



International SEMATECH Equipment Maturity Assessment (EMA) Handbook

**International SEMATECH
Technology Transfer # 01044107A-ENG**

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International SEMATECH Equipment Maturity Assessment (EMA)

Handbook

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International SEMATECH

April 13, 2001

Abstract: This document from the Guidelines and Standards project (304-501) is a reference to assist those performing Equipment Maturity Assessments (EMAs) as described in the International SEMATECH (ISMT) Demonstration Test Methods (DTM) document. This handbook addresses all 27 equipment characteristics listed in the DTM document by providing suggested topics of investigation, as well as areas requiring evidentiary materials that should be reviewed during the EMA. The handbook covers preparatory activities, procedures, reporting requirements, and characteristics worksheets.

Keywords: Equipment Performance, Procedures, Standards

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Table of Contents

1	PURPOSE	1
2	EMA BACKGROUND AND DESCRIPTION	1
3	DOCUMENT REFERENCES	3
4	PREPARATION AND EXECUTION OF THE EMA	3
5	PROCEDURE FOR AN EMA.....	4
	5.1 Before the EMA Deployment	4
	5.2 EMA Deployment.....	6
6	DOCUMENTATION.....	7
7	HELPFUL HINTS – GENERAL.....	7
	7.1 Non-Production Level Maturity Equipment	7
	7.2 Transitional Equipment Not to Be Further Developed.....	7
8	EQUIPMENT MATURITY CHARACTERISTICS WORKSHEET.....	7
	8.1 How to Use a Characteristic Worksheet	8
9	PHASE ONE CHARACTERISTICS.....	9
	9.1 Characteristic 1 – Design Specification.....	9
	9.1.1 Items of Interest	9
	9.1.2 Special Concerns	9
	9.2 Characteristic 2 – Measurable Process Results.....	10
	9.2.1 Items of Interest	10
	9.2.2 Special Concerns	10
	9.3 Characteristic 3 – Safe Operation	11
	9.3.1 Items of Interest	11
	9.3.2 Special Concerns	11
10	PHASE TWO CHARACTERISTICS.....	13
	10.1 Characteristic 4 – Material Handling Functions	13
	10.1.1 Items of Interest	13
	10.1.2 Special Concerns	13
	10.2 Characteristic 5 – Reproducible Process Results.....	14
	10.2.1 Items of Interest	14
	10.2.2 Special Concerns	14
	10.3 Characteristic 6 – Automated Process Recipe	15
	10.3.1 Items of Interest	15
	10.3.2 Special Concerns	15
	10.4 Characteristic 7 – Remote Functions (Support Equipment)	16
	10.4.1 Items of Interest	16
	10.4.2 Special Concerns	16
11	PHASE THREE CHARACTERISTICS.....	18
	11.1 Characteristic 8 – Equipment Footprint.....	18
	11.1.1 Items of Interest	18
	11.1.2 Special concerns	18

11.2	Characteristic 9 – Support Module Footprint	19
11.2.1	Items of Interest	19
11.2.2	Special Concerns	19
11.3	Characteristic 10 – Facilities Layout	20
11.3.1	Items of Interest	20
11.3.2	Special Concerns	20
11.4	Characteristic 11 – Continuous Processing	21
11.4.1	Items of Interest	21
11.4.2	Special Concerns	21
11.5	Characteristic 12 – Equipment Functionality	22
11.5.1	Items of Interest	22
11.5.2	Special Concerns	22
11.6	Characteristic 13 – Automated Operation	23
11.6.1	Items of Interest	23
11.6.2	Special Concerns	23
11.7	Characteristic 14 – Error Handling/Recovery.....	24
11.7.1	Items of Interest	24
11.7.2	Special Concerns	24
11.8	Characteristic 15 – Informal Design for Maintainability (DFM) and Software Usability (SU).....	25
11.8.1	Items of Interest	25
11.8.2	Special Concerns	25
11.9	Characteristic 16 – Ease of Operator Use.....	26
11.9.1	Items of Interest	26
11.9.2	Special Concerns	26
11.10	Characteristic 17 – Process and System Stability.....	27
11.10.1	Items of Interest	27
11.10.2	Special Concerns	27
11.11	Characteristic 18 – Engineering Documentation.....	28
11.11.1	Items of Interest	28
11.11.2	Special Concerns	28
11.12	Characteristic 19 – Engineering Change Control (Hardware).....	29
11.12.1	Items of Interest	29
11.12.2	Special Concerns	29
11.13	Characteristic 20 – Software Revision and Release Control (SRC).....	30
11.13.1	Items of Interest	30
11.13.2	Special Concerns	30
11.14	Characteristic 21 – Environmental Impact Analysis	31
11.14.1	Items of Interest	31
11.14.2	Special Concerns	31
12	PHASE FOUR CHARACTERISTICS	33
12.1	Characteristic 22 – Guideline Conformance.....	33
12.1.1	Items of Interest	33
12.1.2	Special Concerns	33
12.2	Characteristic 23 – Documentation.....	34
12.2.1	Items of Interest	34
12.2.2	Special Concerns	34

12.3	Characteristic 24 – Wafer Process Characterization.....	35
12.3.1	Items of Interest	35
12.3.2	Special Concerns	35
12.4	Characteristic 25 – Manufacturing Performance	36
12.4.1	Items of Interest	36
12.4.2	Special Concerns	36
12.5	Characteristic 26 – Design for Maintainability (DFM)	37
12.5.1	Items of Interest	37
12.5.2	Special Concerns	37
12.6	Characteristic 27 – Environmental Impact Study	38
12.6.1	Items of Interest	38
12.6.2	Special Concerns	38

List of Figures

Figure 1 Flowchart of an EMA Deployed at a Supplier Site..... 6

List of Tables

Table 1 27 Equipment Maturity Characteristics and Their Associated Test Phase 2

Acknowledgements

Thanks to Gino Crispieri, Jackie Ferrell, Harvey Wohlend, Margaret Pratt and Brad Van Eck for helping with this document.

1 PURPOSE

This document is a reference to assist those performing Equipment Maturity Assessments (EMAs) as described in the International SEMATECH (ISMT) Demonstration Test Methods (DTM) document. This handbook addresses all equipment characteristics listed in the DTM document by providing suggested topics of investigation, as well as areas requiring evidentiary materials that should be reviewed during the EMA.

