SEMI E109-1102
PROVISIONAL SPECIFICATION FOR RETICLE AND POD MANAGEMENT (RPMS)

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1 Purpose

1.1 This document provides standardized behavior for lithography, reticle inspection, and bare reticle stocker equipment. It also provides for standardized communication with lithography, reticle inspection, and bare reticle stocker equipment. This includes the coordination, execution, and completion of automated and manual reticle pod transfers to and from the equipment, transfer of reticles to and from the reticle pods, movement of the reticles within the equipment, identification and verification of both reticle pods and reticles, inspection and qualification of reticles, and other relevant information such as tracking reticle usage.

2 Scope

2.1 This is a provisional standard that covers host and equipment communication for equipment that handle reticles. This only includes equipment that handle reticles both in and outside of a reticle pod. The provisional status is required because of the immaturity of implementations of integrated equipment with Automated Material Handling Systems (AMHS) or Automated Reticle Handling Systems (ARHS), and additional specifications may yet be defined to add further functionality. Also, further exception handling and error recovery scenarios need to be defined.

2.2 The scope of this document is to define standards that facilitate the host's knowledge and role in automated and manual reticle pod transfers, reticle transfers to and from the reticle pod, internal reticle movement, identification and verification of ReticleID, inspection and qualification of reticles, and tracking reticle usage. Specifically, this document provides state models and scenarios that define the host interaction with the equipment for the following:

- Reticle pod transfer between AMHS vehicles and production equipment, bare reticle stockers, and reticle inspection equipment reticle load ports.
- Reticle transfers to/from lithography production equipment internal reticle library space.
- Equipment and reticle load port access mode switching.
- Reticle Pod to load port association.
- Reticle Pod ID verification and Reticle Pod slot map verification.

2.3 In order for the provisional status to be removed, the following issues must be resolved:

- Linkage to process job management standard.
- Implementations of this standard must prove validity of the standard before the provisional status can be removed.

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

3 Limitations

3.1 This standard applies to semiconductor equipment that handles reticles and reticle carriers. This standard is intended to be used for lithography production, bare reticle storage, and reticle inspection equipment. It may or may not be applied to other types of equipment.

4 Referenced Standards

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

4.1 *SEMI Standards*

SEMI E15 — Specification for Tool Load Port

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

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

SEMI E41 — Exception Management (EM) Standard

SEMI E53 — Event Reporting

SEMI E84 — Specification for Enhanced Carrier Handoff Parallel I/O interface

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SEMI E99 — Carrier ID Read/Write Functional Standard

SEMI E100 — Specification for a Reticle SMIF Pod (RSP) Used to Transport and Store 6 inch or 230 mm Reticles

5 Terminology

5.1 *Abbreviations and Acronyms*

5.1.1 *AGT* — Automated Guided Transport

5.1.2 *AGV*— Automated Guided Vehicle

5.1.3 *AMHS* — Automated Material Handling System

5.1.4 *ARHS* — Automated Reticle Handling System

5.1.5 *GEM* — Generic Equipment Model

5.1.6 *IRL* — Internal Reticle Library

5.1.7 *OHT* — Overhead Hoist Transport

5.1.8 *PGV* — Person Guided Vehicle

5.1.9 *PIO* — Parallel Input/Output Interface

5.1.10 *RGT* — Rail Guided Transport

5.1.11 *RGV* — Rail Guided Vehicle

5.1.12 *RSP* – Reticle SMIF Pod

5.2 *Definitions*

5.2.1 *Automated Material Handling System* — an automated system to store and transport materials within the factory.

5.2.2 *Automated Reticle Handling System* — a specific type of Automated Material Handling System to store and transport reticles and reticle pods within the factory.

5.2.3 *automation* — the degree to which activities of machines or production systems are self-acting. In this standard automation provides methods that will reduce the amount of operator intervention required.

5.2.4 *buffer* — a set of one or more locations for holding reticles at/inside the production equipment.

5.2.5 *collection event* — a collection event is an event (or grouping of related events) on the equipment that is considered to be significant to the host.

5.2.6 *content map* — Ordered list of reticle identifiers corresponding to slot 1,2,3…n. (Note that this is redundant with the definition in Table 6).

5.2.7 *host* — the factory computer system or an intermediate system that represents the factory and the user to the equipment.

5.2.8 *internal reticle library* — a set of locations within the equipment to store reticles. These locations exclude load ports.

5.2.9 *Internal Pod Buffer* — storage area for reticle pod that is internal to the equipment.

5.2.10 *load* — the operation of placing a pod on a load port.

5.2.11 *load port* — the interface location on the equipment where pods are loaded and unloaded.

5.2.12 *Multi-Reticle Pod* — TBD

5.2.13 *object instantiation* — the act of storing of information related to a physical or logical entity so that it can be recalled on demand based on its public identifier.

5.2.14 *on-line equipment* — equipment that is connected to, and able to communicate fully with, the host.

5.2.15 *pod* — in this document pod refers to an RSP or a Multi Reticle SMIF Pod.

5.2.16 *PodID* — a readable and unique identifier for the pod.

5.2.17 *PodID read* — the process of the equipment reading the PodID from the carrier.

5.2.18 *PodID tag (tag, ID tag)* — a physical device for storing PodID and other information. There are two basic types of tags, read-only tags and read/write tags. [SEMI E99]

5.2.19 *process equipment* — equipment used to produce product, such as semiconductor devices. This excludes metrology and material handling equipment.

5.2.20 *production equipment* — equipment used to produce product, such as semiconductor devices, including substrate sorting, process, and metrology equipment and excluding material handling equipment.

5.2.21 *properties* — a set of name value pairs assigned to an object or used in a service message to include additional information about the object (i.e., pod, port, etc.).

5.2.22 *re-initialization* — a process where production equipment is either powered off then on or when some kind of hardware or software reset is initiated to cause the equipment to reset and possibly reload its software. On production equipment that contains some kind of mass storage device this can also be called a “reboot”.

5.2.23 *read position* — any position where the tag on a pod can be read.

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5.2.24 *reticle* — a mask that contains the patterns to be reproduced on a substrate; the image may be equal to or larger than the final projected image.

5.2.25 *Reticle SMIF Pod (RSP)* — minienvironment compatible carrier capable of holding one 6 inch or one 230 mm reticle in a horizontal orientation during transport and storage and is compatible with a Standard Mechanical Interface (SMIF) per SEMI E19.4.

5.2.26 *single communication connection* — exactly one physical connection using exactly one logical session and a standard set of messages.

