SEMI E123-0303
STANDARD FOR HANDLER EQUIPMENT SPECIFIC EQUIPMENT MODEL (HSEM)

This standard was technically approved by the Global Information and Control Committee and is the direct responsibility of the North American Information and Control Committee. Current edition approved by the North American Regional Standards Committee on November 22, 2002. Initially available at www.semi.org January 2003; to be published March 2003.

NOTICE: This standard replaces SEMI E30.2, which has been removed from publication as of the March 2003 (0303) publication cycle.

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1 Purpose

1.1 This document establishes a Specific Equipment Model (SEM) for Handling equipment (HSEM). The SEM consists of equipment characteristics and behaviors that are applicable to this class of equipment. The intent of this document is to facilitate the integration of Handling equipment into an automated (semiconductor) factory. This document accomplishes this by defining an operational model for Handling equipment as viewed by a factory automation controller. This definition provides a standard host interface and equipment operational behavior.

2 Scope

2.1 The scope of this document is limited to the definition of Handling equipment behavior as perceived by a host. It defines the view of the equipment through the equipment communications interface. It does not define the internal operation of the equipment. It includes a specific processing state model as the basis for the behavior of all equipment of this class.

2.2 This document expands the handler equipment requirements and capabilities in the areas of the processing state model, collection event, alarm documentation, remote commands, variable item, and process program management.

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 *Communications* — HSEM-compliant equipment shall support the High Speed Messaging Service (HSMS) communication standard sending SEMI E5 messages over TCP/IP. The reason behind this requirement is the amount of data available for monitoring from this class of equipment. This specification deals only with the behavior of the handler in communicating with the host.

3.2 *Multi-Process-Site HSEM Implementations* — This SEM makes some demands and assumptions about the Handler with multiple process-sites in a configuration. These requirements are as follows:

3.2.1 Handling equipment in a multiple process-site configuration (i.e., lead conditioning site, electrical test-site) provides identification and status information (see Variable Item) at both the site level and the subsite level. An example could be a handler with both a lead conditioning site and an electrical test-site, with the electrical test-site containing multiple subsites (i.e., test heads).

4 Referenced Standards

4.1 *SEMI Standards*

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

SEMI E37 — High-Speed SECS Message Services (HSMS) Generic Services

SEMI E37.1 — High-Speed SECS Message Services Single Selected-Session Mode (HSMS-SS)

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

5 Terminology

5.1 *Definitions*

5.1.1 *alignment location* — Location that individual packaged units are placed at the process-site (e.g., electrical test).

5.1.2 *chaining* — The process of execution over multiple lots or runs with the same Process Program and the same handler operating conditions.

5.1.3 *electrical test-site* — A process-site on the equipment which is coupled with electrical testing equipment for purposes of performing package electrical testing.

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5.1.4 *execution area* — The area from which a current copy of the process program instructions is executed.

5.1.5 *handling equipment* — An equipment class generally consisting of integrated mechanisms and controls for the purpose of manipulating packaged devices, trays, and tubes during the manufacturing process.

5.1.6 *indexing* — The controlled stepped movement of material through the handler.

5.1.7 *kit* — Specific items of hardware and software as specified by the equipment manufacturer that adapt the equipment for a specific unit or unit package.

5.1.8 *leadconditioning site* — A process-site on the handler where some form of conditioning occurs on the package leadfingers (i.e., warming).

5.1.9 *leadfinger (or substrate connector lead)* — (1) In ceramic packages, an area of refractory metal that has been plated and is designated for the attachment to a process-site. (2) The area of the unit designated for attachment to a process-site.

5.1.10 *leadframe* — A sheet metal framework upon which a chip (sometimes chips) is attached, wire-bonded, and then either molded with plastic epoxy or with ceramic and/or metal.

5.1.11 *media* — A temporary material carrier used to hold and transport units/devices (tubes, trays, etc.).

5.1.12 *media map* — Formatted data used to map functionally good and bad units/devices to an X, Y, Z location in the media. Maps can be requested by the handler for use prior to processing and then updated after processing.

