0.02 in.)	each nominal wafer seating plane	entire bottom of the wafer
*z*11	4	2.9 mm (0.11 in.) minimum	each nominal wafer seating plane	encroachment of FOBIT side domains on clearance above the wafer
*z*12	2, 3, 4, 5	6.25 mm (0.25 in.) nominal	each nominal wafer seating plane	adjacent nominal wafer seating planes
*z*15	2, 3, 4	4.6 mm (0.18 in.) minimum	top nominal wafer seating plane	bottom of FOBIT top domain
*z*23	4	1.5 mm (0.06 in.) maximum	each nominal wafer seating plane	bottom of wafer extraction volume

[#1] These dimensions are for optional features.

5.8 *External Dimensions* — Figures 6 through 8 and Figure 10 show the side, rear, top, and bottom views for the FOBIT, respectively. Table 2 defines all of these dimensions. In this and following figures, the heaviest lines are used for surfaces that have tolerances (not surfaces that have only maximum or minimum dimensions). If an identification tag is used, it must be located at the bottom rear centered on the bilateral datum plane and must be contained within the maximum outer dimensions of the FOBIT.

5.9 *Human Handles* — All handles for use by humans must either be contained within the maximum outer dimensions of the FOBIT, be detached when not in use, or be retractable into the maximum outer dimensions when not in use. Although such handles may extend past *x*53, they must still be contained within the upper limits of *x*50, *y*40, and *r*67. Handles for use by humans (if present) must follow SEMI S8, and they must require the use of both hands (each using a full wrap-around grip, given the minimum clearance requirement in SEMI E15.1). Automation handling features shall not be considered dual purpose unless they are designed to meet SEMI S8 guidelines.

5.10 *Automation Handling Features* — On the top of the FOBIT, there is an optional robotic handling flange for manipulating the FOBIT as illustrated in Figure 9. On the bottom of the FOBIT, there are optional rails for use with roller conveyors or forklifts as shown in Figures 6, 7 and 10. Although they are only required to extend *y*58 behind the facial datum plane on both the left and right sides, it is recommended that they be as long as possible. Beyond *y*58, only the lower bound on *z*43 applies. These optional conveyor rails (defined by *x*56, *x*57, *y*58, and *z*43) are located on the left and right bottom edges of the front-opening box and also have vertical cylindrical pin holes for forklift centering (defined by *d*65).