2 EMA BACKGROUND AND DESCRIPTION

The first stage of an equipment performance test should be to evaluate the maturity of equipment to determine its capability to perform different levels or phases of testing. Testing can be performed at any stage in the development cycle to produce valuable characterization data so that data-driven management and engineering can be applied to decision-making and further development.

Each level, or phase of testing, has different requirements relating to the type, extent, and rigor of the testing to be performed. Four incremental levels of increasingly rigorous testing encompass the ongoing development of equipment throughout the development cycle from a testing perspective. Each phase of testing requires additional capabilities for the equipment to meet the testing requirements. A principle of sound engineering is to perform only that testing that is valid and useful at the developmental maturity level of the test equipment or process.

Equipment characteristics are assessed to establish the functional equipment capabilities in comparison to those required for the most rigorous testing phase. The EMA process described herein addresses both hardware and software maturity issues within 27 fundamental equipment characteristics (see Table 1).

These 27 characteristics are assessed by performing a physical inspection of the equipment to be tested. Some of the characteristics can be evaluated only by looking into the engineering systems or capabilities that produced them. The developmental maturity of the equipment affects not only the phase of testing to be performed, but the test goals and statistical confidence requirements. This concept of test scaling is discussed in the I300I Demonstration Test Method document, Section 5, titled Test Planning.

ISMT has identified specific standards that are directly applicable to the development and requirements for 300 mm equipment. During the EMA, the plans, progress, and level of current conformance will be investigated for inclusion in the EMA report. The ISMT member companies have ratified a common set of standards representing the expectations and requirements for 300 mm semiconductor equipment. During the equipment maturity assessment, the EMA team investigates candidate test equipment for standards conformance. The review consists of determining the progress, current state, and plans for conformance to each standard. It is important to note that ISMT will not perform compliance audits or certification for any of the standards. Standards compliance is the sole responsibility of the supplier.

The evaluation of conformance to the standards is an interactive review conducted during the physical inspection of the candidate equipment. Documentation is also reviewed. Findings of standards conformance will be included in the EMA report and in a final test report if required.

Table 1 27 Equipment Maturity Characteristics and Their Associated Test Phase

Characteristic	Phase 1	Phase 2	Phase 3	Phase 4	Assessment Performed at Equipment or Offline
Design Specification	X	X	X	X	Offline
Measurable Process Results	X	X	X	X	Offline
Safe Operation	X	X	X	X	Equipment
Material Handling Functions		X	X	X	Equipment
Reproducible Process Results		X	X	X	Offline
Automated Process Recipe		X	X	X	Equipment
Remote Functions (Support Equipment)		X	X	X	Equipment
Equipment Footprint			X	X	Equipment
Support Module Footprint			X	X	Equipment
Facilities Layout			X	X	Equipment
Continuous Processing			X	X	Equipment
Equipment Functionality			X	X	Equipment
Automated Operation			X	X	Equipment
Error Handling/Recovery			X	X	Equipment
Informal Design for Maintainability (DFM)			X	X	Equipment
Ease of Operator Use and Software Usability (SU)			X	X	Equipment
Process and System Stability			X	X	Offline
Engineering Documentation			X	X	Offline
Engineering Change Control (Hardware)			X	X	Offline
Software Revision and Release Control (SRC)			X	X	Offline
Environmental Impact Analysis			X	X	Offline
Guideline Conformance				X	Both
Documentation				X	Offline
Wafer Process Characterization				X	Offline
Manufacturing Performance				X	Offline
Design for Maintainability (DFM)				X	Offline
Environmental Impact Study				X	Offline

It is important to understand that the primary output of the EMA process is to provide inputs to the test planning process that establishes the readiness and extent of testing to be performed. There is neither an intrinsic value to a rating of a particular phase, nor does it imply anything about the equipment's probable performance and usability.

3 DOCUMENT REFERENCES

Several documents referencing standards, guidelines, and other methods are used throughout the EMA process. The most current listing of applicable SEMI standards referenced throughout this handbook can be found on the SEMI website at <http://www.semi.org/>. International SEMATECH documents are available on the web at <http://www.sematech.org/>. Key documents referenced herein are as follows:

1. *Demonstration Test Method – Revision 1*, The International 300 mm Initiative (I300I), International SEMATECH Technology Transfer #97063297B-XFR, September 30, 1997.
2. *CMM SM -Based Appraisal for Internal Process Improvement (CBA IPI): Method Description*, Software Engineering Institute, Technical Report, CMU/SEI-96-TR-007, ESC-TR-96-007, Carnegie Mellon University, April 1996
3. *Guidelines for I300I Environmental, Safety & Health (ESH) Equipment Specific Environmental Information and Environmental Impact*, International SEMATECH Technology Transfer #99083803A-TR, November 1999
4. *I300I Factory Guidelines: Version 5.0*, International SEMATECH Technology Transfer #97063311G-ENG, April 2000
5. *I300I Factory Guideline Compliance: Factory Integration Maturity Assessment (FIMA) for 300 mm Production Equipment: Version 4.01*, International SEMATECH Technology Transfer #98023468C-TR, February 2000
6. Emissions Characterization Package – I300I Expectations, Rev. 2.4-b, International SEMATECH, 1998

4 PREPARATION AND EXECUTION OF THE EMA

To prepare for an EMA, certain prerequisites should be reviewed before the assessment. There must be a reasonable expectation that the equipment is ready for the assessment and that the results will meet the requirements for one of the test phases. The evaluation team members should be identified and the team should contain all the requisite skills.

The assessment is a cooperative effort among representatives of the test team and the supplier, who will work together to establish the maturity level of the equipment and determine the correct testing phase. The assessment team must include the following skill sets as a minimum:

- Process technology engineering
- Development engineering
- Software development
- Equipment reliability
- Safety
- Equipment engineering

A review of the supplier's program for equipment development and standards conformance may be discussed at the time of the opening meeting. Once the initial meeting has concluded, the team systematically investigates the current performance and capabilities of each characteristic in the EMA characteristics matrix described in Table 1. As each characteristic is evaluated, documentation or other information that clarifies capabilities is considered. All characteristics that are required for a test phase must be met or the equipment cannot be tested in that phase.

The first order of business for the team is to conduct a physical inspection of the equipment to be tested. Since it is important to understand the point at which each characteristic will be assessed, the last column of Table 1 lists the stage at which the majority of items will be assessed (i.e., a characteristic will be assessed either during the physical, offline, or both stages of the assessment's progression).