5.1.13 *off-line programming (OLP) utility* — Utility to create, edit, and format process programs on a computer, as opposed to creating process programs at the equipment.

5.1.14 *process-site* — A location on the equipment where work is performed on a packaged device (i.e, electrical test-site, lead conditioning site).

5.1.15 *process subsite* — An addressable portion of a process-site.

5.1.16 *reset* — The action of changing the value of a variable, such as wafer count (usually to zero).

5.1.17 *safe state* — A state in which the equipment presents no danger to the product or user. This implies that safety interlocks are in place such that the equipment can be serviced without harm to the operator and that the material being processed has been removed from the processing station into an accessible location.

5.1.18 *slot* — A position in a carrier where a leadframe, tray, tube, or other media element may reside.

5.1.19 *sort category* — Handler specific sorting category related to a physical buffer within a handler where parts are stored after processing based on processing results. Typically there is some software mapping between process results (e.g., Test Result Bins) and a Sort Category.

5.1.20 *tray* — A flat rectangular form of media for holding singulated packaged units. Also referred to as waffle packs or matrix trays. A tray is generally molded plastic with a defined matrix of cells or pockets tailored for specific packages.

5.1.21 *tube* — A hollow form of media for holding packaged units. Also referred to as rails or sticks. A tube is generally composed of extruded polymer with internal section dimensions and features tailored for a specific package.

5.1.22 *unit* — Discreetly addressable element, such as an integrated circuit or chip, handled individually or in groups by a handler for a process tool.

6 State Model

6.1 *State Model* — The purpose is to define the equipment-specific processing state model and other state models necessary to portray the expected operational states of the equipment to enable host tracking and control in place of a local operator.

6.2 *State Model Requirements*

6.2.1 The processing state models in this document are required for implementing an HSEM-compliant handler. A state model consists of the following state model diagram, state definitions, and state transition tables.

6.2.2 A state model represents the host's view of the handler, not necessarily the actual handler's internal operations.

6.2.3 All HSEM state model transitions shall be mapped sequentially into the actual equipment events that satisfy the requirements of those transitions. In certain implementations, the handler may enter a state and have already satisfied all of the conditions required by the HSEM state model for transition to another state. The handler makes the required transition without any additional actions in this situation.

6.2.4 Some equipment may need to include additional states. However, any additional states must not change the HSEM-defined state transitions. All expected transitions between HSEM states must occur.