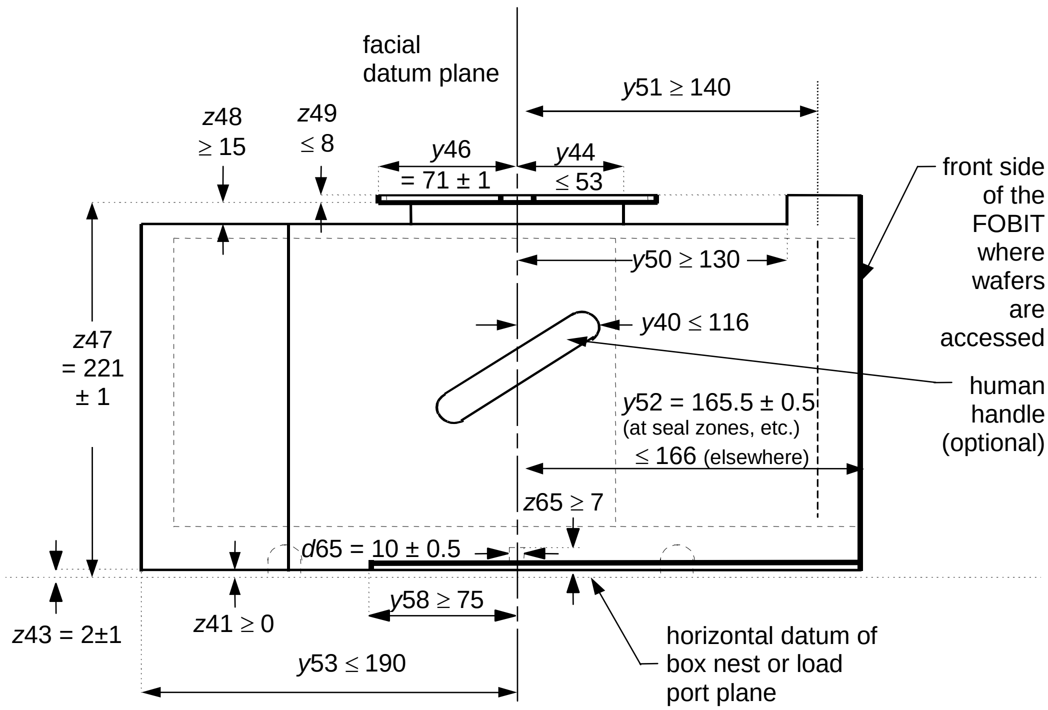

Figure 6
Side View of FOBIT

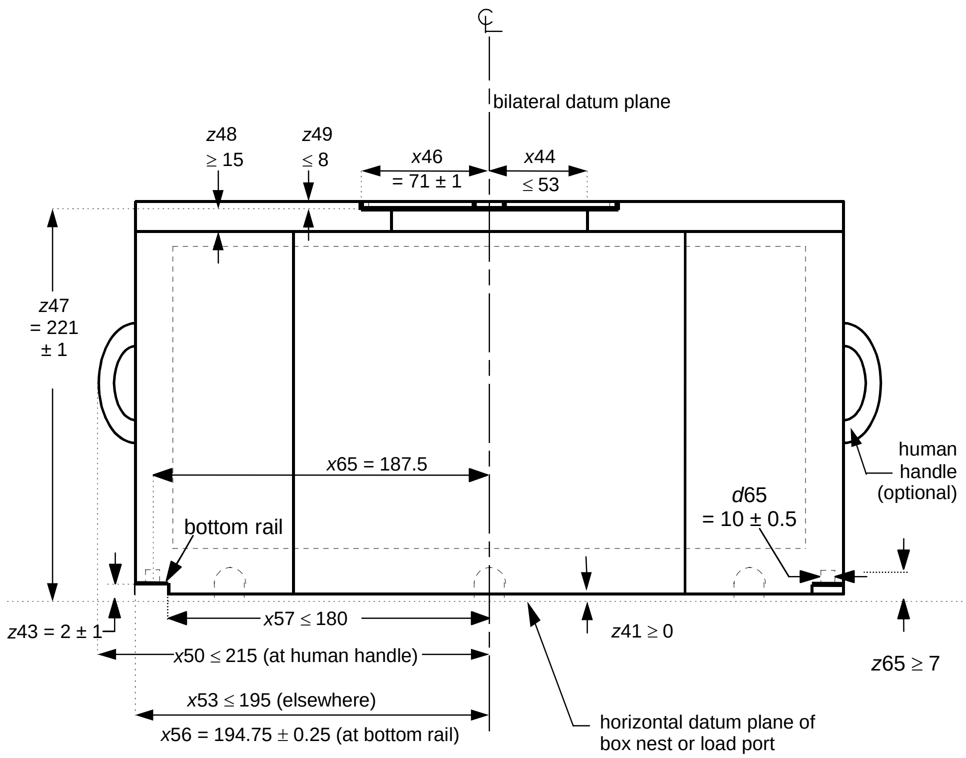

Figure 7
Rear View of FOBIT

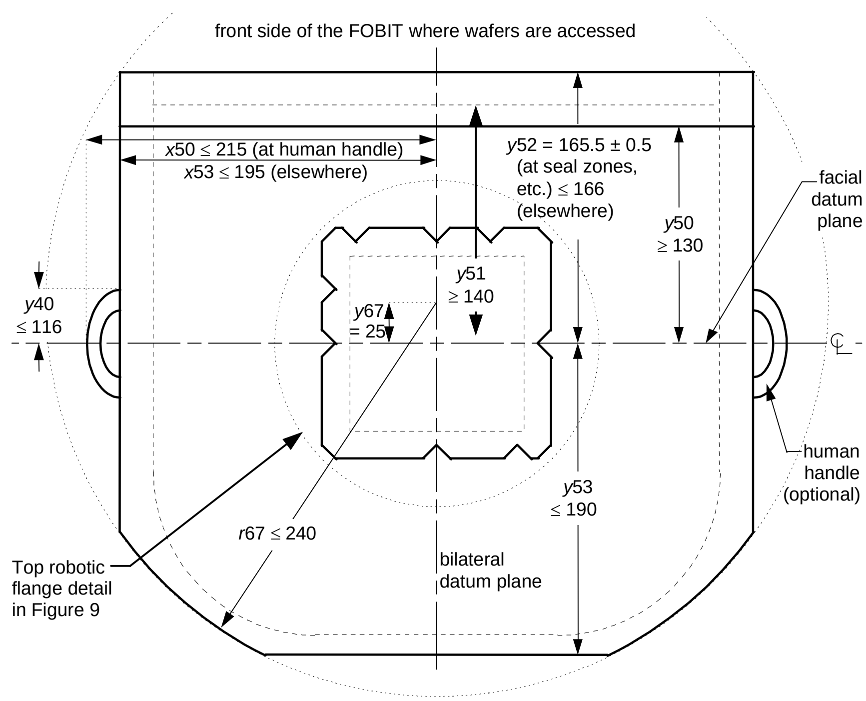

Figure 8
Top View of FOBIT

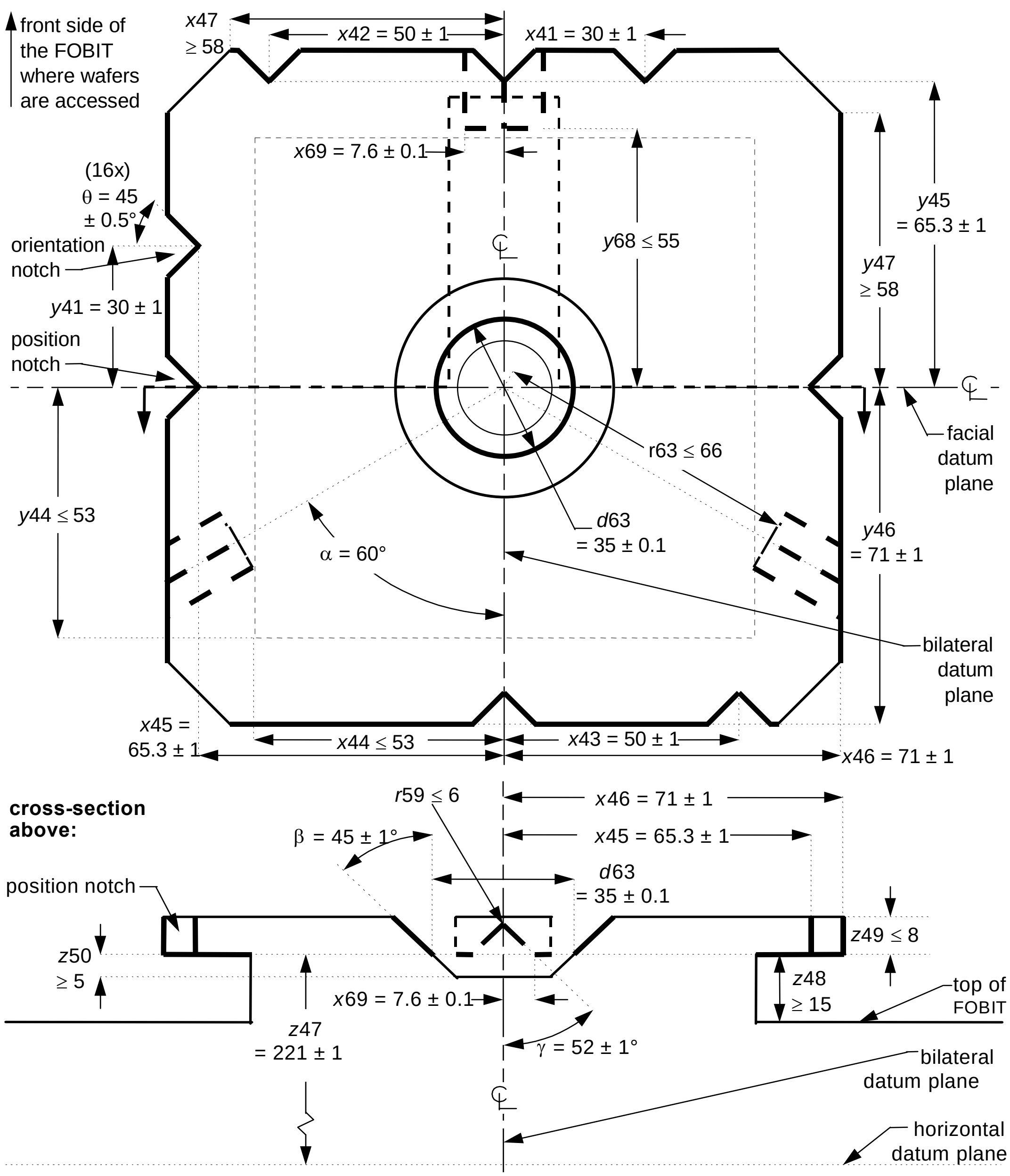

Figure 9
Top Robotic Handling Flange

5.11 *Retaining Features* — Figures 10 and 11 show two features on the bottom of the FOBIT that may be used for retaining the FOBIT onto the kinematic couplings. This may be needed to prevent the FOBIT from being knocked off the kinematic couplings by the action of pushing the FOBIT against the front-opening interface. The front retaining feature contains a ramp that a wheel might roll up while the FOBIT is being pushed toward the front-opening interface. The arm with the wheel (not specified here) then holds the FOBIT down on the kinematic couplings. The center-retaining feature consists of an oblong slot with a chamber above it. The FOBIT can be clamped onto the kinematic couplings by inserting an oblong head on a shaft (not specified here) through the slot and rotating it 90° in either direction. Either retaining feature would only engage after the FOBIT is fully seated on the kinematic coupling pins. Either retaining feature must be able to withstand a force in any direction of at least *f*60. It is recommended that SEMI E15.1 tool load ports be designed to accommodate the minimum hole dimensions of the retaining features to ensure carrier interchangeability. Projections on the tool load ports that mate with the retaining features should also not