

SEMI E10-92

GUIDELINE FOR DEFINITION AND MEASUREMENT OF EQUIPMENT RELIABILITY, AVAILABILITY, AND MAINTAINABILITY (RAM)

1 Scope

1.1 The primary intention of this document is to establish a basis for communication between users and suppliers of semiconductor equipment by providing guidelines for measuring the performance of that equipment in a manufacturing environment. The ultimate goal is to stimulate a spirit of cooperation and partnership among users and suppliers to promote improvement in equipment performance.

1.2 The body of this guideline is presented in two parts. The first part is Section 3 (Equipment States), which defines how equipment time is categorized. The second part is Section 4 (RAM Measurement), which defines how to measure equipment performance.

1.3 The document defines six basic equipment states into which all equipment conditions and periods of time must fall. The equipment states are determined by functional issues, independent of who performs the function.

1.4 The measurement of equipment reliability in this guideline concentrates on the relationship of equipment failures to equipment usage, rather than the relationship of failures to total elapsed time. Productive time and equipment cycles are the indicators of equipment usage presented in this document.

1.5 Effective application of this guideline requires that users track equipment performance (RAM) with regard to time and/or equipment cycles. Supplier and user responsibility issues can only be monitored through the diligent use of an accurate tracking system.

2 Selected Definitions

2.1 *assist* — any unplanned interruption or variance from specifications of equipment operation which requires human intervention of less than six minutes to correct. After six minutes has elapsed, an assist becomes a failure. If intervention is required, but there is no interruption of operation within specifications, and no component is replaced, the action is an assist independent of its duration.

2.2 *cluster tool* — a manufacturing system made up of integrated processing modules mechanically linked together (the modules may or may not come from the same supplier). Effectively reporting RAM measurements requires users to track the performance of the total system and the individual modules.

2.3 *cycle (equipment cycle)* — one complete operational sequence (including product load and unload) of processing, manufacturing, or testing steps for an equipment system or subsystem. In single unit processing systems, the number of cycles equals the number of units processed. In batch systems, the number of cycles equals the number of batches processed.

2.4 *downtime (equipment downtime)* — the time when the equipment is not in a condition, or is not available, to perform its intended function. It does not include any portion of non-scheduled time.

2.5 *failure (equipment failure)* — any interruption or variance from the specifications of equipment operation requiring the replacement of a component (other than specified consumables) due to degradation or failure. Failures also include any assists that interrupt operation and take longer than six minutes. If unplanned corrective action is required (as in slow degradation that will cause a failure), and this action is scheduled for a later time (to avoid interruption of production), the event is logged as a failure at the time of corrective action.

2.6 *maintenance* — the act of sustaining equipment in a condition to perform its intended function. In this document maintenance refers to function, not organization. It includes adjustments, change of consumables, repair, preventive maintenance, etc., no matter who performs the task.

2.7 *non-scheduled time* — a period when the equipment is not scheduled to be utilized in production (see Section 3.7).

2.8 *operations time* — total time minus non-scheduled time (see Figure 1 in Section 3).

2.9 *product* — any unit which is intended to become a functional semiconductor device. This includes functional engineering devices.

2.10 *ramp-down* — the portion of a maintenance procedure required to prepare the equipment for hands-on work. It includes purging, cool-down, warm-up, etc. Ramp down is only included in scheduled and unscheduled downtime.

2.11 *ramp-up* — the portion of a maintenance procedure required, after the hands-on work is completed, to return the equipment to a condition where it can perform its intended function. It includes pumpdown, warm-up, stabilization periods, initialization routines, etc. It does not include equipment or process test time. Ramp-up is only included in scheduled and unscheduled downtime.

2.12 *shutdown* — the time required to put the equipment in a safe condition when entering a non-scheduled state. It includes any procedures necessary to reach a safe condition. Shutdown is only included in non-scheduled time.

2.13 *start-up* — the time required for equipment to achieve a condition where it can perform its intended function, when leaving a non-scheduled state. It includes pumpdown, warm-up, cool-down, stabilization periods, initialization routines, etc. Start-up is only included in nonscheduled time.

2.14 *support tool* — a mechanical device that, although not part of a piece of equipment, is required by, and becomes integral with it during the course of normal operation (e.g., cassettes, wafer carriers, probe cards, etc.)

2.15 *total time* — all time (at the rate of 24 hrs/day, 7 days/week) during the period being measured. In order to have a valid representation of total time, all six basic equipment states must be accounted for and tracked accurately.