In some cases, a characteristic can be evaluated only by investigating the engineering data and systems that produce that functionality. An engineering capability assessment can substantiate findings and quantify current developmental progress and maturity. The engineering capability assessment ensures that all available data sources are considered to determine the appropriate testing phase.

During the EMA, factors that could affect the testing should be identified and investigated. Other factors may be identified that would provide early direction for test planning. These testing recommendations should be captured and included in the EMA report.

5 PROCEDURE FOR AN EMA

When planning for an Equipment Maturity Assessment, several logistical items should be addressed well in advance of its deployment. Following are two procedures that list those items in a hierarchal fashion. Along with logistical issues, the actual performance or deployment of the EMA should be recorded.

5.1 Before the EMA Deployment

1. Distribute copies of the work description to EMA team members
2. Schedule the EMA
 - Set the date of EMA
 - Set the participating Team Members
 - Determine the location(s) where EMA is to be performed
 - Establish schedule and dates for the EMA report review(s) and publication
3. Define the Functional Test Requirements
4. Data may be needed from the Supplier at the time of the assessment
 - Product Specification(s)
 - Design specification(s)
 - Documentation available for review (examples of)
 - Bill of materials
 - Assembly drawings

- Installation drawings
 - Layout drawings
 - Facility service requirements
- Engineering change control procedures and evidence of practice for:
 - Software changes
 - Hardware changes
 - Documentation changes
- Applicable SEMI standards conformance to standards
- Defect tracking
- Software interface manuals

The deployment of an EMA should begin with an introduction during an initial meeting. This meeting should also cover the day's agenda and important logistical issues as required. To provide a status to all persons present, the supplier should then perform a Functional Specification Presentation to inform all parties about the current functional capabilities of the system to be assessed. Following that presentation, the team should disperse to the location of the actual equipment for the physical assessment, which will be performed by the EMA team. During the physical assessment, the EMA team will perform the guideline and standards conformance assessment against as many physical items as possible using a guideline or standards conformance checklist. It is important to remember that equipment time is at a premium and time will be of the essence. At the conclusion of the physical assessment, the team should move to an offline area to address items not easily assessed during the physical and guideline conformance portion of the EMA. This portion of the EMA, known as the Engineering Capability Assessment (ECA), typically addresses documentation, engineering change control loops, and roadmaps for issues found during the physical assessment. During this time, the physical aspects of the guideline and standards conformance assessment are assessed. At the conclusion of the ECA, all items in the appropriate checklists should be populated with results or required action items for closure. To consolidate all findings, the EMA team then meets offline to prepare for a caucus and feedback session that will communicate the assessment's findings, issues, and action items to the supplier. In addition to those items presented to the supplier, maturity-based test recommendations should also be communicated. See Figure 1 for a more general graphical representation of the highlights of an EMA deployment, which begins with the opening meeting, typically held at the time of the assessment.

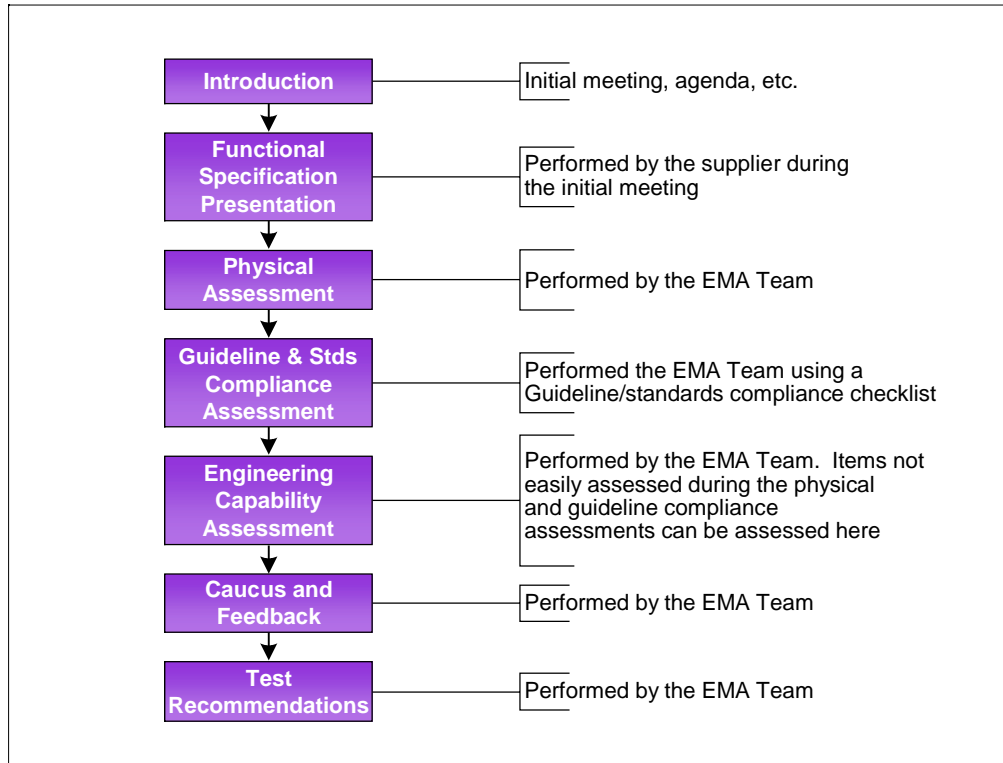


Figure 1 Flowchart of an EMA Deployed at a Supplier Site

5.2 EMA Deployment

- Perform the EMA
 - Kickoff meeting (standard presentation)
 - Physical inspection
 - Engineering Capability Assessment (ECA)
 - Test recommendations
- Caucus and provide preliminary feedback to the supplier
- Write up the official EMA worksheet
- Compile and consolidate reference materials
- Draft the EMA report
- Submit the EMA report for approval
- Publish the EMA report to the assessed party as well as other parties if required

6 DOCUMENTATION

The following information should be included in reporting an EMA:

- Equipment model number, serial number, options, configuration, and software release
- Development maturity of the equipment
- Determination of the test phase to be used for testing purposes
- Standards conformance
- Equipment characteristic summary
- Engineering capability assessment results
- Testing recommendations
- Opportunities for improvement

7 HELPFUL HINTS – GENERAL

7.1 Non-Production Level Maturity Equipment

For each characteristic not at a Phase 4 level of maturity, obtain the plan and schedule (i.e., roadmap) to bring the equipment up to a production level of maturity.