interfere with the misalignment correction function of the kinematic couplings. All dimensions of the FOBIT (such as the wafer location, etc.) are defined with reference to the kinematic coupling pins, and are designed so that all of the their features are in the proper location only when the FOBIT is held in place on the kinematic coupling pins by gravity only.

5.12 *Sensing Pads and Info Pads* — The FOBIT must have the same carrier sensing pads as defined in SEMI E1.9, including the info pads that communicate information about the carrier such as the carrier capacity (number of wafers) and type (cassette or box). See SEMI E1.9 for information about info pad configurations for different wafer carriers similar to FOBITs including front-opening shipping boxes (as defined in SEMI M31) and single-wafer interface (SWIF) systems (as defined in SEMI E103). Two additional sensing pads (that can be used continuously while the FOBIT is advancing into the FIMS interface) must be located near the center of the bottom at the same distance from the horizontal datum plane as the carrier sensing pads (See Figure 12). In addition, the surfaces on the door of the FOBIT that mate with the seal zones and the reserved spaces for vacuum application may also be used for door-presence sensing. It is intended that the FOBIT have the capability to allow customization of the info pad configuration. Therefore, the purchaser of 300 mm carriers needs to specify the desired info pad orientation (up or down) for all four locations, as defined in the Appendix of SEMI E1.9.

