SEMI E189-0524
SPECIFICATION FOR EQUIPMENT MANAGEMENT OF CONSUMABLES AND DURABLES (EMCD)

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NOTICE: The section symbol (§) is used to reference a numbered section, paragraph, or header and all subordinate paragraphs, headers, and embedded material (i.e., EXCEPTIONs, lists) therein. The paragraph symbol (¶) is used to reference a particular numbered paragraph and embedded material therein. When duplicated (i.e., §§ and ¶¶) the symbols are used to reference more than one section or paragraph, respectively.

1 Purpose

1.1 This Specification provides a standardized behavior for host communication with manufacturing equipment during the removal, installation and usage of consumables and durables.

2 Scope

2.1 This Specification defines objects and state models that define the interaction between the host and equipment in the following scenarios:

- Durable removal, installation, and verification
- Durable location state changes and status
- Consumable removal, installation, and verification
- Consumable location state changes and status
- Durable usage
- Consumable usage

2.2 This Specification defines data reporting available to a host related to consumables and durables, including the consumable and durable status information.

NOTICE: SEMI Standards and Safety Guidelines do not purport to address all safety issues associated with their use. It is the responsibility of the users of the documents to establish appropriate safety and health practices, and determine the applicability of regulatory or other limitations prior to use.

3 Limitations

3.1 This Specification does not specify how consumable or durable identifiers are read.

3.2 This Specification does not specify how to determine whether a consumable or durable should be retained or replaced.

4 Referenced Standards and Documents

4.1 *SEMI Standards and Safety Guidelines*

SEMI E39 — Specification for Object Services: Concepts, Behavior, and Services

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

5 Terminology

5.1 *Definitions*

5.1.1 *consumable* — material that is used by or in support of the equipment system, such as dispensing glue, mold compound, epoxy, flux, container, tape, gas, liquids, wire, dopants (calcium, oxygen, boron, etc.), slurry and abrasive

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pads, metal sputtering targets (titanium, zinc, nickel, aluminum, many others), photoresist, deionized water, process gases (silane, ammonia, carbon dioxide, hydrogen, etc.) and etching/cleaning solvents.

5.1.2 *consumable location* — location where a consumable is mounted and unmounted.

5.1.3 *durable* — items that wear out and require periodic replacement, such as feeders, end effectors, squeegees, grippers, adapters, drill bits, nozzles, needles, heating systems, thermode, laser, ionizer, and other cutting instruments.

5.1.4 *durable location* — location where a durable is mounted and unmounted.

5.1.5 *end of life* — the item has reached the end of its useful lifespan and should be replaced, renewed, or replenished.

6 Conventions

6.1 *Requirements Identification*

6.1.1 The following notation specifies the structure of requirement identifiers.

6.1.1.1 The following requirements prefix format is used at the beginning of requirement text. Refer to Table 1 for the format notation of the requirements prefix.

- [Esss.ss-RQ-nnnnn-nn]

6.1.1.2 To mark the end of the requirement text the following suffix format is used.

- [/RQ]

6.1.1.3 Requirements in the body text are highlighted with a border and light green background (may appear gray in black and white printouts).

[Esss.ss-RQ-nnnnn-nn] Requirement text. [/RQ]

Table 1 Requirement Identifiers

Format Notation	*Purpose*
Esss.ss	SEMI Standards Specification identifier. Examples: E087.00, E087.01, E134.00.
RQ	Indicates this is a requirement identifier.
Nnnnn	Unique five-digit number within this Specification. 90000–99999 are reserved for use by SEMI.
.nn	Two-digit number that indicates version level of the requirement (.00 is used for the first version of a requirement).
/RQ	Indicates the end of a requirement.

6.1.2 Requirements in tables are delimited in one of two ways.

6.1.2.1 Where the requirement occupies an entire row in the table, the requirement ID is placed in column 1. No '[/RQ]' is used to mark the end of the requirements text in this case. The table may also contain rows that are not requirements. In this case, the column 1 cell is left blank.

6.1.2.2 Nonrequirements text related to a requirements row may be included in an adjacent row. The relationship between the rows is indicated by a broken line separating the two.

6.1.2.3 Where the requirement occupies only one cell, the text in the cell includes the requirement ID prefix and suffix similar to requirements in the body text.