5.2.27 *slot map* — the information that relates which slots in a reticle pod hold reticles, both correctly and incorrectly.

5.2.28 *slot map read* — the process of the equipment reading the slot map for substrate position and placement within the pod.

5.2.29 *standard message set* — messages conforming to standard message specifications.

5.2.30 *transfer unit* — maximum number of pods allowed in a specific transfer service:

- AA is the maximum number of pods allowed for acquisition at the transfer source.
- BB is the maximum number of pods allowed for deposit at the transfer destination.
- CC is the maximum number of carrier pods allowed for transfer in one transport vehicle.

The transfer unit is the minimum of AA, BB, and CC.

NOTE 2: At the time this document was originally written, December 2000, transfer unit for reticle transfer to process equipment is expected to be equal to one. Transfer unit to other equipment may be greater than one.

5.2.31 *unload* — the operation of removing a pod from a load port.

5.2.32 *write position* — any position on a load port or in an internal buffer from which the tag on a pod can be written to. This position may vary on any particular equipment depending on the write technology selected by the end user. The read position and the write position may or may not be the same position.

6 Requirements

6.1 Reticle and Pod Management compliant equipment is required to provide certain capabilities defined by other standards: accessibility to status information, event reporting, alarm management, and equipment control. These requirements shall be satisfied through compliance to the following sets of standards:

6.2 *Generic Equipment Model Standard (GEM) SEMI E30*

- Event Notification
- Status Data Collection
- Equipment Constants
- Alarm Management
- Equipment Control
- Remote Control
- Error Messages
- Dynamic Event Report Configuration

6.3 *Object-Based Standards*

- Object Services Standard (SEMI E39)
- Event Reporting (SEMI E53)
- Exception Management (SEMI E41)

7 Conventions

7.1 *Objects*

7.1.1 Whenever the equipment is required to know about specific kinds of entities, and required to manage information concerning these entities, it is useful to treat these entities as objects that comply with the basic requirements of SEMI E39 (OSS). This is especially true whenever there are a large number of objects of a given type or when the entities are transient rather than permanent. In both cases, it is difficult to describe a general way for the host and equipment to specify which particular entity is referenced and to get information related only to a specific one out of many.

7.1.2 By defining these entities as objects that comply with SEMI E39, it is only necessary for the host to specify the type of object and its specific identifier in order to inquire about one or more properties of the specific entity of interest.

7.1.3 *Object Properties*

7.1.3.1 A property (attribute) is information about an individual object that is presented as a name/value pair. The name is a formally reserved text string that represents the property, and the value is the current setting for that property.

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7.1.3.2 Properties shall be accessible to the host via the service GetAttr and SetAttr for the Reticle Pod object. Reticle object, and Reticle location object.

- get the list of IDs for the current reticle pods at the equipment, and
- get the specified properties for one or more individual reticle pods.

7.1.4 *Rules for Object Properties*

- Attributes with RO access can not be changed using SetAttr service as defined in OSS.
- Attributes with RW access can be changed using SetAttr service as defined in OSS.
- Additional attributes may be specified by the user or the equipment supplier by using an attribute name starting with "UD" (User Defined). Care should be taken to ensure the name of the attribute is unique.

7.1.5 *Object Attribute Table*

7.1.5.1 The object attribute table is used to list all the attributes related to the defined object as shown below the access is defined as Read only (RO) or Read/Write (RW). The REQD column is used to specify whether the attribute is required for implementation. Finally, the Form column is used to specify the format of that particular attribute.

Table 1 Object Attribute Table

Attribute Name	*Definition*	*Access*	*Reqd*	*Form*
ObjType	Object type	RO	Y	Text = "Carrier"

7.2 *State Model Methodology*

7.2.1 A state model has three elements: definitions of each state and sub-state, a diagram of the states and the transitions between states, and a state transition table. The diagram of the state model uses the Harel State Chart notation. An overview of this notation is presented in an Appendix of SEMI E30. The definition of this notation is presented in Science of Computer Programming 8, "Statecharts: A Visual Formalism for Complex Systems", by D. Harel, 1987.[1]

7.2.2 *State Model Requirements*

7.2.2.1 The state models included in this standard are a requirement for RPMS compliance. A state model consists of a state model diagram, state definitions, and a state transition table. All state transitions in this standard, unless otherwise specified, shall correspond to collection events.

7.2.2.2 A state model represents the host's view of the equipment, and does not necessarily describe the internal equipment operation. All Reticle and Pod Management state model transitions shall be mapped sequentially into the appropriate internal equipment collection events that satisfy the requirements of those transitions. In certain implementations, the equipment may enter a state and have already satisfied all of the conditions required by the RPMS state model for transition to another state. In this case, the equipment makes the required transition without any additional actions in this situation.

7.2.2.3 Some equipment may need to include additional sub-states other than those in this standard. Additional sub-states may be added, but shall not change the Reticle and Pod Management defined state transitions. All expected transitions between Reticle and Pod Management states shall occur.

7.2.2.4 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.

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

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- Actions taken which are most closely associated with the transition.

Table 2 State Transition Table

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

7.3 *Services*

7.3.1 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.

7.3.2 *Service Message Description*

7.3.2.1 A service message description table defines the parameters used in a service, as shown in the following table:

Table 3 Service Message Description Table

Service Name	*Type*	*Description*

NOTE 1: Type can be either "N" = Notification or "R" = Request & Response.

7.3.2.2 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).

7.3.3 *Service Message Parameter Definition*

7.3.3.1 A service parameter dictionary table defines the description, range, and type for parameters used by services, as shown in the following table:

Table 4 Service Message Parameter Definition Table

Parameter Name	*Form*	*Description*

NOTE 1: A row is provided in the table for each parameter used on a service.

7.3.4 *Service Message Definition*

7.3.4.1 A service message description table defines the parameters used in a service message. It also describes each message and its cause/effect to the equipment. The columns labeled Req/Ind and Resp/Conf link the parameters to the direction of the message.

Service Parameter	*Req/Ind*	*Resp/Conf*	*Description*

7.3.4.2 The columns labeled Req/Ind and Rsp/Conf 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". The receiver may then send a "Response", which the original sender terms the "Confirmation".

7.3.4.3 The following codes appear in the Req/Ind and Rsp/Conf columns and are used in the definition of the parameters (e.g., how each parameter is used in each direction):

"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 values of other parameters.

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"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).