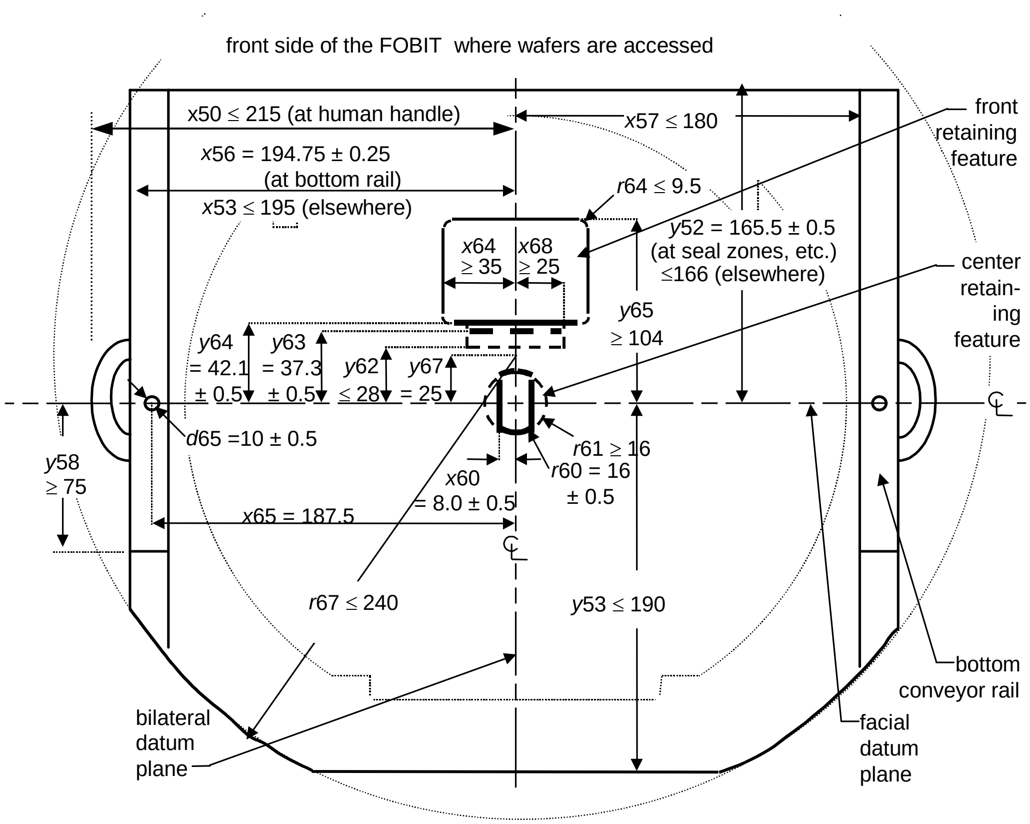

Figure 10
Bottom View of FOBIT

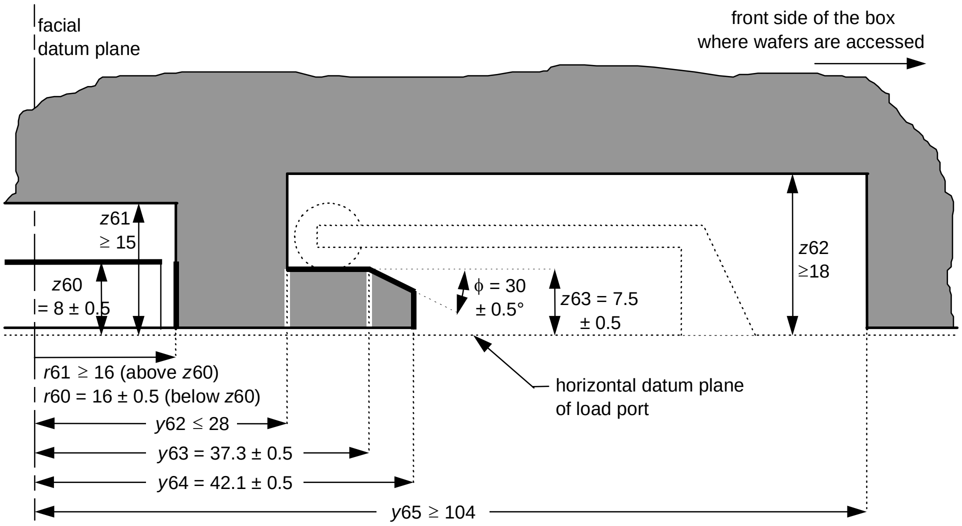

Figure 11
Side View of Retaining Features on Bottom of FOBIT

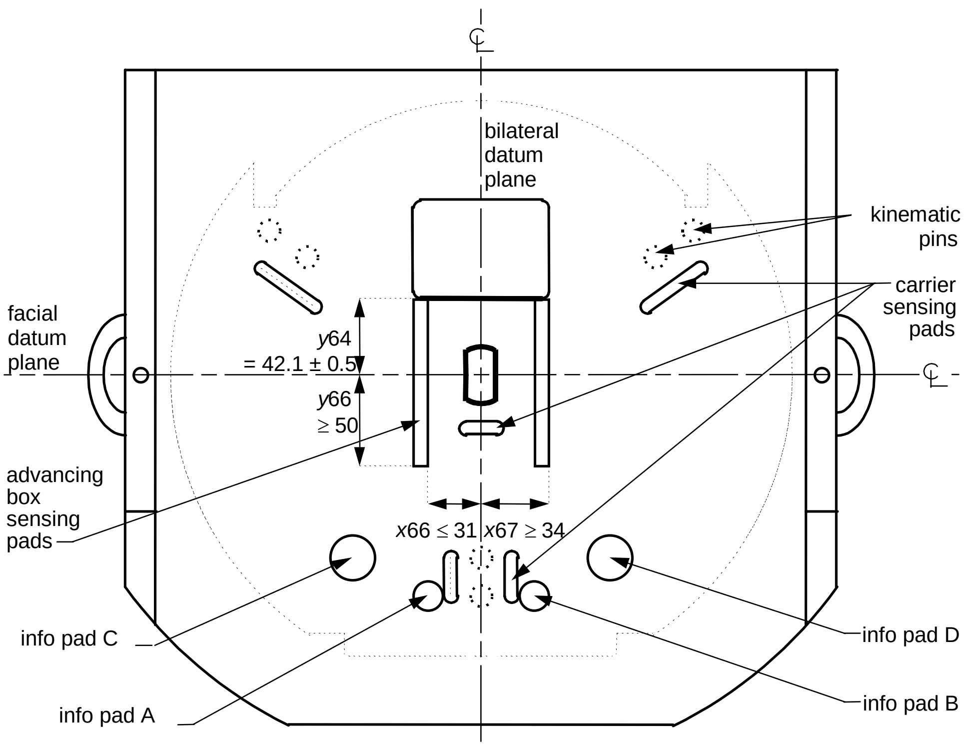

Figure 12
Sensing Pads on Bottom of FOBIT

Table 2 External FOBIT Dimensions (Figures 6–12)

Symbol Used	*Figure Number*	*Value Specified*	*Datum Measured from*	*Feature Measured to*
$\alpha^{\#1}$	9	60°	bilateral datum plane	centerline of the right and left kinematic grooves in the top robotic handling flange
$\beta^{\#1}$	9	45 ± 1°	nominal wafer centerline	surface of the center hole in the top robotic handling flange
$\gamma^{\#1}$	9	52 ± 1°	bilateral datum plane or vertical plane rotated α away from it about nominal wafer centerline	angled surface of the kinematic grooves in the top robotic handling flange
$\theta^{\#1}$	9	45 ± 0.5°	either vertical datum plane	sides of position and orientation notches in the top robotic handling flange
ϕ	11	30 ± 0.5°	horizontal line on bilateral datum plane	ramp of front retaining feature
*d*63‡	9	35 ± 0.1 mm (1.378 ± 0.004 in.)	diameter centered on the nominal wafer centerline	sides the center hole in the top robotic handling flange at height *z*47
$d65^{\#1}$	6, 7, 10	10 ± 0.5 mm (0.39 ± 0.02 in.)	diameter centered on the intersection of *x*65 and the facial datum plane	surface of cylindrical fork-lift pin holes in left and right bottom conveyor rails
*f*60	None	175 N (39.3 lbf.) minimum	not applicable	force in any direction which both retaining features are able to withstand
$r59^{\#1}$	9	6 mm (0.24 in.) maximum	not applicable	radius on peak of kinematic grooves in the top robotic handling flange
*r*60	10, 11	16 ± 0.5 mm (0.63 ± 0.02 in.)	nominal wafer center line	ends of slot for center retaining feature
*r*61	10, 11	16 mm (0.63 in.) minimum	nominal wafer center line	walls of chamber above slot in center retaining feature
$r63^{\#1}$	9	66 mm (2.60 in.) maximum	nominal wafer centerline	near end of the right and left kinematic grooves in the top robotic handling flange
*r*64	10	9.5 mm (0.37 in.) maximum	not applicable	corners of front retaining feature
*r*65	None	1 mm (0.04 in.) maximum	not applicable	all required concave features (radius)
*r*66	None	2 mm (0.08 in.) maximum	not applicable	all required convex features (radius)
*r*67	8, 10	240 mm (9.45 in.) maximum	*y*67 in front of nominal wafer centerline	any part of FOBIT
*r*69	None	10 mm (0.39 in.) minimum (required) 15 mm (0.59 in.) (recommended for ergonomic reasons)	not applicable	correctable FOBIT misalignment in any horizontal direction
$x41^{\#1}$	9	30 ± 1 mm (1.18 ± 0.04 in.)	bilateral datum plane	front right orientation notch on the top robotic handling flange
$x42^{\#1}$	9	50 ± 1 mm (1.97 ± 0.04 in.)	bilateral datum plane	front left orientation notch on the top robotic handling flange
$x43^{\#1}$	9	50 ± 1 mm (1.97 ± 0.04 in.)	bilateral datum plane	rear orientation notch on the top robotic handling flange
$x44^{\#1}$	7, 9	53 mm (2.09 in.) maximum	bilateral datum plane	encroachment of supports under the outer edge of the top robotic handling flange
$x45^{\#1}$	9	65.3 ± 1 mm (2.57 ± 0.04 in.)	bilateral datum plane	nearest point of side position and orientation notches on the top robotic handling flange
$x46^{\#1}$	7, 9	71 ± 1 mm (2.80 ± 0.04 in.)	bilateral datum plane	outside edge (right & left sides) of the top robotic handling flange