6.1.2.4 No cell in a table will contain both requirement and nonrequirement text.

6.1.2.5 Cells that contain requirements are shaded light green.

6.1.2.6 Table 2 provides an example of requirements in a table. Note that in this example, the same requirement is presented in two alternative formats. In practice, mixing the two approaches in the same table is not typically done.

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Table 2 Example Table with Requirements

RequirementID	*Statement*	*Additional Detail*
Esss.ss-RQ-nnnnn-nn	The light shall be blue.	There shall be no similar color in the light panel.
	The blue light is typically placed at the leftmost position in the light panel.	
	[Esss.ss-RQ-nnnnn-nn] The light shall be blue. There shall be no similar color in the light panel. [/RQ]	The blue light is typically placed at the leftmost position in the light panel.

6.1.3 Only text marked with the requirement identifier is a requirement of this Specification.

6.1.3.1 Clarification, examples, and related recommendations may be provided near a requirement, but are not part of the requirement.

6.1.3.2 Note that the word 'should' is used in some nonrequirements text and it denotes a recommendation or a best practice, not a requirement.

6.1.4 Parent-child relationships of requirements are noted in the tables in Appendix 1. Where a parent requirement includes conditions or selection criteria, these are passed to their children. For example, if a parent requirement is stated to apply only to photolithography equipment, any child requirements also apply only to such equipment. The condition need not be restated for each child requirement.

6.2 *Naming*

6.2.1 The dashes in names of collection events, status variables, states and other items are not considered not part of the name but instead indicate a continuation of the name. For example, an item named "aPrettyLongAndDescriptive-Name" would be interpreted as having the name "aPrettyLongAndDescriptiveName".

7 Requirements

7.1 *General Requirements*

[E189.00-RQ-00001-00] Each state model transition shall have a unique collection event triggered when the new state is entered. [/RQ]

7.2 *Consumables*

7.2.1 *General Information*

7.2.1.1 This section defines state models and objects for consumables and consumable locations.

7.2.1.2 Consumables and consumable locations are SEMI E39 objects.

7.2.2 *Consumable Location State Model*

[E189.00-RQ-01001-00] Each consumable location modeled in the equipment shall implement the Consumable Location State Model including the transition table with the listed collection events and associated data variables. [/RQ]

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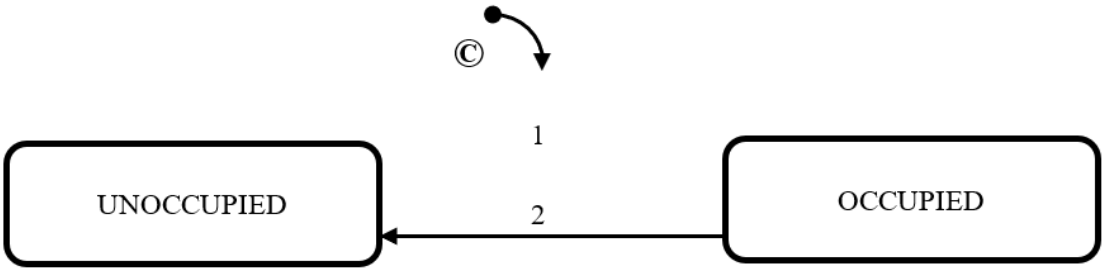

Figure 1
Consumable Location State Model

7.2.3 *Consumable Location State Definitions*

7.2.3.1 *UNOCCUPIED* — A consumable can be mounted while in this state.

7.2.3.2 *OCCUPIED* — A consumable is mounted while in this state and can be unmounted.

7.2.4 *Consumable Location Transition Table*

Table 3 Consumable Location Transition Definition

#	*Previous State*	*Trigger*	*New State*	*Actions*	*Comment*
1	UNOCCUPIED	Consumable is mounted at the consumable location.	OCCUPIED		data variables: ConsumableLocationID ConsumableObjID
2	OCCUPIED	Consumable is unmounted at the consumable location	UNOCCUPIED		data variables: ConsumableLocationID ConsumableObjID-Removed

7.2.5 *Consumable State Model*

[E189.00-RQ-01002-00] Each consumable modeled in the equipment shall implement the Consumable State Model including the transition table with the listed collection events and associated data variables. [/RQ]