7.4 *Alarm Requirements Definition*

7.4.1 An alarm requirements definition table defines the specific set of alarms required by RPMS. The table is divided up by equipment configuration, and then by alarm. The danger and affected columns are marked with "X" characters to show each alarm and its possible impact to operators, equipment, and material. The table format is shown in the following example:

Equipment		*Danger*		*Affected*		
Configuration	*Alarm Text*	*Potential*	*Imminent*	*Operator*	*Equipment*	*Material*
Configuration 1	Alarm 1	X		X	X	X
	Alarm 2		X			X
Configuration 2	Alarm 3	X		X	X	
	Alarm 4	X			X	X

8 Overview

8.1 The Reticle and Pod Management standard defines the behavior, data, and services required for equipment supporting automated reticle pod transfer, reticle pod management, and reticle management. This document provides a standard interface for host/equipment communications regarding the transfer of reticle pods, reticle pod identification and verification, transfer of reticles to and from equipment, reticle identification and verification, reticle inspection and qualification, and tracking of reticles. The standardized reticle pod transfer host interface include transfers to and from the external reticle load ports and internal reticle pod locations, the standardized reticle host interface include transfers to and from the reticle pod, transfers to and from the internal reticle library positions, and reticle identification, inspection, verification, qualification and tracking of reticles.

8.2 *Single Connection Requirement*

8.2.1 The expectation of the production and storage equipment supplier is that this standard be implemented in conjunction with the GEM interface to their production equipment and without the use of a separate communication connection.

9 Load Port

9.1 A reticle pod load port (port) is used by the factory to load and unload reticle pods to and from Lithography, reticle inspection, and bare reticle storage equipment. A reticle pod load port may be used as a reticle pod input load port, a reticle pod output load port, or as a reticle pod input/output load port, depending upon equipment type, configuration and/or factory practices. This classification may be fixed or it may be programmable by the user. A reticle pod load port is generally designed to handle one specific carrier type, reticle SMIF pods (RSP).

9.1.1 The equipment supplier is free to implement Load Ports as objects, but this is not a requirement for compliance to this standard.

9.2 *Load Port Numbering*

9.2.1 The reticle pod load port number shall be assigned incrementally from the bottom left to bottom right, then top left to top right when facing the reticle load ports. The numbering system should start with 101 to differentiate from FOUP load ports. The reticle pod load port-numbering requirement is to provide a common reference base to external entities, such as humans.

9.3 *Reticle Pod Slot Numbering*

9.3.1 The slot numbers for a reticle pod shall be assigned incrementally from the bottom, starting with "1."

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9.4 *Reticle Pod Load Port Resource Sharing*

9.4.1 A model of a reticle pod load port must account for any mechanical assemblies that are either active during reticle pod transfer or are capable of interacting with the transfer. The reticle pod load port is responsible for such mechanisms when the reticle pod load port is in the TRANSFER READY state. If these mechanisms are shared with other reticle pod load ports, then the sharing must be coordinated.

9.5 *Reticle Pod Load Port Transfer State Model*

9.5.1 The purpose of the Reticle Pod Load Port Transfer State Model is to define the host view of a reticle pod transfer, which includes the host interactions with the equipment necessary to transfer reticle pods to and from equipment reticle pod load ports. Each reticle pod load port on the equipment shall maintain an independent instance of this state model.

9.5.2 *Reticle Pod Load Port Transfer State Model Diagram*

9.5.2.1 Figure 1 is the diagram for the Reticle Pod Load Port Transfer State Model.

9.5.3 *Reticle Pod Load Port Transfer State Definitions*

9.5.3.1 RETICLE POD LOAD PORT TRANSFER — The super state for the IN SERVICE and OUT OF SERVICE states.

9.5.3.2 OUT OF SERVICE — Transfer to/from this reticle pod load port is disabled. A transition to IN SERVICE is required to continue using this reticle pod load port for transfers.

9.5.3.3 IN SERVICE — Transfer to/from this reticle pod load port is enabled. A transition to OUT OF SERVICE disables the reticle pod load port for transfer use.

9.5.3.4 TRANSFER READY — A sub-state of IN SERVICE. The reticle pod load port is available for pod transfer. The transfer can either be manual or automated, and can be a load or an unload. This state contains two sub-states, which are used depending on whether or not a reticle pod is present on the load port (READY TO LOAD and READY TO UNLOAD).

9.5.3.5 READY TO LOAD — A sub-state of TRANSFER READY. When transitioning to the TRANSFER READY state, if a reticle pod is not present on the specified reticle pod load port, this is the active sub-state. In this state, the reticle pod load port is available to be loaded with an external reticle pod.

9.5.3.6 READY TO UNLOAD — A sub-state of TRANSFER READY. When transitioning to the TRANSFER READY state, if a reticle pod is present on the specified reticle pod load port, this is the active sub-state. In this state, the reticle pod load port is available for unloading of a reticle pod from the reticle pod load port to material handling equipment. When the reticle pod load port is being used by the equipment, the state shall transition to TRANSFER BLOCKED.

9.5.3.7 TRANSFER BLOCKED — The reticle pod transfer state is neither READY TO LOAD nor READY TO UNLOAD. Because of reticle pod load port related activity being performed, transfer is not available to/from this reticle pod load port at this time.

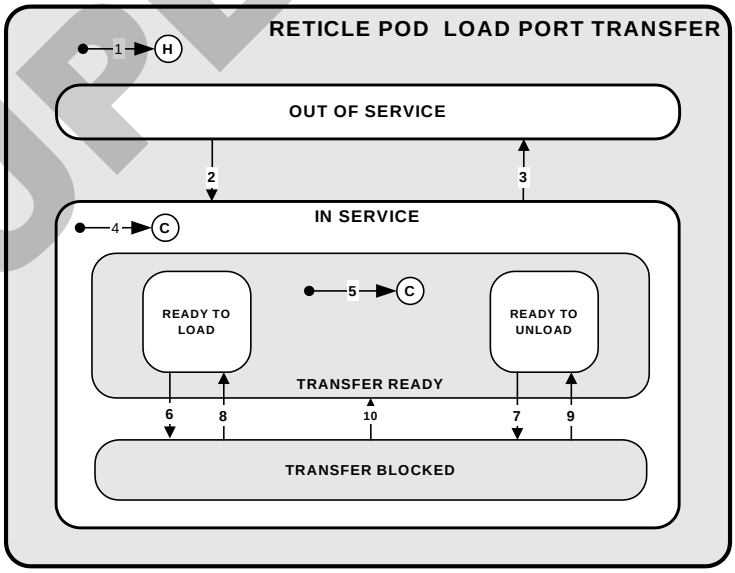

Figure 1
Reticle Pod Load Port Transfer State Model Diagram

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9.5.4 *Reticle Pod Load Port Transfer State Transition Table*