Symbol Used	*Figure Number*	*Value Specified*	*Datum Measured from*	*Feature Measured to*
$x47^{\#1}$	9	58 mm (2.28 in.) minimum	bilateral datum plane	end of the top robotic handling flange front and rear
$x50^{\#1}$	7, 8, 10	215 mm (8.46 in.) maximum	bilateral datum plane	furthest reach of human handles
$x53$	7, 8, 10	195 mm (7.68 in.) maximum	bilateral datum plane	FOBIT sides (apart from human handles)
$x56^{\#1}$	7, 10	194.75 ± 0.25 mm (7.667 ± 0.010 in.)	bilateral datum plane	outside edge of bottom conveyor rails
$x57^{\#1}$	7, 10	180 mm (7.09 in.) maximum	bilateral datum plane	FOBIT sides underneath bottom conveyor rails
$x60$	10	8 ± 0.5 mm (0.31 ± 0.02 in.)	bilateral datum plane	sides of slot for center retaining feature
$x64$	10	35 mm (1.38 in.) minimum	bilateral datum plane	sides of front retaining feature
$x65^{\#1}$	7, 10	187.5 mm (7.38 in.)	bilateral datum plane	vertical axis of cylindrical fork-lift pin holes in left and right bottom conveyor rails
$x66$	12	31 mm (1.22 in.) maximum	bilateral datum plane	near side of advancing box sensing pads
$x67$	12	34 mm (1.34 in.) minimum	bilateral datum plane	far side of advancing box sensing pads
$x68$	10	25 mm (0.98 in.) minimum	bilateral datum plane	sides of volume above ramp on front retaining feature
$x69^{\#1}$	9	7.6 ± 0.1 mm (0.299 ± 0.004 in.)	bilateral datum plane or vertical plane rotated α away from it about nominal wafer centerline	beginning of angled surface of the kinematic grooves in the top robotic handling flange
$y40^{\#1}$	6, 8	116 mm (4.57 in.) maximum	facial datum plane	furthest extent of human handles toward the front
$y41^{\#1}$	9	30 ± 1 mm (1.18 ± 0.04 in.)	facial datum plane	left orientation notch on robotic handling flange
$y42$	None	± 0.5 mm (± 0.02 in.) flatness over each area	facial datum plane	surfaces that mate with the seal zones
$y44^{\#1}$	6, 9	53 mm (2.09 in.) maximum	facial datum plane	encroachment of supports under the outer edge of the top robotic handling flange
$y45^{\#1}$	9	65.3 ± 1 mm (2.57 ± 0.04 in.)	facial datum plane	nearest point of front and rear position and orientation notches on the top robotic handling flange
$y46^{\#1}$	6, 9	71 ± 1 mm (2.80 ± 0.04 in.)	facial datum plane	outside edge (front & rear) of the top robotic handling flange
$y47^{\#1}$	9	58 mm (2.28 in.) minimum	facial datum plane	end of robotic handling flange sides
$y50$	6, 8	130 mm (5.12 in.) minimum	facial datum plane	rear of upper door frame volume
$y52$	1, 6, 8, 10	165.5 ± 0.5 mm (6.52 ± 0.02 in.) at door and frame seal zones and at reserved spaces for vacuum application and 166 mm (6.54 in.) maximum elsewhere on door or box shell	facial datum plane	FOBIT front
$y53$	6, 8, 10	190 mm (7.48 in.) maximum	facial datum plane	FOBIT rear

Symbol Used	*Figure Number*	*Value Specified*	*Datum Measured from*	*Feature Measured to*
*y*58[#1]	6, 10	75 mm (2.95 in.) minimum	facial datum plane	end of left and right conveyor rails
*y*62	10, 11	28 mm (1.10 in.) maximum	facial datum plane	rear of front retaining feature
*y*63	10, 11	37.3 ± 0.5 mm (1.47 ± 0.02 in.)	facial datum plane	rear of ramp on front retaining feature
*y*64	10, 11, 12	42.1 ± 0.5 mm (1.66 ± 0.02 in.)	facial datum plane	front of ramp on front retaining feature and front side of advancing box sensing pads
*y*65	10, 11	104 mm (4.09 in.) minimum	facial datum plane	front of front retaining feature
*y*66	12	50 mm (1.97 in.) minimum	facial datum plane	rear side of advancing box sensing pads
*y*67	8, 10	25 mm (0.98 in.)	facial datum plane	origin of *r*67 on bilateral datum plane
*y*68[#1]	9	55 mm (2.17 in.) maximum	facial datum plane	near end of the front kinematic groove in the top robotic handling flange
*z*2	None	2 mm (0.08 in.) maximum	horizontal datum plane	bottom of carrier sensing pads and info pads (when down)
*z*41	6, 7	0 mm (0 in.) minimum	external horizontal datum plane	bottom of FOBIT
*z*43[#1]	6, 7	2 ± 1 mm (0.08 ± 0.04 in.)	external horizontal datum plane	bottom conveyor rails
*z*47[#1]	6, 7, 9	221 ± 1 mm (8.70 ± 0.04 in.)	external horizontal datum plane	bottom surface of the top robotic handling flange
*z*48[#1]	6, 7, 9	15 mm (0.59 in.) minimum	bottom of robotic handling flange	encroachment of FOBIT top underneath robotic handling flange
*z*49[#1]	6, 7, 9	8 mm (0.31 in.) maximum	bottom of robotic handling flange	top of robotic handling flange and upper door frame volume
*z*50[#1]	9	5 mm (0.20 in.) minimum	bottom of robotic handling flange	encroachment of FOBIT top underneath the center hole in the top robotic handling flange
*z*60	11	8.0 ± 0.5 mm (0.31 ± 0.02 in.)	external horizontal datum plane	top of slot in center retaining feature
*z*61	11	15 mm (0.59 in.) minimum	external horizontal datum plane	top of chamber above slot in center retaining feature
*z*62	11	18 mm (0.71 in.) minimum	external horizontal datum plane	top of front retaining feature
*z*63	11	7.5 ± 0.5 mm (0.30 ± 0.02 in.)	external horizontal datum plane	top of ramp on front retaining feature
*z*65[#1]	6, 7	7 mm (0.28 in.) minimum	horizontal datum plane	upper boundary of cylindrical fork-lift pin holes in left and right bottom conveyor rails

[#1] These dimensions are for optional features.