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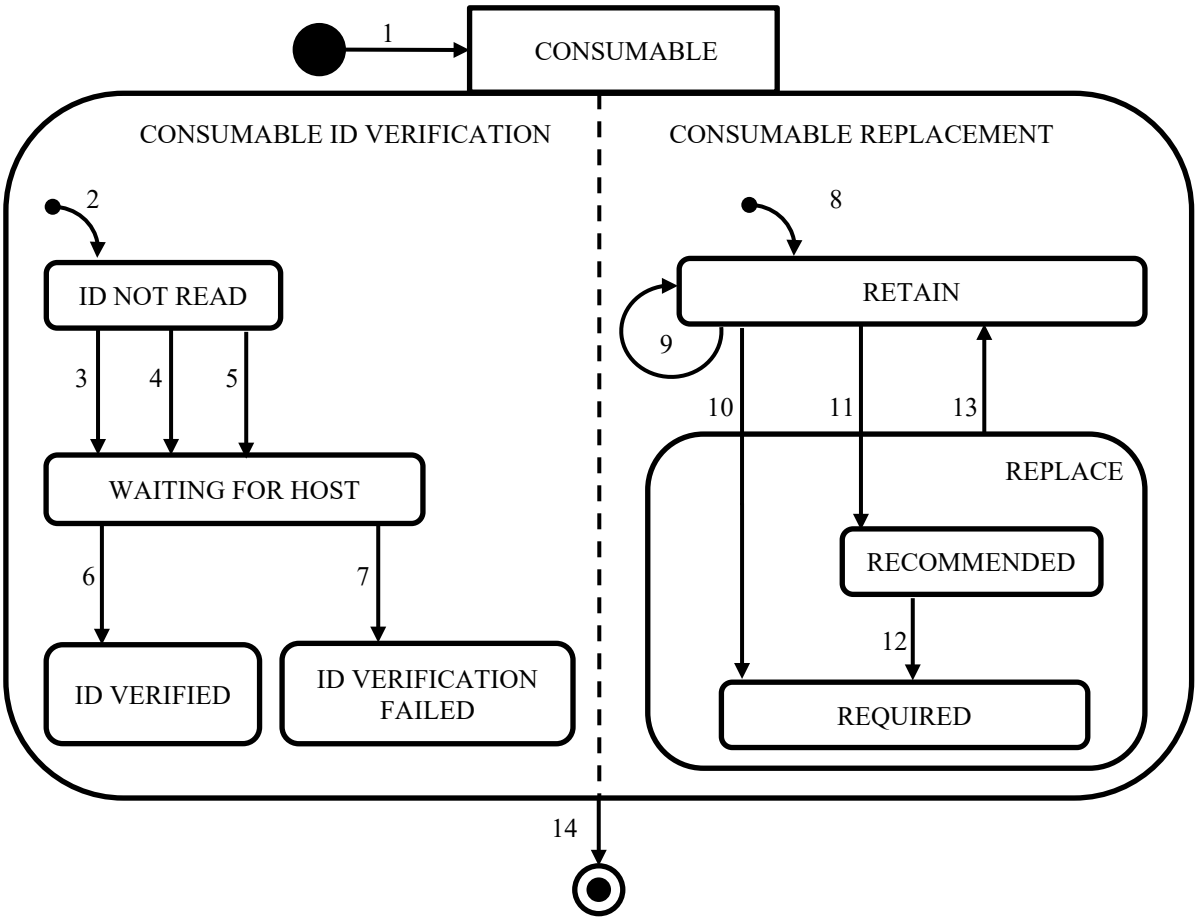

Figure 2
Consumable State Model

7.2.6 *Consumable State Definitions*

7.2.6.1 *CONSUMABLE* — The CONSUMABLE state has two fundamental states including CONSUMABLE ID VERIFICATION and CONSUMABLE REPLACEMENT.

7.2.6.2 *CONSUMABLE ID VERIFICATION* — This is a substate of CONSUMABLE and indicates the status of id verification. The initial state is always ID NOT READ. A consumable should not be used unless CONSUMABLE ID VERIFICATION is disabled or the consumable is in the ID VERIFIED state.

7.2.6.2.1 *ID NOT READ* — Active when the consumable is first instantiated. The equipment assigns a unique object identifier (ObjID) to the consumable.