Table 5 Reticle Pod Load Port Transfer State Transition Definition

#	*Previous State*	*Trigger*	*New State*	*Actions*	*Comments*
1	(no state)	System reset.	OUT OF SERVICE or IN SERVICE (History)		This transition is based on what the current transfer status was prior to system reset. Data required to be available for this event report: PortID
2	OUT OF SERVICE	The host or an operator has invoked the ChangeServiceStatus service for this load port with a value of IN SERVICE.	IN SERVICE		Reticle Pod Load port is now usable for transfer. Data required to be available for this event report: PortID
3	IN SERVICE	The host or an operator has invoked the ChangeServiceStatus service for this load port with a value of OUT OF SERVICE.	OUT OF SERVICE		Reticle Pod Load port is now rendered unusable for transfer. Attempted usage of the reticle pod load port for reticle pod transfer after the state transition results in an alarm. Data required to be available for this event report: PortID
4	IN SERVICE	*Service:* The host or an operator has invoked the ChangeServiceStatus service for this load port with a value of IN SERVICE. *System Reset:* This transition can be activated by an equipment re-initialization.	TRANSFER READY or TRANSFER BLOCKED		This is the default entry into IN SERVICE. The state is TRANSFER BLOCKED if the reticle pod, or reticle pod load port, is not available for pod transfer. Otherwise, the state is TRANSFER READY. Data required to be available for this event report: PortID
5	TRANSFER READY	*Service:* The host or an operator has invoked the ChangeServiceStatus service for this load port with a value of IN SERVICE. *System Reset:* This transition can be activated by an equipment re-initialization. *Failed Transfer:* If a transfer fails, this transition is activated by transition #10.	READY TO LOAD or READY TO UNLOAD		When entering the TRANSFER READY state, if a reticle pod is present, the sub-state is READY TO UNLOAD, else the sub-state is READY TO LOAD. If the state is READY TO LOAD, data required to be available for this event report: PortID If the state is READY TO UNLOAD, data required to be available for this event report: PortID PodID
6	READY TO LOAD	*Manual*: "The equipment recognizes the logical indication of the start of a manual load transfer. This trigger is configurable by the user, examples are included in table 8." *Automated*: The PIO load transfer is beginning and the PIO ready signal is activated.	TRANSFER BLOCKED		Data required to be available for this event report: PortID

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#	Previous State	Trigger	New State	Actions	Comments
7	READY TO UNLOAD	*Manual*: The equipment recognizes a logical indication of the start of an unload transfer. *Automated*: The PIO unload transfer is beginning and the PIO ready signal is activated.	TRANSFER BLOCKED		Data required to be available for this event report: PortID
8	TRANSFER BLOCKED	*Manual:* The reticle pod unload transfer has completed, and the reticle load port is now empty and ready for load transfer. *Automated:* The PIO unload transfer ends with a PIO complete signal.	READY TO LOAD		Data required to be available for this event report: PortID
9	TRANSFER BLOCKED	*Manual: Activities using reticles contained within the pod have completed* the reticle pod is ready to be removed. *Automated:* Handling for reticles destined for the reticle pod has completed, or a CancelPod/ CancelPodAtPort service has been issued, and the reticle pod is ready to be removed. This is indicated by a PIO unload request signal.	READY TO UNLOAD		The reticle pod on the reticle pod load port can now be unloaded from the reticle load port to an external entity. Data required to be available for this event report: PortID PodID
10	TRANSFER BLOCKED	The transfer was unsuccessful, and the reticle pod was not loaded or unloaded.	TRANSFER READY		The sub-state of TRANSFER READY, which is decided by transition #5. Data required to be available for this event report: PortID

10 Reticle Pod Object

10.1 Information about a reticle pod is encapsulated as an object. This allows the host to exchange information with the equipment about one or more specific reticle pods using services defined in SEMI E39, Object Services Standard. A reticle pod has properties (attributes) that are defined in Table 6, Pod Attribute Definition.

10.2 *Object Instantiation*

10.2.1 The reticle pod object is a software representation of the reticle pod in the equipment. Under normal circumstances this object is instantiated by the equipment when the host uses the Bind, ReticleTransferJob, or PodNotification service or when the equipment successfully reads the PodID from the reticle pod. A reticle pod object is instantiated by PodID read only if there are no currently existing objects of the same object type with the PodID just read. A reticle pod object can also be instantiated by either the ProceedWithPod or CancelPod Services on an UNASSOCIATED port. (This implies a failed PodID read event.) The ContentMap attribute will be an empty list (a list of zero) when the instantiation is done by PodID read. The SlotMap attribute should be a list consisting of all slots enumerated as "UNDEFINED" when the reticle pod object is instantiated by PodID read.

10.2.2 From the host point of view, an object is instantiated if the host is able to query the equipment about that object, it's current state, and other attributes. Once instantiated, the object is considered destroyed (no longer instantiated) if the response to such queries is "unknown object".

10.2.3 Summary of reticle pod object instantiation:

1. Bind, ReticleTransferJob, or PodNotification Service;
2. PodID read with no currently existing pod objects having the PodID just read; and
3. ProceedWithPod or CancelPod Service on an UNASSOCIATED port with a pod.

10.2.4 *Reticle Pod Object Identifier (ObjID)*

10.2.4.1 The purpose of an Object Identifier is to allow references to an object within the system. The object

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identifier is created when an object is instantiated and should be unchanged or persistent until the end of the object lifecycle. The Object Identifier shall be unique at the equipment during lifecycle of the object. The PodID is the Reticle Pod Object Identifier. The equipment is responsible for ensuring uniqueness of the PodID prior to instantiation by the bind, pod notification, or ReticleTransferJob service.

10.2.5 *Reticle Pod Object Destruction*

10.2.5.1 Normally, the Reticle Pod Object reaches the end of its lifecycle when the reticle pod is unloaded from the equipment. Abnormally, the Reticle Pod Object reaches the end of it's lifecycle when a CancelBind, CancelReticleTransferJob, or CancelPodNotification service is executed prior to the reticle pod being loaded, or when an equipment based pod verification fails following pod instantiation by the bind service.

10.2.5.2 Summary of reticle pod object destruction:

1. A reticle pod is unloaded from the equipment;
2. A CancelBind, CancelReticleTransferJob or CancelPodNotification service is received; and
3. An equipment based verification fails (after the object has been instantiated via the bind services).