6 Related Documents

6.1 *SEMI Standards*

SEMI E22.1 — Cluster Tool Module Interface 300 mm: Transport Module End Effector Exclusion Volume Standard

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

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

RELATED INFORMATION 1
APPLICATION NOTES

NOTICE: This Related Information is being balloted as an official part of SEMI E119 by full letter ballot procedures. The recommendations in this appendix are optional and are not required to conform to this standard.

R1-1

R1-1.1 Although FOBIT parameters supporting effective reuse and cleaning (washing/drying) are not defined in this document, it is essential that these capabilities be considered for a successful overall transportation box design.

R1-1.2 It is important to note that transportation boxes containing wafers are typically bagged for shipment. It is therefore important to design the outer surfaces of the box to be compatible with this common practice.

SEMI E124-1103
PROVISIONAL GUIDE FOR DEFINITION AND CALCULATION OF OVERALL FACTORY EFFICIENCY (OFE) AND OTHER ASSOCIATED FACTORY-LEVEL PRODUCTIVITY METRICS

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1 Purpose

1.1 This guide describes metrics that show how well a factory is operating compared to how well it could be operating (for the given product mix). These metrics can be used for tracking factory performance (in value-added production) in a way that rewards good operational decisions and that is not easy to adversely manipulate. They can be used in a process of ongoing improvement that can be visible to all levels of a semiconductor manufacturing organization.

1.2 The metrics in this guide are intended for evaluating the relative efficiency of factory production after the factory is in production, not for capacity analysis while the factory is being designed or redesigned. However, some of these metrics can be used in factory simulations for choosing equipment sets and scheduling policies.

2 Scope

2.1 To evaluate the overall effectiveness of a factory, there are at least three things in need of measurement: production, utilization of assets, and costs. This guide focuses on evaluating production; utilization of assets and costs (as well as other economic factors) are outside its scope. See Section R3-1.1 in Related Information 3 for a discussion of metrics in other areas.

2.2 This guide describes metrics for an entire integrated production line. Multiple production lines in the same factory may be evaluated separately if they do not share resources (such as material handling or production equipment).

2.3 This guide is provisional because *overall factory efficiency* (*OFE*) is a new concept. Once the metrics have been validated by collecting data in production factories, computing the metrics, and evaluating their sensitivity to the data, this guide should be modified and upgraded from provisional status (as specified in the SEMI regulations). Also, additional supplemental metrics may be defined, and the metric definitions given here may be expanded to truly comprehend assembly operations.

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 In the context of this guide, it is important to note that factory-level productivity is impacted greatly by factors beyond the factory itself, including material availability, efficiency of product device designs, and customer demand.

3.2 The metrics in this guide are intended for evaluating the overall efficiency of factory production, not for diagnosing problems (or opportunities for improvement) in the factory, although some component metrics can be used that way. See Section R3-1.2 in Related Information 3 for a discussion of the differences between the two kinds of metrics.

3.3 This guide provides metrics and calculations for measuring the overall productivity only of manufacturing environments (such as wafer fabs, flat panel factories, and some disk-drive production facilities) in which product substrates move through the factory with no assembly or disassembly processes. These metrics can be applied in a post-wafer back-end chip production facility if the lead frames are considered to be consumable materials (not units of production in their own right). However, in the future this guide may be extended to comprehend other, more complex manufacturing environments (including assembly operations).

4 Referenced Standards

4.1 *SEMI Standards*

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

SEMI E79 — Standard for Definition and Measurement of Equipment Productivity

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

5 Terminology

NOTE 1: All of the metrics defined below should be calculated with respect to the period being measured.

5.1 *Definitions*

5.1.1 *actual throughput rate* — the finished units out divided by the total time (shows how fast finished wafers flow out of the factory). See Equation 19.

5.1.2 *availability efficiency* (time divided by time) — the fraction of total time that the equipment is in a condition to perform its intended function (SEMI E79).

5.1.3 *average cycle time* — the (unweighted) average of cycle time over all of the units of production in finished units out.

5.1.4 *average work in process (WIP)* — the average cycle time multiplied by the actual throughput rate (shows how many eventually finished units of production fill the "pipeline" on average). See Equation 15.

NOTE 2: This metric is not an average of the *WIP* over time, since that would include units that are later scrapped before finishing.

5.1.5 *balance efficiency* — the *critical WIP* divided by the *process capacity* (measures how well the equipment sets are balanced). See Equation 5.

5.1.6 *best-case cycle time* — the larger of the *theoretical cycle time* and the quotient of the *average WIP* divided by the *bottleneck throughput rate* (shows the best cycle time that the factory can do given the WIP loading). See Equation 18.

5.1.7 *best-case throughput rate* — the smaller of the *bottleneck throughput rate* and the quotient of the *average WIP* divided by the *theoretical cycle time* (shows the best throughput rate that the factory can do given the WIP loading). See Equation 20.

5.1.8 *bottleneck throughput rate* ($R_{\max}$) — the upper bound on the factory throughput rate imposed by the current bottleneck equipment set. If a process change for a product causes this metric to change, it should be considered a different product for the purposes of performing these computations. See Equation 17.

NOTE 3: This metric is similar to (but not the same as) the *theoretical unit throughput by recipe* metric (see Section 5.1.32) from SEMI E79.

NOTE 4: This metric is not an average over the bottleneck throughput rates of each product.

5.1.9 *critical WIP* (W_0) — the *theoretical cycle time* multiplied by the *bottleneck throughput rate* (gives the WIP level that theoretically allows the factory to have the highest throughput rate with the shortest cycle time). See Equation 10.

5.1.10 *cycle time* — the amount of time a unit of production spends as WIP in the factory.

5.1.11 *finished units out* — the number of units of production that finish processing and testing during the period being measured.

5.1.12 *good unit equivalents (GUE) out* — the (possibly non-integer) number of units of production required to contain all of the good product that exits the factory during the period being measured. See Equation 12.

5.1.13 *line yield* — the fraction of units leaving the factory that have finished processing (measures relative material losses such as scrapped units). See Equation 6.

5.1.14 *normalized production efficiency* — the *production efficiency* to the power of the *normalizing exponent* (measures the normalized efficiency of the process with respect to factory dynamics). See Equation 4.

5.1.15 *normalizing exponent* — power that normalizes the *production efficiency* so that a value of ½ for *normalized production efficiency* indicates that the factory is performing at the level of the threshold case (which divides a well run factory from one badly operated). See Equation 9. See Sections R1-1.7 and R1-1.8 in Related Information 1 for a discussion of the meaning of the threshold case and a derivation of mathematical expression for the *normalizing exponent*.