7.2 Transitional Equipment Not to Be Further Developed

Assessment of transitional equipment that is not planned to be further developed should focus on the equipment that is the subject of the study. In other words, no special consideration will be given to the equipment or the supplier because the equipment is not intended to be mass-produced. This is partially because some transitional equipment is sold for pilot line or test purposes. In this scenario where equipment is not to be developed further but is being assessed, the resultant EMA maturity level cannot be greater than Phase 3.

8 EQUIPMENT MATURITY CHARACTERISTICS WORKSHEET

The EMA worksheet should be used as an aid for determining the amount of testing that will be performed for the equipment. Each of the characteristics (1–27) is individually assessed, where the sub-elements are the representative attributes of each characteristic. The characteristic attributes are indicative of the criteria to be investigated and assessed during the EMA. The characteristics are cumulative and are consistent with the representative phase of maturity. All characteristics of a given maturity level are required to meet a test threshold. Characteristics 1–3 are required for a Phase 1 classification, 1–7 for Phase 2, 1–21 for Phase 3, and finally all characteristics, 1–27, for Phase 4.

8.1 How to Use a Characteristic Worksheet

See the example below that describes how an equipment characteristic worksheet might be completed during an assessment.

When completing the worksheet, progress through each equipment characteristic to find evidence related to each attribute listed. As evidence is or is not found, a check mark (✓) or an “x” (x) should be used to denote agreement that evidence relating to the item is acceptable or in question. The comment section should be used to address any item or attribute that is denoted as questionable.

Sub-element	Yes/No
Example Attribute 1	Yes
<input checked="" type="checkbox"/> Question 1	
Example Attribute 2	No
<input checked="" type="checkbox"/> Question 1	
<input type="checkbox"/> Question 2	
<input checked="" type="checkbox"/> Question 3	
Characteristic Result:	
No	
Comments	
Example – Evidence relating to this characteristic was not sufficient to allow conformance to be stated as	
“Pass.” Please see Attribute 2, question 2.	

Example 1. Example of How a Checklist Should be Completed

Finally, it is also important to understand that the attribute questions for each characteristic are not intended to be definitive or exhaustive or something that would cover every aspect of semiconductor equipment development. This handbook should function as a guide and worksheet for an assessor during a maturity assessment. The handbook is designed to facilitate the assessment such that key areas of semiconductor equipment development are assessed from a maturity standpoint. As a maturity assessment progresses, it should be understood that assessors may look beyond questions contained in each of the 27 characteristics. Attribute questions requiring a “Yes/No” response should be supported with evidentiary materials if the response is affirmative.

9 PHASE ONE CHARACTERISTICS

9.1 Characteristic 1 – Design Specification

9.1.1 Items of Interest

There is a design specification for this product. The design specification describes the technical approach, the target process, and performance goals and details every function to be supported by the mature equipment including standards compliance.

9.1.2 Special Concerns

None identified.

Sub-element	Yes/No
Defined Functions <input type="checkbox"/> Are all machine functions defined? (supplier provide list) <input type="checkbox"/> Are all remote functions defined? (supplier provide list) <input type="checkbox"/> Are the required automation capabilities defined? (list)	
Defined Process <input type="checkbox"/> Is the process defined? <input type="checkbox"/> Where can process targets be found in the design specification? <input type="checkbox"/> Are operating ranges defined? <input type="checkbox"/> Is the method of achieving the desired results defined? <input type="checkbox"/> Are special recipes that do not require material cited?	
Continuous processing capability <input type="checkbox"/> Is there a buffer design addressed in the spec?	
Manufacturing performance goals <input type="checkbox"/> Is SEMI E10 cited in the specification?	
Included standards and methods <input type="checkbox"/> Which standards are relevant to this equipment? <input type="checkbox"/> Are the relevant software standards cited?	
Software platform and User Interface (UI) <input type="checkbox"/> Are there any remote communication ports defined? <input type="checkbox"/> Is the platform cited in the design specification? <input type="checkbox"/> How many controllers are to be required for the equipment to successfully perform its functions? <input type="checkbox"/> Are all software functions enumerated? (i.e., UI)	
Environmental impact <input type="checkbox"/> Are ESH concerns present in the specification	
Maintainability <input type="checkbox"/> Are there definitions for e-Diagnostic capabilities <input type="checkbox"/> Are there tracking methods for equipment performance or usage defined?	
Characteristic Result:	
Comments	

9.3 Characteristic 3 – Safe Operation

9.3.1 Items of Interest

The equipment must be safe to operate for the duration of the test. The degree of operational safety required (proportional to equipment maturity) will increase as the equipment matures. This would include the appropriate level of hardware and software interlocks.

9.3.2 Special Concerns

None identified.

Sub-element	Yes/No
Roadmap <input type="checkbox"/> Has there has been an S2 assessment conducted on this platform? <input type="checkbox"/> Is this equipment S2 compliant? <input type="checkbox"/> In lieu of not having S2 compliance, what plans and schedules are in place to achieve S2 compliance? <input type="checkbox"/> Who is the project leader? <input type="checkbox"/> Is there a project number assigned? <input type="checkbox"/> Is there a 3rd party relationship? <input type="checkbox"/> If results from an S2 assessment are available, does it indicate significant areas for improvement? <input type="checkbox"/> For any cited areas of improvement, is there schedule for corrective action available?	
Safe Operation for Testing <input type="checkbox"/> What happens when the system is initialized? <input type="checkbox"/> What types of hazards are present which are not normally covered in an S2 assessment <input type="checkbox"/> Do there appear to be any obvious safety issues present? (i.e., sharp edges, noxious gases, etc.,)	
Safety Interlocks <input type="checkbox"/> Perform a brief physical inspection of the equipment; do the mechanical interlocks appear to be adequate? <input type="checkbox"/> Do the process interlocks appear to be adequate? <input type="checkbox"/> Do the software interlocks appear to be adequate? <input type="checkbox"/> Are there process and software safety interlocks present which appear to be sufficient for routine operator safety?	
Characteristic Result:	
Comments	

10 PHASE TWO CHARACTERISTICS

10.1 Characteristic 4 – Material Handling Functions

10.1.1 Items of Interest

The equipment must have at least one of each of the material handling and process functions listed in the design specification. The material handling and process functions must operate as an integrated system.