10.3 *Reticle Pod Attribute Definitions*

10.3.1 The following table contains the attributes that are of importance to the host and/or the equipment in order to manage the history and the reports about the reticle carrierpod object.

10.3.2 *REQD Column*

10.3.2.1 All attributes in the following table are required to be associated with the reticle pod object. However only the attributes marked with a "Y" in the REQD column are always required to be maintained and updated by the equipment. The attributes marked with an "N" in the REQD column are only required to be maintained if they are provided by the host by either the Bind, PodNotification, ReticleTransferJob or ProceedWithPod Services or if the equipment has means of determining the attribute values. (For example, if the equipment has a ReticleID reader, the equipment can determine the ContentMap).

10.3.3 *ACCESS Column*

10.3.3.1 Even though a value may be marked as RO (read only), the initial value for the attribute may be provided by the host when attached to either the Bind, PodNotification, ReticleTransferJob or ProceedWithPod services. The only other time the PodCapacityStatus attributes are updated is at the first ProceedWithPod service.

10.3.4 *Pod Attribute Definition Table*

Table 6 Pod Attribute Definition

Attribute Name	*Definition*	*Access*	*Reqd*	*Form*
ObjType	Object type.	RO	Y	Text equal to "Reticle Pod".
ObjID	Object identifier.	RO	Y	Text 1 to 80 characters equal to the PodID.
Capacity	Maximum number of reticles in pod.	RO	Y	Positive integer. If a pod arrives at a load port with no warning the default value is one.
PodIDStatus	Current state of the PodID verification.	RO	Y	Enumerated: ID NOT READ, WAITING FOR HOST ON ID STATUS, ID VERIFICATION OK, ID VERIFICATION FAILED.
ReticlePodAccessing-Status	The current accessing state of the reticle pod by the equipment. The current substate of the ReticlePodAccessingStatus state model.	RO	Y	Enumerated: NOT AVAILABLE, AVAILABLE, IN ACCESS, COMPLETE
ContentMap	Ordered list of reticle identifiers corresponding to slot 1,2,3……n	RO	Y	Ordered list of n elements, where n is equal to the value of "Capacity" above, and each element consists of a ReticleID. When a slot has no reticle, the ReticleID value should be null.
ReticlePodLocationID	Identifier of current location of the reticle pod.	RO	Y	Text 1 to 80 characters.

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Attribute Name	*Definition*	*Access*	*Reqd*	*Form*
ReticlePodLocking-Status	The current state of pod locking by the equipment. The current substate of the ReticlePodLockingStatus.	RO	Y	Enumerated: NOT LOCKED, RELEASED AND LOCKED, HOLD
SlotMap	Ordered List of slot status as provided by the host until a successful slot map read, then as read by the equipment.	RO	Y	Ordered List of n elements where n is equal to the value of "Capacity" above. 1. Enumerated $_1$. n. Enumerated$_n$ Enumerated: UNDEFINED, EMPTY, CORRECTLY OCCUPIED. The number shown above is the slot number.
SlotMapStatus	Current state of slot map verification.	RO	Y	Enumerated: SLOT MAP NOT READ, WAITING FOR HOST ON SLOT STATUS, SLOT MAP VERIFICATION OK, SLOT MAP VERIFICATION FAILED.

10.3.5 *Rules for Reticle Pod Attributes*

- The equipment shall change object attributes, ContentMap and SlotMap, provided by the host. All other attributes, such as LocationID, shall be set and maintained by the equipment.
- The attributes, Capacity, ContentMap, Reticle count, shall be provided with Bind, PodNotification, ReticleTransferJob, or ProceedWithPod service before or when SlotMap is provided.
- The SlotMap shall be provided with Bind, PodNotification, ReticleTransferJob or ProceedWithPod to verify PodID, when the SlotMap verification is equipment based. And it shall not be provided when the SlotMap verification is host based.
- Reticle pod properties may be provided before the reticle pod arrives as part of the Bind, PodNotification, or ReticleTransferJob service and should be retained until either a CancelBind, CancelPodNotification, or CancelReticleTransfer-Job service is received or the reticle pod is removed.
- Reticle pod properties may also be provided by the ProceedWithPod service. The reticle pod properties that are provided by the ProceedWithPod service may differ based whether or not the object is instantiated by the service.
- Reticle pod properties that are required shall be actively updated by the equipment.

10.3.6 *Reticle Pod Location*

10.3.6.1 A reticle pod location, signified by LocationID, is used for tracking. A reticle pod location is any physical area that is capable of holding a pod. It is not intended to represent entire mechanisms, which may have a variety of other properties of interest, but only that portion where a reticle pod may rest.

10.3.7 *Reticle Pod Location Examples*

10.3.7.1 Reticle Pod Locations include reticle pod load port locations, internal pod buffer locations, as well as grippers, conveyors, and elevators that are used internally for moving the pod from one fixed location to another.

10.3.8 *Slot Map Relation to Content Map* — The slot map attribute and content map attribute hold similar information. The purpose of these attributes differs. The slot map is provided so that the equipment or host can quickly verify that the pod has reticles correctly placed in the correct slot (as provided by the host). This verification is based on a slot map read. The content map is provided so that the host can communicate the specific ReticleID in a specific slot as delivered and that the equipment can communicate the specific ReticleID that it places in a specific slot.

10.3.9 *Reticle Pod Location Naming* — All locations shall be assigned a unique name. Information about the reticle pod location can be obtained by querying the Pod Object for the ReticlePodLocationID or by asking the equipment for the PodLocationMatrix. The text form of the ReticlePodLocationID shall be descriptive of the location.

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10.3.10 *Capacity*

10.3.10.1 The Capacity parameter can be sent to the equipment by the host in either the PodNotification, Bind, ReticleTransferJob, or the ProceedWithPod service. However the equipment shall update this

10.3.10.2 parameter based on the results of the read slot map operation. Furthermore, the equipment shall update the parameter based on it's own actions. . If the equipment does not know the value of Capacity prior to instantiation, the equipment shall instantiate the reticle pod object with the value of one for Capacity.*Reticle Pod Accessing Status*

10.3.11 *The ReticlePodAccessing*

10.3.11.1 Status is used by the host to know whether or not the reticle pod owned by the equipment can be transferred from the equipment.

10.3.11.2 Enumerated values of ReticlePodAccessing-Status correspond to the substates of ReticlePodAccessingStatus (see Figure 2).