5.1.16 *operational efficiency* (time divided by time) — the fraction of equipment *uptime* that the equipment is processing actual units (SEMI E79).

5.1.17 *overall equipment efficiency* (*OEE*) (time divided by time) — a metric of equipment performance, expressing the theoretical production time for the effective unit output divided by the *total time* (SEMI E79).

5.1.18 *overall factory efficiency* (*OFE*) — the *volume efficiency* multiplied by the *yield efficiency* (shows how well a factory is operating compared to how well it could be operating for the given product mix). See Equation 1.

5.1.19 *process capacity* — the maximum number of *units of production* that can be processed simultaneously throughout the factory (including units being transported by material handling vehicles). See Equation 11.

5.1.20 *production efficiency* — the *throughput-rate and cycle-time efficiency* multiplied by the *WIP* *efficiency* (measures the efficiency of production with respect to factory dynamics). See Equation 8.

5.1.21 *quality efficiency* (time divided by time) — the theoretical production time for effective units divided by the theoretical production time for actual units (SEMI E79).

5.1.22 *scrapped units out* — the number of units of production (including broken units, external rework, etc.) that exit the factory without finishing production during the period being measured.

5.1.23 *set of bottleneck equipment* (F_{e*}) — the collection of production equipment of the same type that has the highest average *operational efficiency* in the factory during the period being measured. Elements of this set are indicated by "*f*", and the equipment type is indicated by "*e**".

NOTE 5: This set of bottleneck equipment might not be the equipment set (often the expensive lithography exposure equipment) that was planned to be the bottleneck in the factory, but rather the equipment set with the highest average *operational efficiency* (the fraction of time in use when available) during the period being measured. If another equipment set experiences significantly lower availability than expected, it might become the bottleneck. Thus, the sets of bottleneck equipment may be different between two adjacent time periods, and the set of bottleneck equipment for the period combining the two adjacent periods may be different from the other two sets.

5.1.24 *set of equipment of type e* (F_e) — the collection of production equipment of type $e \in E$ in the factory. Elements of this set are indicated by "*f*".

5.1.25 *set of equipment types* (E) — the collection of the different types of production equipment in the factory, including metrology equipment and material handling vehicles and conveyors. Elements of this set (which are the different types of equipment) are indicated by "*e*".

NOTE 6: If units are transported manually between process steps, then the human transporters (and any carts or mechanized vehicles that they operate to perform the movement) should be considered a type of equipment for the purpose of computing the metrics in this guide. This is not intended to dehumanize people, but to ensure that the manual transport time is included in such metrics as *theoretical cycle time*.

5.1.26 *set of process steps of product type p on equipment type e* (S_{pe}) — the collection of the different process steps (including metrology inspection and material handling transport) planned for a unit of production of product type *p* on equipment of type *e* in the factory. Elements of this set are indicated by "*s*".

5.1.27 *set of product types* (P) — the collection of the different types of products manufactured in the factory. Elements of this set are indicated by "*p*".

5.1.28 *test yield* — the fraction of units leaving the factory that have finished processing and have passed final testing (measures relative losses due to parametric or functional failure). See Equation 7.

5.1.29 *theoretical cycle time* (T_{min}) — the minimum time required to process a unit of production through the factory (including material handling transport time) if the unit never has to wait for equipment or a vehicle to become available and if sequence-dependent set-ups never have to be performed. This is also known as the raw process time. If a process change for a product causes this metric to change, it should be considered a different product for the purposes of performing these computations. If more than one product (or process flow) is represented in the output, an average is taken over each of the products' *theoretical cycle time* weighted by the fraction of that product found in *finished units out*. See Equation 16.

NOTE 7: This metric is similar to (but not the same as) the *theoretical production time per unit* (*THT*) metric (see Section 5.1.30) used in SEMI E79 from CSM 21 and 42[1].

5.1.30 *theoretical production time per unit* (*THT*) (time per unit) — for a given production recipe performed by a given processing module, the minimum time to complete processing on one unit of production assuming no efficiency losses are present. The determination of *theoretical production time per unit* is based on continuous operation of the processing module, where the module is assumed to operate in an ideal condition. For equipment cycles that simultaneously process more than one unit, *theoretical production time per unit* is the minimum time to perform the cycle on an equipment load whose size is optimized for throughput divided by the number of units in that optimized load (CSM 21 and 42).

5.1.31 *theoretical throughput rate* — the smaller of the *bottleneck throughput rate* and the quotient of the *WIP capacity* divided by the *theoretical cycle time* (gives an unreachable upper bound on the factory throughput rate). See Equation 21.

5.1.32 *theoretical unit throughput by recipe* (units per time) — for a given production recipe, the number of units per period of time that theoretically could be processed by the equipment. For each recipe,

1 *CSM 21: Closed-Loop Measurement of Equipment Efficiency & Capacity*, 1995: and *CSM 42: Productivity Metrics for Flexible-Sequence Cluster Tools*, 1998; Engineering Systems Research Center, University of California, Berkeley http://esrc.berkeley.edu/csm/csmreports.html.

theoretical unit throughput is equal to the reciprocal of theoretical production time per unit (SEMI E79).

5.1.33 *throughput rate* — the number of units of production that pass through a process per period of time.

5.1.34 *throughput-rate and cycle-time efficiency* — the *best-case cycle time* divided by the *average cycle time* (shows the relative performance of the factory with respect to throughput rate and cycle time). See Equation 13. See Section R1-1.6 in Related Information 1 for a discussion of this metric.

5.1.35 *total time* — all time (at the rate of 24 hours per day, seven days per week) during the period being measured. In order to have a valid representation of *total time*, all six basic equipment states must be accounted for and tracked accurately (SEMI E10).

NOTE 8: For factory-level productivity metrics, total time should be larger than the average cycle time (and is recommended to be twice as large as the average cycle time and larger than the cycle time of any individual unit in finished units out).

5.1.36 *unit* (*of production*) — the basic entity in the factory (such as a wafer in a fab, a glass pane in a flat panel factory, or a die in a post-wafer back-end chip production facility) which acts as a product substrate (and moves through the factory with no assembly or disassembly processes). Only product units are included (as opposed to test wafers or other non-product devices).

NOTE 9: This definition is more restrictive than that given in SEMI E10 in order to be sufficiently specific.

NOTE 10: Production lot sizes can (and typically do) include multiple units of production, and units can (and typically do) contain multiple product devices (usually of the same type but possibly of different types). The user may chose to have the production lot be the *unit of production*, but that is not recommended because:

- the choice of lot size (and its inherent waiting time while its individual units are serially processed) would no longer be a relevant factor in evaluating how well the factory is running,
- lots can vary in size (even in the same factory),
- the meaning of *unit* would be inconsitent with other SEMI standards, and
- *scrapped units out* would not be properly accounted for.