10.1.2 Special Concerns

None identified.

Sub-element	Yes/No
Wafer Handling Attributes <input type="checkbox"/> Verify that the automation functions listed in Characteristic 1 (Design Specification) are present? <input type="checkbox"/> Verify that all material handling standards listed in Characteristic 1 are present.	
Integrated wafer handling/process platform <input type="checkbox"/> What level of automation is present in the form of material supply to the production area? <input type="checkbox"/> <u>To EFEM</u> (FOUP compatible load port) <ul style="list-style-type: none"> ○ Is SEMI E84 supported? <input type="checkbox"/> <u>EFEM wafer transfer to/from equipment</u> <ul style="list-style-type: none"> ○ Are carrier management functions present as required by SEMI E87 <input type="checkbox"/> <u>Process Station</u> <ul style="list-style-type: none"> ○ Are substrate tracking functions supported as described in SEMI E90? <input type="checkbox"/> Is the supply of material to the equipment fully automated, semi-automated or is it primarily moved to the area manually? <input type="checkbox"/> What evidence is present which proves that the amount of physical loading has been minimized?	
Characteristic Result:	
Comments	

10.3 Characteristic 6 – Automated Process Recipe

10.3.1 Items of Interest

The equipment must be capable of executing an automated process recipe. The recipe must include all set points, sequencing, control, and data collection functions for fully automated processing.

10.3.2 Special Concerns

None identified.

Sub-element	Yes/No
Recipe Elements <input type="checkbox"/> Does the process recipe include all input parameters and set points? <input type="checkbox"/> How does the equipment’s design ensure that data is collected correctly? <input type="checkbox"/> Can the recipe steps be viewed on the UI? <input type="checkbox"/> Are the parameters provided to the UI updated real-time? <input type="checkbox"/> Can recipes be edited, modified, or deleted? <input type="checkbox"/> Can parameters be adjusted? <input type="checkbox"/> Can the recipe be executed? <input type="checkbox"/> Can the recipe be paused? <input type="checkbox"/> Can the recipe be restarted? <input type="checkbox"/> Can the recipe be stopped? <input type="checkbox"/> Can the recipe be aborted?	
Integration Level <input type="checkbox"/> Can the recipe be downloaded from the host? <input type="checkbox"/> Are there any unplanned interrupts, wait states, or manual interventions required?	
Characteristic Result:	
Comments	

11 PHASE THREE CHARACTERISTICS

11.1 Characteristic 8 – Equipment Footprint

11.1.1 Items of Interest

The equipment footprint is final and not expected to change. The cleanroom and support space size of the equipment is known and quantified. The dimensions of the system are available, and the layout or spatial relationships of all functional elements are fixed. The actual and predicted final footprint in terms of shape, layout, and support space is requested.

11.1.2 Special concerns

None identified.

Sub-element	Yes/No
Current size, shape, and layout <input type="checkbox"/> Actual plus predicted final shape of the equipment <input type="checkbox"/> Actual plus predicted final layout footprint <input type="checkbox"/> Actual plus predicted final support space footprint <input type="checkbox"/> What are the footprint requirements of equipment elements that can be located remote from the equipment, such as in a support or remote centralized location? Examples include such thing as vacuum pumps, chemical supplies, chillers, gas cabinets, RF generators, etc.	
Planned changes <input type="checkbox"/> Does the footprint have the same square footage requirement, as well as the final dimensional relationship in width, depth and height? <input type="checkbox"/> Does the equipment have all of the functional modules projected for the production phase equipment, including duplicates if required for a cluster equipment? <input type="checkbox"/> Are the functional modules in the final position and relationship to each other?	
Cost of Ownership <input type="checkbox"/> What is the estimated Cost of Ownership that may have been calculated during testing? <input type="checkbox"/> Describe comparisons to industry and CoO expectations.	
Characteristic Result:	
Comments	

11.2 Characteristic 9 – Support Module Footprint

11.2.1 Items of Interest

All support module footprints are final and not expected to change. The sizes and shapes are fixed and available. The location, proximity, and orientation factors are defined and fixed with no expectation of change.

11.2.2 Special Concerns

None identified.

Sub-element	Yes/No
Description, location, and distances <input type="checkbox"/> Was a list of remote or support equipment provided for Characteristic 7 (Support Equipment)? <input type="checkbox"/> Are the locations (in relation to each other) of the support equipment fixed? <input type="checkbox"/> What are the maximum distances that are specified for the support equipment to successfully operate?	
Current size, shape, and layout <input type="checkbox"/> Actual plus predicted final shape of the equipment <input type="checkbox"/> Actual plus predicted final layout footprint <input type="checkbox"/> Actual plus predicted final support space footprint	
Planned changes <input type="checkbox"/> Is the footprint not only the same square footage requirement, but also the final dimensional relationship in width, depth and height? <input type="checkbox"/> Does the equipment have all of the functional modules projected for the production phase equipment, including duplicates if required for a clustered equipment? <input type="checkbox"/> Are the functional modules in the final position and relationship to each other?	
Cost of Ownership <input type="checkbox"/> What is the estimated Cost of Ownership that may have been calculated during testing? <input type="checkbox"/> Describe comparisons to industry and CoO expectations.	
Characteristic Result:	
Comments	

11.6 Characteristic 13 – Automated Operation

11.6.1 Items of Interest

The equipment must be capable of fully automated operation. This is defined as the pod-to-pod complete process cycle, including lot and substrate slot integrity.

11.6.2 Special Concerns

None identified.

Sub-element	Yes/No
Processing is recipe driven <input type="checkbox"/> Describe the steps required to initiate a recipe operation. <input type="checkbox"/> Is operator support required to enable a recipe once it has been commenced?	
Pod to pod processing <input type="checkbox"/> Is the equipment capable of performing a mechanical dry run? <input type="checkbox"/> Describe the steps required to initiate a mechanical dry run. <input type="checkbox"/> Initiate a mechanical dry run recipe that will move a lot to and from the process station. <ul style="list-style-type: none"> <input type="checkbox"/> Is operator support required to enable a recipe once commenced? <input type="checkbox"/> Are wafers returned to the same slot from which they originated? <input type="checkbox"/> Was the lot dry run successful? 	
Host Operation <input type="checkbox"/> Describe all remote functions present per SEMI standards E30, E37, E40, E58, E84, E87, E90, E94, etc. (list others if applicable) <input type="checkbox"/> Describe how the equipment processes host commands for material delivery and substrate processing. <input type="checkbox"/> How does the equipment handle material delivery and removal?	
Characteristic Result:	
Comments	

11.7 Characteristic 14 – Error Handling/Recovery

11.7.1 Items of Interest

The equipment must have error handling and recovery for all routine failure mechanisms. Error handling must have failsafe modes to protect in-process materials. Error recovery should be designed to prevent manual interventions.