10.4 *Reticle Pod State Model*

10.4.1 The purpose of the Reticle Pod State Model is to define the host's view of a reticle pod. The equipment shall maintain a separate and independent state model for each reticle pod in/at the equipment.

10.4.2 *Reticle Pod State Model Diagram*

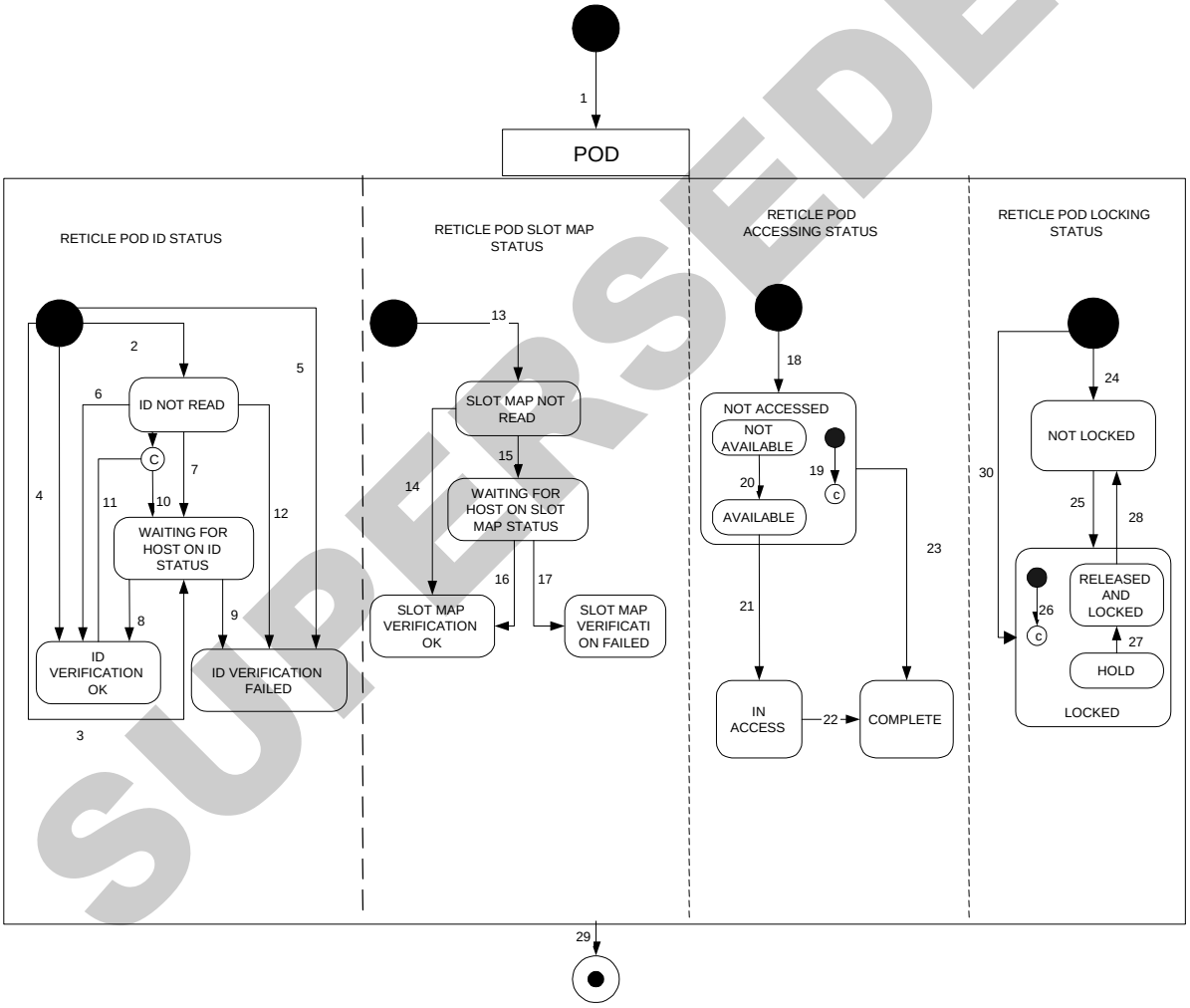

Figure 2
Reticle Pod State Model Diagram

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10.4.3 *Reticle Pod State Definitions*

10.4.3.1 *RETICLE POD* — The RETICLE POD state has four ANDed (orthogonal) substates: RETICLE POD ID STATUS, RETICLE POD SLOT MAP STATUS, RETICLE POD ACCESSING STATUS, AND RETICLE POD CLAMPING STATUS.

10.4.3.1.1 *RETICLE POD ACCESSING STATUS* — This is a substate of RETICLE POD and indicates the current accessing status of the pod. It has three substates, NOT ACCESSED, IN ACCESS, and COMPLETE. The initial default entry substate is NOT ACCESSED.

10.4.3.1.1.1 *NOT ACCESSED* — This is a substate of RETICLE POD ACCESSING STATUS and is active when the reticle pod has not been opened. It has two substates NOT AVAILABLE and AVAILABLE.

10.4.3.1.1.1.1 *NOT AVAILABLE* — This is a substate of NOT ACCESSED and is active when the reticle pod has been instantiated via service but has not been received by the equipment.

10.4.3.1.1.1.2 *AVAILABLE* — This is a substate of NOT ACCESSED and is active when the reticle pod has been received by the equipment but not opened.

10.4.3.1.1.2 *IN ACCESS* — This is a substate of RETICLE POD ACCESSING STATUS and is active when reticle pod has been opened once, and the reticle pod should not be unloaded from the equipment. In this state the slot map is read and reticles may be moved in and out of the reticle pod.

10.4.3.1.1.3 *COMPLETE* — This is a substate of RETICLE POD ACCESSING STATUS and is active when all known activity, as defined by the ReticleTransferJob service, for the reticle pod has completed, or the PodComplete service has been received, and the reticle pod has been closed. The reticle pod may be unloaded from the equipment.

10.4.3.1.2 *RETICLE POD LOCKING STATUS* — This is a substate of RETICLE POD and indicates the current status of the pod with respect to removability.

10.4.3.1.2.1 *NOT LOCKED* — This is a substate of RETICLE POD LOCKING STATUS and is active when there are no physical or logical mechanisms that prevent removal of the reticle pod by an external entity.

10.4.3.1.2.2 *LOCKED* — This is a substate of RETICLE POD LOCKING STATUS and is active when there are physical mechanisms that prevent removal of the reticle pod by an external entity. It has two substates RELEASED AND LOCKED and HOLD.