[E189.00-RQ-01003-00] This state shall remain active when consumable ID verification is bypassed at this location (refer to equipment constant $BypassConsumableIDVerification_i$) and the equipment shall not attempt to read the consumable ID. [/RQ]

[E189.00-RQ-01004-00] When consumable ID verification is not bypassed (refer to equipment constant $BypassConsumableIDVerification_i$), the equipment shall attempt to read the consumable identifier. [/RQ]

7.2.6.2.2 *WAITING FOR HOST* — Active after the equipment has attempted to read the consumable identifier. Also, active when bypass consumable ID verification is disabled and the equipment does not have a consumable id reader at this location.

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7.2.6.2.3 *ID VERIFIED* — Active when the host or operator has verified the consumable ID.

7.2.6.2.4 *ID VERIFICATION FAILED* — Active when the host or operator has caused consumable ID verification to fail.

7.2.6.3 *CONSUMABLE REPLACEMENT* — This is a substate of CONSUMABLE and indicates the status of the consumable's replacement.

7.2.6.3.1 *RETAIN* — Active when the consumable is expected to be in a usable state.

7.2.6.3.2 *REPLACE* — This superstate is active when the consumable is recommended or required to be replaced. The host or equipment can change a consumable to this state based on measured, calculated, or estimated information.

7.2.6.3.3 *RECOMMENDED* — Consumable replacement is recommended.

7.2.6.3.4 *REQUIRED* — Consumable replacement is mandatory.

[E189.00-RQ-01005-00] A consumable shall not be used when CONSUMABLE REPLACEMENT is in a REQUIRED state. An attempt to use a consumable in the REQUIRED state shall result in an alarm. [/RQ]

7.2.7 *Consumable Transition Table*

7.2.7.1 The following data variables are required for all CONSUMABLE state model transition collection events:

- ConsumableLocationID
- ConsumableObjID
- ConsumableIDVerificationState

7.2.7.2 The following additional data variables are required for all CONSUMABLE REPLACEMENT collection events:

- ConsumableAcquiredID
- ConsumableAssignedID
- ConsumableCapacity
- ConsumableReplacementState
- ConsumableExpirationDate
- ConsumableType
- ConsumableUnit
- ConsumableRemainingQuantity
- ConsumableInstallationDate

Table 4 Consumable Transition Definition

#	*Previous State*	*Trigger*	*New State*	*Actions*	*Comment*
1	(no state)	A consumable is instantiated. For example, when a new consumable is mounted. This transition occurs before a consumable's identifier is read.	CONSUMABLE		
2	(no state)	A consumable is instantiated.	ID NOT READ		
3	ID NOT READ	Consumable ID is successfully read.	WAITING FOR HOST		additional data variables: ConsumableAcquiredID
4	ID NOT READ	Error reading consumable ID.	WAITING FOR HOST		additional data variables: ConsumableReadError

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#	*Previous State*	*Trigger*	*New State*	*Actions*	*Comment*
5	ID NOT READ	No ID reader is available at this location.	WAITING FOR HOST		
6	WAITING FOR HOST	Equipment receives a ProceedWithConsumable service from the host or operator.	ID VERIFIED		additional data variables: ConsumableAcquiredID ConsumableAssignedID
7	WAITING FOR HOST	Equipment receives a CancelConsumable service from the host or operator.	ID VERIFICATION FAILED		additional data variables: ConsumableAcquiredID
8	(no state)	A consumable is instantiated.	RETAIN		
9	RETAIN	Equipment evaluates the consumable and determines that it can be retained.	RETAIN		
10	RETAIN	Equipment recognizes that the consumable is to be replaced. This is initiated by the: 1. Equipment software 2. Operator, or 3. Host using a ReplaceConsumable service	REQUIRED		additional data variables: ConsumableReplace-Initiator ConsumableReplace-Reason
11	RETAIN	Equipment recognizes that consumable should be replaced. This is initiated by the: 1. Equipment software 2. Operator, or 3. Host using a ReplaceConsumable service	RECOMMENDED		additional data variables: ConsumableReplace-Initiator ConsumableReplace-Reason
12	RECOMMEND-ED	Equipment recognizes that consumable must be replaced. This is initiated by the: 1. Equipment software 2. Operator, or 3. Host using a ConsumableReplaceRequired service	REQUIRED		additional data variables: ConsumableReplace-Initiator ConsumableReplace-Reason
13	REPLACE	Equipment determines that the consumable replacement is no longer recommended or required. This is initiated by the: 1. Equipment software 2. Operator, or 3. Host using a RetainConsumable service	RETAIN		additional data variables: ConsumableReplace-Initiator ConsumableReplace-Reason
14	CONSUMABLE	Consumable was removed	(no state)		