5.1.37 *uptime* (*equipment uptime*) — the hours when the equipment is in a condition to perform its intended function. It includes productive, standby, and engineering time, and does not include any portion of non-scheduled time (SEMI E10).

5.1.38 *volume efficiency* — the *normalized production efficiency* times the *balance efficiency* (measures the total efficiency of the process with respect to factory dynamics). See Equation 2.

5.1.39 *WIP capacity* (W_{max}) — the maximum number of units of production the factory can contain (including on shelves, in stockers, on material handling transport vehicles, on equipment load ports, in internal carrier buffers, and in process chambers, but not including space required for non-product units such as test wafers, dummy wafers, and monitor wafers).

NOTE 11: This is not a practical WIP level, because it represents total gridlock of the factory.

5.1.40 *WIP efficiency* — the quotient of the smaller of the *critical WIP* and the *average WIP* divided by the larger of the two (measures the efficiency of *WIP* levels with respect to factory dynamics). See Equation 14.

5.1.41 *WIP turnover* — the *finished units out* divided by the *average WIP* (shows how often the inventory of work in process was replaced during the period being measured). See Equation 22.

5.1.42 *work in process* (*WIP*) — the number of units of production that have been released into the factory but have not yet been scrapped, sent out for external rework, or finished processing through all of their production steps.

5.1.43 *yield efficiency* — the *line yield* times the *test yield* (shows overall material efficiency). See Equation 3.

NOTE 12: This metric is similar to (but not the same as) the *quality efficiency* metric (see Section 5.1.21) from SEMI E79.

6 Calculated Metrics

6.1 Figure 1 shows how the terms defined in Section 5 feed into each other. Arrows go from subordinate terms to the term in which they are cited as a part of the primary definition. Shown in the top row (in red rounded rectangles) are the basic building-block metrics for which no equations are needed in this guide; the remaining metrics have their equation numbers given. At the very bottom is the overall factory efficiency metric into which almost everything feeds, although many of its subordinate terms are useful in their own right (if data availability or reliability is a problem). Along the left side (in green rounded rectangles) are the quality metrics that show the efficiency of the process with respect to use of materials. The remainder of the metrics (in blue rectangles) are production metrics that show the efficiency of the process with respect to factory dynamics (without the effects of yield and scrap losses). Related Information 1 gives an exposition of the underlying science behind these production metrics.

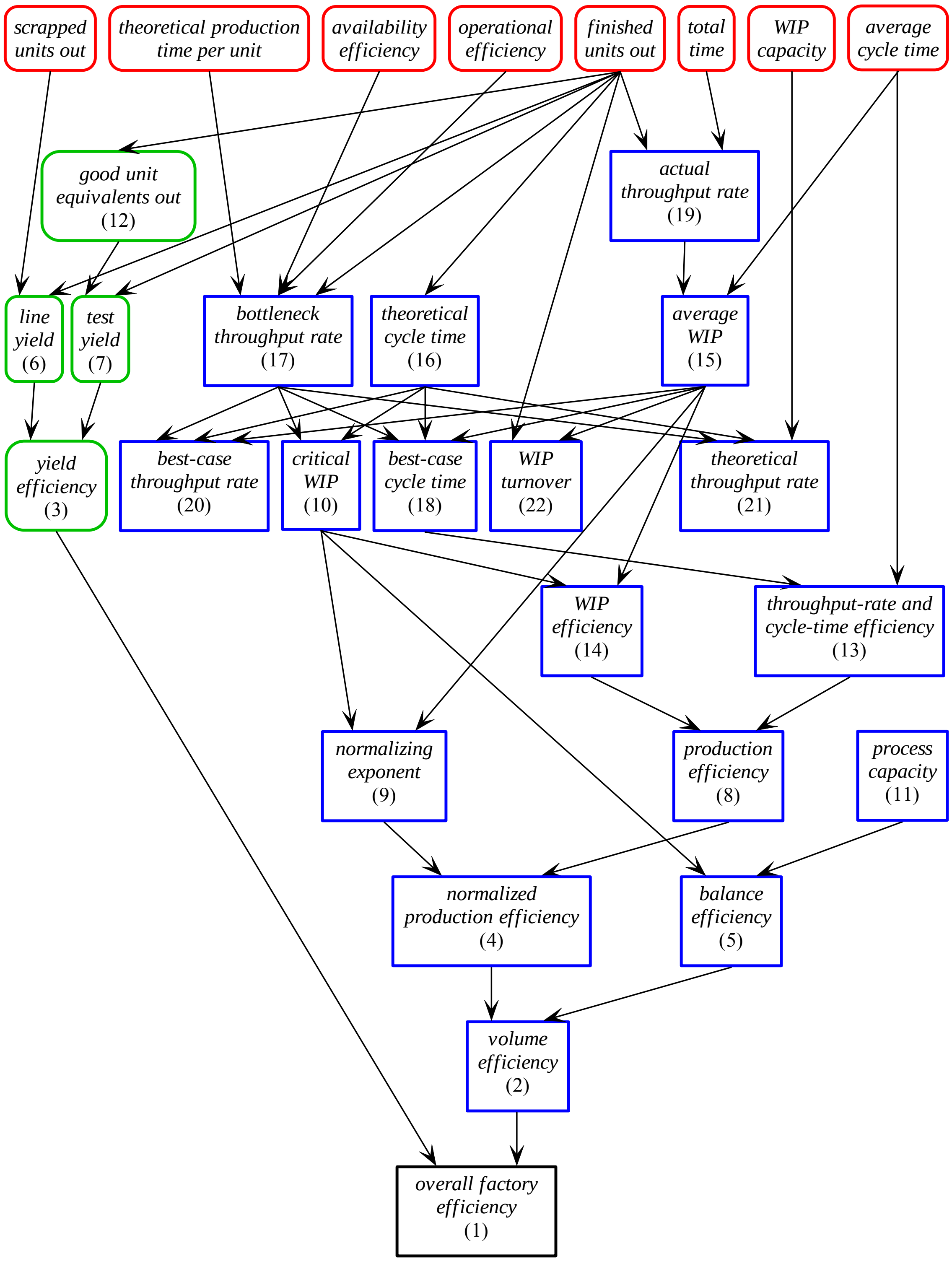

Figure 2
Definition Tree for Factory-Level Productivity Metrics