10.4.3.1.2.2.1 *RELEASED AND LOCKED* — This is a substate of LOCKED and is active when the pod may be released by the equipment.

10.4.3.1.2.2.2 *HOLD* — This is a substate of LOCKED and is active when there are physical or logical mechanisms that prevent removal of the pod engaged and the pod release flag is set to host release and the PodRelease service has not been received.

10.4.3.1.3 *RETICLE POD ID STATUS* — This is a substate of RETICLE POD and indicates the current status of the pod with respect to its identifier. It has four substates, ID NOT READ, WAITING FOR HOST ON ID STATUS, ID VERIFICATION FAILED, ID VERIFICATION OK. The initial substate is conditional based on information the equipment has about the reticle pod. When the PodID is provided by the Bind, ReticleTransferJob, or the PodNotification service, the reticle pod object shall be instantiated in the ID NOT READ substate. When the PodID is provided by the PodID read, the reticle pod shall be instantiated in the WAITING FOR HOST ON ID STATUS substate. When the Reticle Pod is instantiated by the ProceedWithPod service, the reticle pod shall be instantiated in the ID VERIFICATION OK substate. Finally when the reticle pod is instantiated by the CancelPod service, the pod will be instantiated in the ID VERIFICATION FAILED substate.

10.4.3.1.3.1 *ID NOT READ* — This is a substate of RETICLE POD ID STATUS. This state is active whenever the PodID has not been read by the equipment.

10.4.3.1.3.2 *ID VERIFICATION FAILED* — This is a substate of RETICLE POD ID STATUS and is active when the PodID has verification by the host with the CancelPod service. This is a final state.

10.4.3.1.3.3 *ID VERIFICATION OK* — This is a substate of RETICLE POD ID STATUS and is active as soon as the PodID has been accepted. The ID is determined to be accepted by either successful verification by the equipment or the host, or by bypassing ID read because a PodID reader is not available and the BypassReadID variable is set to true. This is a final state.

10.4.3.1.3.4 *WAITING FOR HOST ON ID STATUS* — This is a substate of RETICLE POD ID STATUS and is active during the period of time when the PodID has been read by the equipment successfully or unsuccessfully and has not yet been verified.

10.4.3.1.4 *RETICLE POD SLOT MAP STATUS* — This is a substate of RETICLE POD and indicates the current status of the reticle pod with respect to its slot map. It has four substates, SLOT MAP NOT READ,

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WAITING FOR HOST ON SLOT MAP STATUS, SLOT MAP VERIFICATION FAILED, SLOT MAP VERIFICATION OK. The initial default entry sub-state is SLOT MAP NOT READ.

10.4.3.1.4.1 *SLOT MAP NOT READ* — This is a substate of RETICLE POD SLOT MAP STATUS and is the default entry state. It is active when the Reticle Pod is first loaded at the equipment until the Slot Map has been read successfully by the equipment.

10.4.3.1.4.2 *SLOT MAP VERIFICATION FAIL* — This is a substate of RETICLE POD SLOT MAP STATUS and is active when the Slot Map has been read by the equipment and has failed verification by the host. This is a final state.

10.4.3.1.4.3 *SLOT MAP VERIFICATION OK* — This is a substate of RETICLE POD SLOT MAP STATUS and is active as soon as the slot map has been verified. This is a final state.

10.4.3.1.4.4 *WAITING FOR HOST ON SLOT MAP STATUS* — This is a substate of RETICLE POD SLOT MAP STATUS and is active when the equipment is waiting for input from the host.

10.4.4 *Reticle Pod State Transition Table*

10.4.4.1 Table 7 indicates the triggers and the expected behavior of the instantiated reticle pod object.

Table 7 Reticle Pod State Transition Definition

#	*Previous State*	*Trigger*	*New State*	*Actions*	*Comment*
1	(no state)	A reticle pod is instantiated.	RETICLE POD	None.	Data required to be available for this event report: PodID
2	(no state)	*Normal:* A Bind, ReticleTransferJob or PodNotification service is received.	ID NOT READ	None.	Data required to be available for this event report: PodID
3	(no state)	*Normal:* A PodID not currently existing at the equipment is successfully read. *Abnormal:* A PodID is read successfully but an equipment based verification failed.	WAITING FOR HOST ON ID STATUS	None.	Data required to be available for this event report: PodID PortID Normally, this transition will happen after a successful ID read if a bind or ReticleTransferJob service has not been issued (host based verification) or abnormally if a bind or ReticleTransferJob service is followed by a successful ID read and an unsuccessful equipment based verification.
4	(no state)	*ID Read fail*: A ProceedWithPod service is received.	ID VERIFICATION OK	A reticle pod is instantiated having the PodID provided by the ProceedWithPod service.	Data required to be available for this event report: PodID This transition can happen only if a bind or ReticleTransferJob, service has not been received.
5	(no state)	*ID Read fail:* A CancelPod service is received.	ID VERIFICATION FAIL	A reticle pod is instantiated having the PodID provided by the Cancel Pod service.	Data required to be available for this event report: PodID This transition can happen only if a bind or ReticleTransferJob service has not been received.

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#	*Previous State*	*Trigger*	*New State*	*Actions*	*Comment*
6	ID NOT READ	PodID is read successfully and the equipment has verified the PodID successfully.	ID VERIFICATION OK	None.	Data required to be available for this event report: PortID PodID
7	ID NOT READ	PodID is read unsuccessfully.	WAITING FOR HOST ON ID STATUS	None.	Data required to be available for this event report: PortID PodID
8	WAITING FOR HOST ON ID STATUS	A ProceedWithPod service is received.	ID VERIFICATION OK	None.	Data required to be available for this event report: PortID PodID
9	WAITING FOR HOST ON ID STATUS	A Cancel Pod Service is received.	ID VERIFICATION FAILED	None.	Data required to be available for this event report: PortID PodID
10	ID NOT READ	$BypassReadID_i$ variable is set to FALSE, and a reticle pod is received when the id reader is not in service or not installed.	WAITING FOR HOST ON ID STATUS	Wait for ProceedWithPod.	Data required to be available for this event report: PortID PodID
11	ID NOT READ	$BypassReadID_i$ variable is set to TRUE, and a reticle pod is received when the id reader is not in service or not installed.	ID VERIFICATION OK	None.	Data required to be available for this event report: PortID PodID
12	ID NOT READ	The equipment successfully reads, but unsuccessfully verifies a reticle PodID.	ID VERIFICATION FAILED	None.	This transition should be followed by the equipment performing a self initiated CancelBind service (see transition 29) Data required to be available for this event report: PodID (of the pod instantiated in the Bind service) Data required to be available for this event report: PortID PodID
13	(no state)	A reticle pod is instantiated.	SLOT MAP NOT READ	None.	No event is required for this transition.
14	SLOT MAP NOT READ	Slot Map is read and verified successfully by the equipment.	SLOT MAP VERIFICATION OK	None.	Data required to be available for this event report: PortID (if valid) PodID LocationID