7.2.8 *ConsumableLocation Object*

[E189.00-RQ-01006-00] Each consumable location modeled in the equipment shall be represented as a ConsumableLocation SEMI E39 object with all required attributes. [/RQ]

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[E189.00-RQ-01007-00] A consumable location object and its attribute values shall be persisted when an equipment is shut down and restarted. [/RQ]

Table 5 ConsumableLocation Object Definition

Attribute Name	*Definition*	*Access*	*Reqd*	*Form*
ObjType	Object type	RO	Y	Text 'ConsumableLocation'
ObjID	Object identifier An identifier assigned by the Equipment designer uniquely identifying the instance of the ConsumableLocation object within this Equipment.	RO	Y	Text 1–80 characters.
				[E189.00-RQ-01008-00] Shall conform to SEMI E39 restrictions for ObjID. [/RQ]
ConsumableObjID	Consumable identifier relevant to the location. Corresponds to the Consumable object's ObjID attribute. Empty string when UNOCCUPIED.	RO	Y	Text
ConsumableAcquiredID	Consumable acquired identifier relevant to the location. Corresponds to the Consumable object's AcquiredID attribute. Empty string when UNOCCUPIED.	RO	Y	Text
ConsumableAssignedID	Consumable assigned identifier relevant to the location. Corresponds to the Consumable object's AssignedID attribute. Empty string when UNOCCUPIED.	RO	Y	Text
LocationState	Consumable location state	RO	Y	Enumerated: UNOCCUPIED OCCUPIED

7.2.9 *Consumable Object*

7.2.9.1 There are up to three ways to identify a consumable object. The ObjID attribute is always available. The AcquiredID attribute is only available when the equipment has successfully read the ID. The AssignedID attribute is only available when a host or operator assigns an identifier.

[E189.00-RQ-01009-00] Each consumable modeled in the equipment shall be represented as a Consumable SEMI E39 object with all required attributes. [/RQ]

[E189.00-RQ-01010-00] A consumable object and its attribute values shall be persisted when an equipment is shut down and restarted. [/RQ]

7.2.9.2 Custom attributes can also be added to describe unique properties of a consumable. For example, it might be useful to report the warm-up time for flux.

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Table 6 Consumable Object Definition

Attribute Name	*Definition*	*Access*	*Reqd*	*Form*
ObjID	Object identifier An identifier assigned by the Equipment designer uniquely identifying the instance of the Consumable object within this Equipment. This identifier is assigned without any host or operator interaction.	RO	Y	Text 1–80 characters
				[E189.00-RQ-01011-00] Shall conform to SEMI E39 restrictions for ObjID. [/RQ]
ObjType	Object type	RO	Y	Text ‘Consumable’
AcquiredID	The identifier of the consumable acquired by the equipment. Empty if the identifier is not successfully read by the Equipment. Also empty before the identifier is read.	RO	Y	Text 0–1024 characters
AcquiredTag	Additional consumable information acquired by the equipment. For example, this might be additional information acquired from a data matrix code, barcode, or RFID reader.	RO	Y	Text
AssignedID	Identifier designated by the host or operator. Empty if not assigned by the host or operator.	RO	Y	Text 0–1024 characters
Capacity	Consumable’s capacity. The unit is determined by attribute Unit.	RO	N	Positive floating point
ReplacementState	The CONSUMABLE REPLACEMENT substate.	RO	Y	Enumerated: RETAIN RECOMMENDED REQUIRED
ExpirationDate	Consumable’s expiration date and time. This can be the manufacturer’s expiration date. This can be updated based on the consumable’s usage. For example, some consumable’s must be used within a certain time after first use. Empty string if an expiration date and time is not applicable.	RW	Y	Date and time
IDVerificationState	State of Consumable identifier verification.	RO	Y	Enumerated: NOT READ WAITING FOR HOST ID VERIFIED ID VERIFICATION FAILED
InstallationDate	Date and time when the Consumable was installed.	RO	Y	Date and time
LocationID	Identifier for the current Consumable location.	RO	Y	Text 1–80 characters
RemainingQuantity	Quantity of remaining consumable.The unit is determined by attribute Unit.	RO	N	Floating point
Type	Type of consumable. For example, flux, epoxy, or wire.	RW	Y	Text 0–512 characters

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