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6.3 *HSEM State Model*

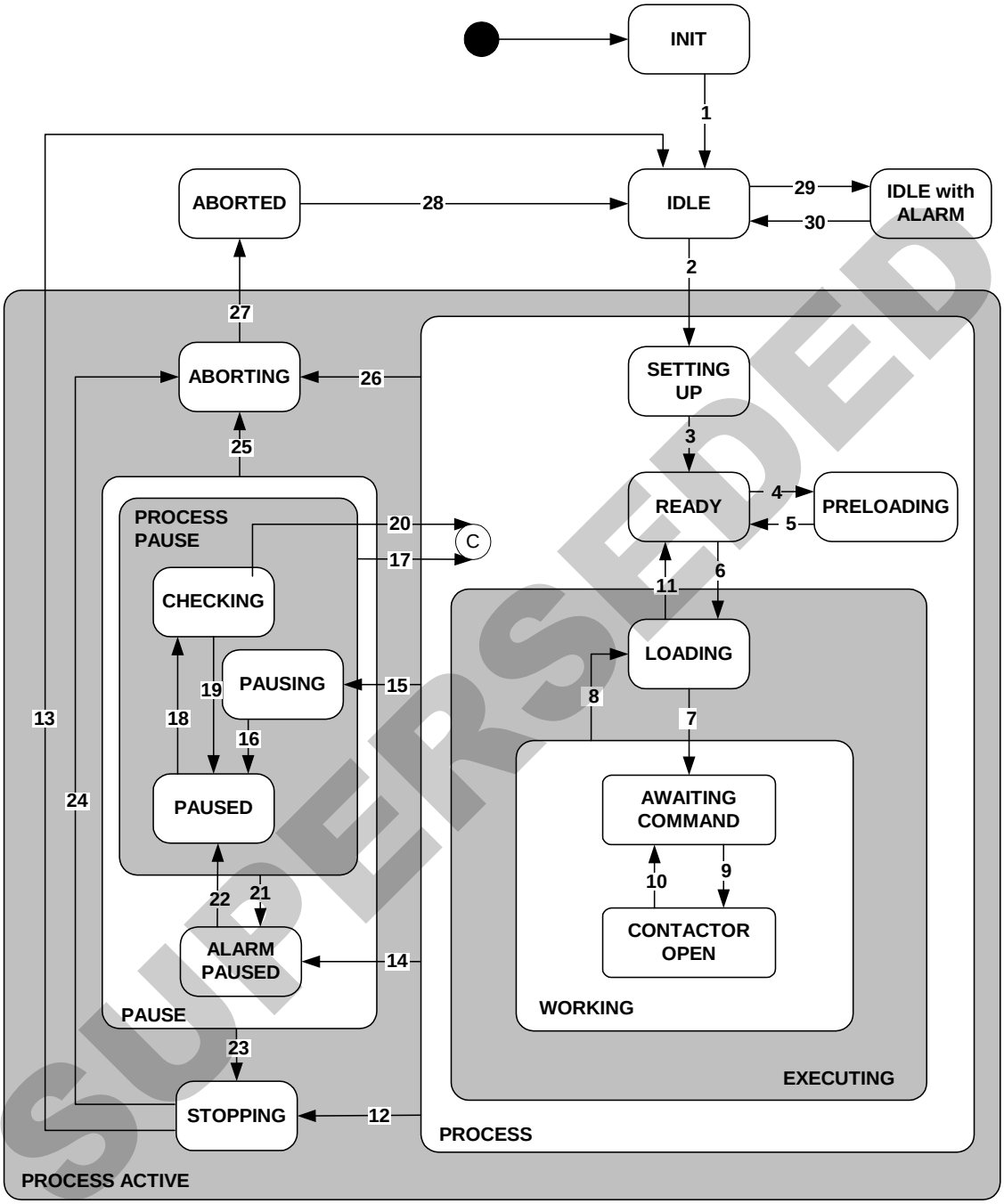

Figure 1
HSEM Processing State Model

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6.4 *Description of Handler Processing States*

6.4.1 *ABORTED* — All activity is suspended as a result of an ABORT command. Any alarm and abort conditions must be cleared and verified by an operator before exit from this state.

6.4.2 *ABORTING (PROCESSING ACTIVE Sub-State)* — The handler has received an ABORT command. All activity is suspended. The handler is taking appropriate action to bring itself and material to a "safe" state where possible. Unit or Lot data may be invalid or not available.

6.4.3 *ALARM PAUSED (PAUSE Sub-State)* — An alarm has occurred in the PROCESS or PROCESS PAUSE states, and the handler is waiting for the alarm to be cleared.

6.4.4 *CHECKING (PROCESS PAUSED Sub-State)* — The handler verifies that updates made to the process program are valid (i.e., possible errors induced via an operator during the pause).

6.4.5 *EXECUTING (PROCESS Sub-State*) — The handler is processing material automatically and can continue to do so without external intervention. This state may include interaction with the host or operator.

6.4.6 *IDLE* — Awaiting a command. IDLE is free of ALARMS and error conditions.

6.4.7 *IDLE with ALARMS* — An alarm has occurred in the IDLE state, and the handler is waiting for all alarms to be cleared.

6.4.8 *INIT* — Handler initialization is occurring.

6.4.9 *LOADING (EXECUTING Sub-State)* — This is the state the next unit or units are transferred from the input media or input buffers to the process site(s) and/or removed from the process site(s) to sort categories.

6.4.10 *PAUSE (PROCESSING ACTIVE Sub-State)* — The PROCESS state will be suspended at the completion of the current unit or next opportunity. Actions to put the handler in a safe state are performed. The handler is awaiting a command (RESUME, STOP, or ABORT) or for alarm(s) to be cleared.