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#	*Previous State*	*Trigger*	*New State*	*Actions*	*Comment*
15	SLOT MAP NOT READ	*Normal host based verification:* Slot Map is read successfully and the equipment is waiting for host verification. *Equipment based verification:* Slot map is read successfully but equipment based verification has failed. *Slot map read fail:* Slot Map cannot be read.	WAITING FOR HOST ON SLOT MAP STATUS	Save new slot map in the SlotMap attribute.	Data required to be available for this event report: PortID (if valid) PodID LocationID SlotMap (if valid) Reason
16	WAITING FOR HOST	A ProceedWithPod service is received.	SLOT MAP VERIFICATION OK	Proceed with the Reticle Pod as instructed.	Data required to be available for this event report: PortID (if valid) PodID LocationID
17	WAITING FOR HOST	A CancelPod service is received.	SLOT MAP VERIFICATION FAIL	Prepare the Reticle Pod for Unload.	Data required to be available for this event report: PortID (if valid) PodID LocationID
18	(no state)	A reticle pod object is instantiated.	NOT ACCESSED	None.	Data required to be available for this event report: PodID
19	(no state)	A reticle pod object is instantiated.	NOT AVAILABLE or AVAILABLE	None.	This is the default entry into NOT ACCESSED. If the reticle is instantiated by service, the state is NOT AVAILABLE. If instantiated by PodID read the state is AVAILALBLE Data required to be available for this event report: PodID
20	NOT AVAILABLE	The reticle pod is received by the equipment.	AVAILABLE	None.	Data required to be available for this event report: PodID PortID
21	AVAILABLE	The equipment opens the reticle pod.	IN ACCESS	None.	Data required to be available for this event report: PodID

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#	*Previous State*	*Trigger*	*New State*	*Actions*	*Comment*
22	IN ACCESS	*Normal with ReticleTransfer-Job service for pod with OutputPortID not equal to zero:* The actions defined in the reticle transfer job have completed and the equipment closes the reticle pod. *PodComplete service:* The host sends the PodComplete service and the equipment closes the reticle pod. *Internal Pod Buffer:* The PodOut service has been received. *Abnormal:* The pod has failed slot map verification and / or a CancelPod service is received and the pod is ready for unload.	COMPLETE	None.	Data required to be available for this event report: PodID
23	NOT ACCESSED	*Via ID verification failure:* The pod has failed ID verification and the carrier is ready for unload. *Via Service:* A CancelBind, CancelPodNotification, CancelPod, or CancelReticleTransferJob has been received prior to pod arrival.	COMPLETE	None.	Data required to be available for this event report: PodID
24	(no state)	A reticle pod is instantiated.	NOT LOCKED	None.	Data required to be available for this event report: PodID PortID
25	NOT LOCKED	A reticle pod is clamped or otherwise physically restrained from removal by an entity external to equipment.	LOCKED	None.	Data required to be available for this event report: PortID PodID
26	NOT LOCKED	A reticle pod is clamped or otherwise physically restrained from removal by an entity external to equipment.	RELEASED AND LOCKED or HOLD	None.	This is the default entry into LOCKED. If the PodRelease flag is set to Equipment Release the state is RELEASED AND LOCKED. If the PodRelease flag is set to Host Release the state is HOLD. Data required to be available for this event report: PortID PodID
27	HOLD	A PodRelease service has been received by the equipment.	RELEASED AND LOCKED		

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#	Previous State	Trigger	New State	Actions	Comment
28	RELEASED AND LOCKED	*MANUAL Access Mode:* The POD ACCESSING state enters COMPLETE and a reticle pod is unclamped or has had any restraints preventing removal by an external entity removed. *AUTO Access Mode and Unclamp control trigger set to Pod Closed:* The POD ACCESSING state enters COMPLETE and a reticle pod is unclamped or has had any restraints preventing removal by an external entity removed. *AUTO Access Mode and Unclamp control trigger set to AMHS Triggered Unclamp:* The POD ACCESSING state is COMPLETE and the AMHS arrives and starts a PIO sequence.	NOT LOCKED	None.	Data required to be available for this event report: PortID PodID
29	POD	*Normal:* The reticle pod is unloaded from the equipment. *Abnormal by service:* CancelBind, CancelPodNotification, or CancelReticleTransferJob service is received prior to pod load. *Abnormal by equipment:* An equipment-based verification fails and the equipment performs a self-initiated CancelBind service.	(no state)	The equipment destroys the instance of this reticle pod object.	Data required to be available for this event report: PodID
30	(no state)	A Reticle Pod is loaded, locked, and the id is read on a load port for which no previous reticle pod has been instantiated	LOCKED		Data required to be available for this event report: PodID PortID

NOTE 1: Only one collection event report is required when entering the Reticle Pod State Model (instantiating a reticle pod object). This event report shall include the entry state of the all the substates of Reticle Pod State Model, (including RETICLE POD ID STATUS substate, the RETICLE POD SLOT MAP STATUS substate, the RETICLE POD ACCESSING STATUS, and the RETICLE POD LOCKING STATUS).

10.4.5 *Slot Map Read Details*

10.4.5.1 The Slot Map shall be read on all production equipment prior to removal of reticles from the reticle pod.

10.4.6 *Pod Read Failure* — A pod read failure occurs when the PodID reader is present, in service, and reports that it is unable to read the ID of a pod. This represents a transient random failure rather than a steady condition.

10.4.7 *Bypass Read ID* — A PodID reader may be unavailable: either out of service, not installed, or otherwise malfunctioning and unable to execute a read operation. This represents a steady condition that often is known in advance. The equipment shall provide a user-configurable variable BypassReadID that the user is able to set to specify the action to take when a pod is received to an ASSOCIATED load port. In this case, the reticle pod object is instantiated in the ID NOT READ state, and when the reticle pod is received, the state model transitions to either WAITING FOR HOST or ID VERIFICATION OK, depending upon whether BypassReadID is FALSE (the default value) or TRUE. When TRUE, then the PodID received in the Bind is used automatically. Otherwise, the pod

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