11.7.2 Special Concerns

Does normal operational error handling appear robust, in line with a mature platform and within the limits of available sensorization?

Sub-element	Yes/No
Error Handling <input type="checkbox"/> When an error occurs, does the machine fail to a safe state? <input type="checkbox"/> Have you identified routine failure mechanisms for hardware? <input type="checkbox"/> Have you identified routine failure mechanisms for software?	
Possible Failure Modes <input type="checkbox"/> Has a Failure Modes Effects and Criticality Analysis (FMECA) been performed? <input type="checkbox"/> Is a list of failure states available? <input type="checkbox"/> Was fault-insertion (FINS) testing based upon theoretical faults described in the FMECA?	
Error recovery strategy <input type="checkbox"/> Describe the equipment's error recovery strategy <input type="checkbox"/> Are errors captured in a historical event log? <ul style="list-style-type: none"> <input type="checkbox"/> Are the errors time-stamped? <input type="checkbox"/> Are the errors prioritized? <input type="checkbox"/> Is there a documented protocol for error recovery? <input type="checkbox"/> Is there safe recovery for less than catastrophic failures? <input type="checkbox"/> Are there auto-recovery software mechanisms available?	
FINS Testing <input type="checkbox"/> Have fault-insertion (FINS) tests been performed? Results? <input type="checkbox"/> <i>Perform a short robot deservo test (if present and functional)</i> <ul style="list-style-type: none"> <input type="checkbox"/> Was the induced fault identified by the system via an error message to the operator? <input type="checkbox"/> Was the fault captured in the error log? <input type="checkbox"/> <i>Perform other induced error conditions such as carrier removal and replacement (elapsed time of 5 or 6 seconds) during a substrate transfer to the processing area.</i> <ul style="list-style-type: none"> <input type="checkbox"/> Was the fault identified by the system? <input type="checkbox"/> Was the fault captured in the error log? <ul style="list-style-type: none"> <input type="checkbox"/> Is an operator required to verify that a <i>substrate</i> slot is open after a carrier has been removed and replaced? <input type="checkbox"/> <i>Load a control job and purposely deliver a different lot ID?</i> <ul style="list-style-type: none"> <input type="checkbox"/> Does the equipment handle host created errors such as the creation of control jobs without defining process jobs? 	
Characteristic Result:	
Comments	

11.8 Characteristic 15 – Informal Design for Maintainability (DFM) and Software Usability (SU)

11.8.1 Items of Interest

In terms of hardware, this aspect of the assessment should focus on changes to the layout or access for improved maintenance, activities at cross-functional efforts and previous learnings or experience, and those changes during the physical portion of the assessment to understand changes that may have not been implemented as a part of a “formal” process such as a Design For Maintainability (DFM) study.

11.8.2 Special Concerns

Refer to characteristic 26 for the formal aspect of this characteristic.

Sub-element	Yes/No
Design Considerations <input type="checkbox"/> Documentation of design for maintainability inputs, changes or actions <input type="checkbox"/> Documentation of design for usability inputs, changes or actions	
Formal Methodologies <input type="checkbox"/> Has a “formal” process such as a Design for Maintainability and Software Usability (from the designer/developer point of view) Study been performed? <input type="checkbox"/> What evidence is available that describes the formal methodology in terms of DFM/SU activities based upon the <i>accessibility</i> of components used in the system? <input type="checkbox"/> What evidence is available that describes the formal methodology in terms of DFM activities based upon the <i>layout</i> of components used in the system?	
Informal Embodiment of DFM/SU Activities <input type="checkbox"/> Lacking formal DFM/SU studies, describe or show any development/design activity that may <i>enable improved access</i> for maintenance activities. <input type="checkbox"/> Lacking formal DFM/SU studies, show the results of any development/design activity that changed the layout of the equipment’s subsystems so that improved maintenance could be realized.	
Characteristic Result:	
Comments	

11.9 Characteristic 16 – Ease of Operator Use

11.9.1 Items of Interest

Reasonable levels of manual dexterity and user interface complexity (screen design) are required for routine operation.

11.9.2 Special Concerns

Level of nesting for software usability.

Sub-element	Yes/No
Compliance Roadmap <input type="checkbox"/> Has there has been a SEMI S8 assessment conducted on this platform? <input type="checkbox"/> Is this equipment S8 compliant? <input type="checkbox"/> In lieu of not having S8 compliance, what plans and schedules are in place to achieve S8 compliance? <input type="checkbox"/> Who is the project leader? <input type="checkbox"/> Is there a project number assigned? <input type="checkbox"/> Is there a 3rd party relationship? <input type="checkbox"/> If results from an S8 assessment are available, do the results indicate significant areas for improvement? <input type="checkbox"/> For any cited areas of improvement, is there schedule for corrective action available?	
Routine Operation Requirements <input type="checkbox"/> Describe the routine operation of this equipment from and operator’s standpoint. <input type="checkbox"/> What are the manual precision and dexterity requirements necessary for equipment operation? <input type="checkbox"/> How many keystrokes are required to select and execute a recipe? <input type="checkbox"/> How many keystrokes are required to repeat the same process?	
Ergonomic Development Methods <input type="checkbox"/> What is the methodology used to design in and evaluate <i>ergonomic</i> factors?	
Design Considerations <input type="checkbox"/> Documentation of design for <i>usability</i> inputs, changes or actions	
Formal Methodologies <input type="checkbox"/> Has a “formal” process such as a Software Usability (SU) Study (from the end user/GUI point of view) been performed? <input type="checkbox"/> What evidence is available that describes the formal methodology in terms of SU activities based upon the <i>usability</i> of components used in the system?	
Informal Embodiment of SU Activities <input type="checkbox"/> Lacking a formal SU study, describe or show any development/design activity that may enable improved <i>usability</i> of the system for routine operation.	
Characteristic Result:	
Comments	

11.10 Characteristic 17 – Process and System Stability

11.10.1 Items of Interest

The equipment must be functionally stable and able to produce statistically stable process outputs. Data must be available that statistically validate process stability.