6.4.11 *PAUSED (PROCESS PAUSE Sub-State)* — The PROCESS state has been suspended, and the handler is waiting for a command (RESUME, STOP, or ABORT). In this state, the operator may correct error conditions that do not affect the current Process Program selection. One of the possible corrective actions is for the operator to manually align the units being processed.

6.4.12 *PAUSING (PROCESS PAUSE Sub-State)* — The PROCESS state will be suspended at the completion of the current unit or next opportunity. The handler cannot transition to PAUSED state until the current unit is completed and the handler is in a "safe state".

6.4.13 *AWAITING COMMAND (WORKING Sub-State)* — Unit is moved to process-site (e.g., for electrical test, to insert into contactor). Actuator piston(s) is extended to the alignment test site(s) if applicable. If contactors must be "closed" before processing can occur, then contactors are in the closed condition. In this state, handler has completed all loading and is awaiting the next command from Host to signal process complete.

6.4.14 *CONTACTOR OPEN (WORKING Sub-State)* — Unit process is complete and host issued a BREAK-CONTACT or RECONTACT command. (e.g. Actuator piston(s) is retracted from the alignment test site(s), contactors are open.) If RECONTACT command was issued, unit will return to alignment for a step and repeat. Otherwise Handler will remain in this state until a MAKE-CONTACT is received to resume processing. Commands such as STOP, ABORT and PAUSE are still valid and follow the respective required transitions.

6.4.15 *PRELOADING (PROCESS Sub-State)* — Handler has received a PRELOAD-UNITS command to begin preloading units to soak chambers or some equivalent process buffers. Units should not be transferred to process sites in this state. During this time, test equipment may also go through its internal setup process in parallel, such as testhead calibrations. If handler does not implement any process buffers, the remote command from Host must still be accepted and state transition followed, in which case handler will transition back to READY state immediately with PreloadComplete event sent to Host.

6.4.16 *PROCESS (PROCESS Sub-State)* — This state is the parent of those sub-states that refer to the preparation and execution of a process program.

6.4.17 *PROCESS PAUSE (PAUSE Sub-State)* — The handler is free of alarm conditions in the PAUSE state.

6.4.18 *READY (PROCESS Sub-State)* — The handler is ready to begin processing and is awaiting a START or PRELOAD-UNITS command from the operator or host.

6.4.19 *SETTING UP (PROCESS Sub-State)* — The handler is satisfying conditions so that processing can begin. This includes the receipt of any process programs, the material to be processed, and machine-specific calibration. While in this state, the handler can be single-stepped through each process in order for the operator to ensure that the handler is moving the unit correctly.

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6.4.20 *STOPPING (PROCESSING ACTIVE Sub-State)* — The handler has completed a Process Program or has been instructed to stop processing and shall do so at the next opportunity. All necessary cleanup is completed within this state with regard to material, data, control system, etc. Data is preserved. Any error condition is cleared before exiting from this state.

6.4.21 *WORKING (EXECUTING Sub-State)* — The handler is processing a specific unit.

6.5 *HSEM Processing State Transitions Table*

6.5.1 Unless specified, if a command is stated as a possible trigger for a state transition, it is implied that the command or its equivalent can come from the host or operator or any other command interface provided by the equipment, for example a GPIB command interface.