2.16 *training (off-line)* — the instruction of personnel in the operation and/or maintenance of equipment done outside of operations time. Off-line training is only included in non-scheduled time.

2.17 *training (on-the-job)* — the instruction of personnel in the operation and/or maintenance of equipment done during the course of normal work functions. On-the-job training typically does not interrupt operation or maintenance activities and can therefore be included in any equipment state (except standby and non-scheduled) without special categorization.

2.18 *unit* — any wafer, die, packaged device, or piece part thereof (includes product and non-product units).

2.19 *uptime (equipment uptime)* — the hours when the equipment is in a condition to perform its intended function. It includes productive, standby, and engineering time, and does not include any portion of non-scheduled time (see Figure 1 in Section 3).

2.20 *verification run* — any unit or units (product or nonproduct) processed by the equipment to establish that it is performing its intended function within specifications.

3 3 Equipment States

3.1 To clearly measure certain aspects of equipment performance (RAM), this document defines six basic equipment states into which all equipment conditions and periods of time must fall.

The equipment states are determined by function, not by organization. Any given maintenance procedure, for example, is classified the same way no matter who performs it: an operator, a production technician, a maintenance technician, or a process engineer.

Figure 1 is a stack chart of the six basic equipment states. Key blocks of time are identified for use in equations given later in this document. These basic equipment states can be divided into as many substates as are required to achieve the equipment tracking resolution that a manufacturing operation desires.

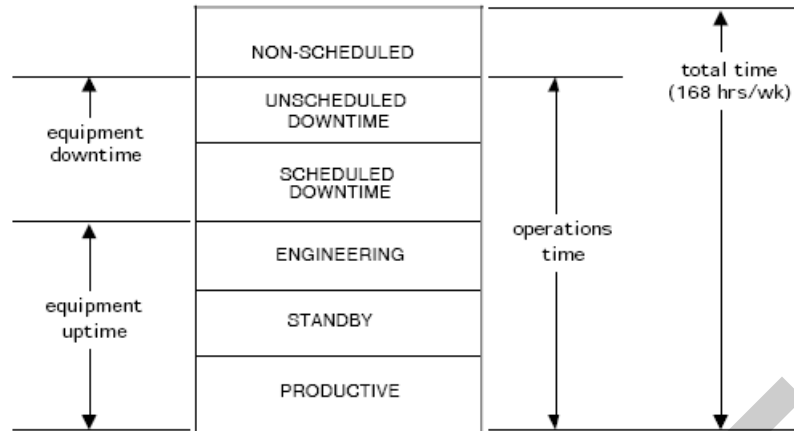


Figure 1
Equipment States Stack Chart

3.2 PRODUCTIVE STATE — A period of time (productive time) when the equipment is performing its intended function. It includes:

1. Regular production (including loading and unloading of product)
2. Work for third parties
3. Rework
4. Production test — verification runs other than those following a preventive maintenance, setup, or repair procedure
5. Engineering runs done in conjunction with production; may or may not be product units (e.g., split lots, and new applications)

3.3 STANDBY STATE— A period of time (standby time), other than non-scheduled time, when the equipment is in a condition to perform its intended function, chemicals and facilities are available, but it is not operated. It includes:

1. No operator available (including breaks, lunches, and meetings)
2. No product available (including no product due to lack of available support equipment, such as metrology tools)
3. No support tools (e.g., cassettes, wafer carriers, probe cards, etc.)
4. Waiting for results of production test
5. In cluster tools: associated cluster module down

3.4 ENGINEERING STATE — A period of time (engineering time) when the equipment is in a condition to perform its intended function (no equipment or process problems exist), but is operated to conduct engineering experiments. It includes:

1. Process engineering (e.g., process characterization)
2. Equipment engineering (e.g., equipment evaluation)

3.5 SCHEDULED DOWNTIME STATE — a period of time (scheduled downtime) when the equipment is not available to perform its intended function due to planned downtime events.

3.5.1 Maintenance Delay — A period during which the equipment cannot perform its intended function because it is waiting for either user or supplier personnel or parts (including consumables/chemicals) associated with maintenance. Maintenance delay may also be due to an administrative decision to leave the equipment down and postpone maintenance.

NOTE 1: Since this subject receives so much attention in supplier/user communications, it is important for users to accurately track how much delay time is associated with maintenance, and who is responsible for it. Supplier and user maintenance delay must therefore be tracked separately; each beginning at the point of notification that maintenance is required.