11.10.2 Special Concerns

None identified.

Sub-element	Yes/No
Process of Record <input type="checkbox"/> What is the process? <input type="checkbox"/> Is the data from the similar platform running an identical process?	
Data from the same platform configuration or model number <input type="checkbox"/> Is there an identical software load on another equipment? <input type="checkbox"/> Is there a similar software load on another equipment?	
Results <input type="checkbox"/> What type of analysis is performed against the data? <input type="checkbox"/> Describe how the software error rate is tracked through the development cycle. <input type="checkbox"/> How many data points or samples are present in the data set? <input type="checkbox"/> Are sequential data points present showing stable process results?	
Characteristic Result:	
Comments	

11.13 Characteristic 20 – Software Revision and Release Control (SRC)

11.13.1 Items of Interest

Closed-loop software revision and release control system must be in use (for the software that is being used or is to be used on the equipment under assessment only). The controls must be compatible with the development environment in use.

11.13.2 Special Concerns

For hardware-specific controls, see characteristic 19.

Sub-element	Yes/No
Software Configuration Management Methods <input type="checkbox"/> Describe how techniques such as the Software Engineering Institute's CBA-IPi method (as well as others) may have been used to design the SRC system.	
Software Revision and Release Control (SRC) Attributes <input type="checkbox"/> Describe or show the SRC approval loop. <input type="checkbox"/> Does the software process use revision and release control? <input type="checkbox"/> Does the available documentation reflect a closed loop structure? <input type="checkbox"/> Are all changes to the equipment under an SRC or similar system? <input type="checkbox"/> How are change requests initiated and tracked? <input type="checkbox"/> Is the change control system available to all engineers through a networked environment? <input type="checkbox"/> Describe the unit check-out/check-in capabilities utilized at the development facility. <input type="checkbox"/> Does the change control system appear to prevent concurrent unit code development? <input type="checkbox"/> Describe how differences are handled in the case where the same module is checked out to two or more persons. <input type="checkbox"/> Does a review of available change requests provide evidence that a process is in place? <input type="checkbox"/> What is the release control strategy for software going to the field? <input type="checkbox"/> Are release notes provided with all field releases of the software?	
Characteristic Result:	
Comments	

11.14 Characteristic 21 – Environmental Impact Analysis

11.14.1 Items of Interest

Analysis of the materials selected, the manufacturing assembly process, and operational effluent should be considered.

11.14.2 Special Concerns

Pay special interest to the supplier's manufacturing operation for producing equipment with regard to the above items of interest.

Look for internal controls and reports along with a responsible corporate officer.

Sub-element	Yes/No
Current Methods <input type="checkbox"/> Describe the current process that analyzes the impact of this equipment's manufacture and operation causes on the environment.	
Results <input type="checkbox"/> Has there has been an Environmental impact analysis assessment performed? <input type="checkbox"/> Is this equipment and its manufacture considered safe to the environment? <input type="checkbox"/> In lieu of not having an Environmental Impact analysis, what plans and schedules are in place to achieve perform one? <input type="checkbox"/> Who is the project leader responsible for the analysis? <input type="checkbox"/> Is there a project number assigned? <input type="checkbox"/> Is there a 3rd party relationship? <input type="checkbox"/> If results from an analysis are available, does the analysis indicate significant areas for improvement? <input type="checkbox"/> For any cited areas of improvement, is there a schedule for corrective action available?	
Characteristic Result:	
Comments	

12 PHASE FOUR CHARACTERISTICS

12.1 Characteristic 22 – Guideline Conformance

12.1.1 Items of Interest

Conformance to standards and guidelines is required. All standards of interest that require conformance must be considered. Every applicable certification must be present.

12.1.2 Special Concerns

The software revision in use must have all the required data collection elements for the process of interest.

The requirement for ESH guideline conformance includes an S2 and S8 report, CE marking or detailed plan, and an equipment-specific emissions characterization according to <http://www.sematech.org/public/resources/300mm/general/emschpkg.pdf>.

Sub-element	Yes/No
Conformance Roadmap <ul style="list-style-type: none"> <input type="checkbox"/> Has there has been an exhaustive internal conformance assessment conducted on this platform? <input type="checkbox"/> In the case where an internal assessment has been performed, is a report available? <input type="checkbox"/> In the case where an assessment has not been performed, what plans and schedules are in place to determine the conformance levels? <input type="checkbox"/> Who is the project leader? <input type="checkbox"/> Is there a project number assigned? <input type="checkbox"/> Is there a 3rd party relationship? 	
Assessment Results <ul style="list-style-type: none"> <input type="checkbox"/> Who performed the assessment? <input type="checkbox"/> What was the date of the assessment? <input type="checkbox"/> Was a report supplied to or by this assessor? <input type="checkbox"/> What methodology was used for the assessment? <input type="checkbox"/> If results from an internal assessment are available, does it indicate significant areas for improvement? <input type="checkbox"/> For any cited areas of improvement, is there a schedule for corrective action available? 	
Conformance Testing Methodology <ul style="list-style-type: none"> <input type="checkbox"/> Describe the remote-operation test procedure used to verify standards conformance on this equipment? <input type="checkbox"/> Has the supplier submitted the event log files that were generated from testing performed using the remote operation test procedure described above? <input type="checkbox"/> Do historical event logs provide data from simulated or real runs that include processing data? <input type="checkbox"/> What is this equipment's software revision level? <input type="checkbox"/> What is the tester's software revision level? 	
Characteristic Result:	
Comments	

12.2 Characteristic 23 – Documentation

12.2.1 Items of Interest

Documentation is published and under formal document controls. This includes engineering, manufacturing, facilitation, operation, software, data communication, and maintenance documentation.