Table 1 Processing State Transitions Table

#	*Current State*	*Trigger*	*New State*	*Actions*	*Comments*
1	INIT	All handler initialization is complete with no alarms or error conditions.	IDLE	None	None
2	IDLE	A Process Program is selected.	SETTING UP	Handler-dependent	Commit has been made to setup.
3	SETTING UP	All setup activity has completed, and the handler is ready to receive a START command.	READY	The handler is waiting for a START command.	The selected Process Program is available for execution, and material is present at the input port.
4	READY	Handler receives a PRELOAD-UNITS command.	PRELOADING	Handler starts preloading units to temperature soak chambers or some process buffers, where some type of pre-work can be applied to units before processing. No units should be transferred to process sites at this point.	For handlers that do not support process buffers of any type, this will just be a pass-thru state. Transition #5 is taken immediately.
5	PRELOADING	Handler completes preloading of units to its process buffers, e.g. unit(s) is ready to be transferred to process site(s) from buffers.	READY	PreloadComplete collection event reported to Host.	
6	READY	The handler receives a START command.	LOADING	Transfers the next unit to the process-site.	LOAD is an EXECUTING sub-state.
7	LOADING	A unit(s) is loading to the process –site(s) or been removed from process site(s).	AWAITING COMMAND	The actuator(s) is extended to the alignment process site(s) if applicable. If unit(s) is loaded to process site(s), UnitsReady event is sent to Host with loaded status of each process site.	None
8	WORKING	The processing of the current unit(s) completes normally and handler received a BIN-UNITS command.	LOADING	This unit(s) is transferred from the process sites specified in the remote command and next unit(s) is loaded to the now empty process site(s).	None
9	AWAITING COMMAND	The processing of the current unit(s) completed. The handler has received a RECONTACT or BREAK-CONTACT command.	CONTACTOR OPEN	The actuator(s) is retracted from the alignment test site(s). If RECONTACT command is received, handler will attempt to contact unit(s) again.	None

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#	Current State	Trigger	New State	Actions	Comments
10	CONTACTOR OPEN	The handler has received a MAKE-CONTACT command or continuation of RECONTACT and handler has completed contacting of the unit(s).	AWAITING COMMAND	The actuator(s) is extended to the alignment process site(s). UnitsReady event is sent to Host with loaded status of each site.	None
11	LOADING	The handler completes unload of last unit and there are no more unit(s) available for loading.	READY	The handler completes sorting the last unit(s). LastUnitCompleted collection event reported to Host.	None
12	PROCESS	The handler has received a STOP command.	STOPPING	The handler completes the current unit in the WORKING state and unloads it.	The handler begins its cleanup procedure.
13	STOPPING	The handler cleanup is complete, and the handler is free of alarms.	IDLE	None	None
14	PROCESS	An alarm occurs.	ALARM PAUSED	PROCESS activity is suspended, and the handler is waiting for all alarms to be cleared.	ALARM PAUSED is a PAUSE sub-state.
15	PROCESS	The handler has received a PAUSE command.	PAUSING	The PROCESS state shall be suspended at the completion of the current unit. Any necessary actions to put the handler in a safe state are performed.	PAUSING is a PAUSE sub-state.
16	PAUSING	The handler has completed Processing the Current unit in the WORKING state and achieved a safe condition.	PAUSED	The handler is waiting for a command (RESUME, STOP, or ABORT).	None
17	PROCESS PAUSE	The handler has received a RESUME command.	STATE based on conditional table.	Return to previous state or state per process resume conditions.	None
18	PAUSED	A RESUME command was received.	CHECKING	Validation of the Process Program Parameters.	None
19	CHECKING	Error was detected in new parameter setting being validated in the CHECKING state.	PAUSED	None	None
20	CHECKING	Parameter checking completes successfully.	STATE based on conditional table.	Return to previous state or state per process resume conditions.	None
21	PROCESS PAUSE	An alarm is set by the handler.	ALARM PAUSED	The handler waits for all alarms to be cleared or for a STOP or ABORT command.	None
22	ALARM PAUSED	All alarms are cleared.	PAUSED	The handler is waiting for a command (RESUME, STOP, or ABORT).	None
23	PAUSE	The handler has received a STOP command.	STOPPING	The handler proceeds with cleanup.	Data is preserved and is valid.
24	STOPPING	The handler has received an ABORT command.	ABORTING	Any unsafe condition is resolved, if possible.	Data may be invalid or unavailable.
25	PAUSE	The handler has received an ABORT command.	ABORTING	Any unsafe condition is resolved, if possible.	Data may be invalid or unavailable.
26	PROCESS	The handler has received an ABORT command from operator, host, or self-generated.	ABORTING	The handler is put in a “safe” state.	Unit or lot data may be invalid or not available.

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