12.2.2 Special Concerns

There are three aspects to the sub-elements of this characteristic. Documents should be

1. Complete, of high quality, and ready for publication
2. Under revision control
3. Comprehensive and covering every aspect of the equipment

Sub-element		Sub-element		Sub-element	
Are the documents complete, of high quality, and ready for publication?		Are the documents under document and revision control?		Is there a full set of documents?	
<input type="checkbox"/> Engineering <input type="checkbox"/> Manufacturing <input type="checkbox"/> Facilitation <input type="checkbox"/> Operation <input type="checkbox"/> Software <input type="checkbox"/> Data communication <input type="checkbox"/> Maintenance		<input type="checkbox"/> Engineering <input type="checkbox"/> Manufacturing <input type="checkbox"/> Facilitation <input type="checkbox"/> Operation <input type="checkbox"/> Software <input type="checkbox"/> Data communication <input type="checkbox"/> Maintenance		<input type="checkbox"/> Engineering <input type="checkbox"/> Manufacturing <input type="checkbox"/> Facilitation <input type="checkbox"/> Operation <input type="checkbox"/> Software <input type="checkbox"/> Data communication <input type="checkbox"/> Maintenance	
Exception Comments		Exception Comments		Exception Comments	
Yes/No		Yes/No		Yes/No	
Sub-element				Yes/No	
Methods					
<input type="checkbox"/> Is there a procedure that describes the documentation process? <input type="checkbox"/> Who is in charge of the documentation process?					
Characteristic Result (Yes/No):					
Comments					

12.3 Characteristic 24 – Wafer Process Characterization

12.3.1 Items of Interest

Representative process characterization data are required.

12.3.2 Special Concerns

None identified.

Sub-element	Yes/No
Process of Record <input type="checkbox"/> What is the process? <input type="checkbox"/> All process capabilities characterized <input type="checkbox"/> What was the expected result? <input type="checkbox"/> Is the data from a similar platform running an identical process?	
Data from the same platform configuration or model number <input type="checkbox"/> Is there an identical software load on another equipment? <input type="checkbox"/> Is there a similar software load on another equipment?	
Results <input type="checkbox"/> How was the analysis performed against the data? <input type="checkbox"/> Are graphical representations of the response space available? <input type="checkbox"/> Has the process been characterized with high statistical confidence? <input type="checkbox"/> How many replications of the desired response were measured? <input type="checkbox"/> Was the optimization performed via a design of experiments (DOE)? <input type="checkbox"/> If a DOE was not utilized to perform the optimization, describe the methodology	
Characteristic Result:	
Comments	

12.4 Characteristic 25 – Manufacturing Performance

12.4.1 Items of Interest

Representative parametric and manufacturing performance data are required.

12.4.2 Special Concerns

None identified.

Sub-element	Results	Yes/No
Data Sources <input type="checkbox"/> How many equipments of this type are fielded? <input type="checkbox"/> How many are currently on the manufacturing floor? <input type="checkbox"/> What is the source of the supplied data? <input type="checkbox"/> Are other sources available?		
Types of Data <input type="checkbox"/> Is process performance data available (i.e., uniformity, etch rate, etc.)? <input type="checkbox"/> Is manufacturing performance data available (i.e., yield %, MTBF, productivity, etc)		
Expected Results <input type="checkbox"/> What are the expected performance levels for this equipment? <input type="checkbox"/> Do these levels appear to be in line with typical equipment of a similar maturity level? <input type="checkbox"/> What is the basis for the expected results?		
Software Fault Performance <input type="checkbox"/> What is the latent defect rate? <input type="checkbox"/> What is the error rate? <input type="checkbox"/> What is the complexity of the software? <input type="checkbox"/> Release rate?		
Characteristic Result:		
Comments		

12.5 Characteristic 26 – Design for Maintainability (DFM)

12.5.1 Items of Interest

Evidence of formal Design for Maintainability is required. See characteristic 15 for the informal aspect of this characteristic.

12.5.2 Special Concerns

None identified.

Sub-element	Yes/No
Formal Process <input type="checkbox"/> Is there an internal DFM program or process that considers maintainability issues as a part of ongoing development? <input type="checkbox"/> Was there an internal DFM study performed during this equipment’s development? <input type="checkbox"/> In the case where an internal study has been performed, is a report available? <input type="checkbox"/> In the case where a study was not performed, what informal methodologies were found in Characteristic 15, Informal DFM? <input type="checkbox"/> Who was/is the project leader? <input type="checkbox"/> Is there a project number assigned?	
Study Results <input type="checkbox"/> Who performed the study? <input type="checkbox"/> What was the date of the study? <input type="checkbox"/> Was a report supplied to this assessor? <input type="checkbox"/> What methodology was used for the study? <input type="checkbox"/> If results from the study are available, does the study indicate areas of improvement that were addressed during the development process? <input type="checkbox"/> Were the aforementioned improvements implemented in the design? <input type="checkbox"/> For any remaining areas of improvement, is there a schedule for implementation available?	
Characteristic Result:	
Comments	

12.6 Characteristic 27 – Environmental Impact Study

12.6.1 Items of Interest

Evidence of a formal Environmental Impact Study is required.

12.6.2 Special Concerns

Look for an independent third-party environmental impact study containing the nine elements outlined in the following documents:

1. <http://www.sematech.org/public/docubase/abstracts/3803atr.htm>
2. <http://www.sematech.org/public/resources/300mm/general/3803atr.pdf>

Note 1: This characteristic (document or study provided by the supplier) distinguishes between the emissions characterization study required in item #21 and a full environmental impact study encompassing the entire lifetime of the equipment studied.

Sub-element	Yes/No
Formal Process <input type="checkbox"/> What is the methodology used to evaluate and minimize environmental impact of materials, operation and effluent of the design? <input type="checkbox"/> Is there an internal environmental impact program or process that considers environmental issues as a part of ongoing development? <input type="checkbox"/> Was there a formal environmental impact study performed as a part of this equipment's development? <input type="checkbox"/> Are reports available as a result of each study? <input type="checkbox"/> In the case where a study was not performed, what was addressed as a result of findings from Characteristic 21, Environmental Impact Analysis? <input type="checkbox"/> Who was/is the project leader? <input type="checkbox"/> Is there a project number assigned? <input type="checkbox"/> Is there a 3rd party relationship?	
Study Results <input type="checkbox"/> Who performed the study? <input type="checkbox"/> What was the date of the study? <input type="checkbox"/> Was a report supplied to this assessor? <input type="checkbox"/> What methodology was used for the study? <input type="checkbox"/> If results from the study are available, does it indicate areas of improvement that were addressed during the development process? <input type="checkbox"/> Were the aforementioned improvements implemented in the design? <input type="checkbox"/> For any cited areas of improvement, is there a schedule for corrective action available?	
Characteristic Result:	
Comments	

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