Requirement on Enhanced Equipment Quality Assurance upon Equipment Installation (EEQA)

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Japan Electronics Information Technology Association (JEITA)

Semiconductor Leading Edge Technologies (Selete)

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1. Background

1.1. Activity Framework

The Semiconductor Manufacturing Technology Committee of Japan Electronics Information Technology Association (JEITA) has selected the action challenges which the industry should face with among the challenges of semiconductor manufacturing issues and possible solutions discussed at the Factory Integration Technology Working Group (FITWG) of Semiconductor Technology Roadmap of Japan/the International Technology Roadmap of Semiconductor (ITRS). The selected challenges have been summarized in the form of users' guideline as the requirements from device manufacturers.
The Semiconductor Manufacturing Technology Committee of JEITA also has been promoting to the semiconductor related industry the direction of the technology development and of the response based on the guideline.

Semiconductor Leading Edge Technologies (Selete), has carried out the examination of further detail requirements and the system specification for materializing the users' guideline, the examination of system from business standpoint, and the verification of fundamental technologies from implementation viewpoint. Furthermore, Selete participates in the standardization activities of Semiconductor Equipment and Materials International (SEMI) to reflect the voice of device manufacturers in various stages of standardization process of various kinds of standards.

JEITA and Selete, in order to get cooperation of equipment suppliers, have been trying to enhance information exchange and to cooperate in prototype equipment with equipment suppliers individually. JEITA and Selete also cooperates with Semiconductor Equipment Association of Japan (SEAJ), and have been doing information exchange including business aspects issues and PR and promotional activities. The figure 1 shows the industry collaboration scheme.

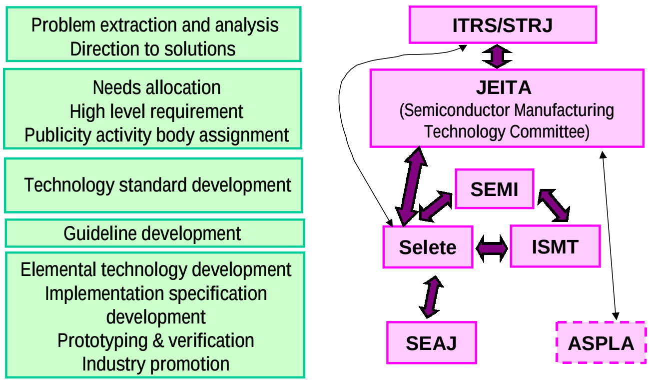


Fig. 1 Industry Collaboration Scheme of EES Development as of March 2004

1.2. Outline

1.2.1 History

In December, 1999 when the construction of 300mm factories started in Japan, Intel brought up a concept about e-Diagnostics and the proposal led discussion. The e-Diagnostics concept proposed from Intel showed that the equipment information is sent to equipment suppliers outside of the factories so that the equipment maintenance support can be expected to receive from them. There was a need to improve manufacturing productivity by increasing low equipment operation ratio through introduction of IT technologies into manufacturing. That is a background of e-Diagnostic proposal. The proposal was discussed at ITRS meetings, however, the change of security procedure and the way of business was pointed out as critical issues.

Then, in the U.S., the project centering on ISMT was formed, the examination of e-Diagnostics progressed, and the announcement of the guideline was done in July 2000. In response, the e-Manufacturing examination WG was formed by JEITA under the Subcommittee on Semiconductor Manufacturing Technology and examination was started also in Japan. In this examination WG, the device maker, the equipment supplier, and the software supplier collaborated with cooperation from SEMI and SEAJ from the beginning stage.

At the training camp during three consecutive national holidays in Nagano in September 2000, the new system concept called EES (Equipment Engineering System: equipment engineering system) was completed. Afterward, through the collaboration among ISMT (International SEMATECH) , JEITA, and Selete, the EES guideline reached to a global consensus. Consequently, EES became one of a few fundamental system concept originated from Japan and has been accepted all over the world widely. Refer to the Figure 2 for the activity history of the EES development.

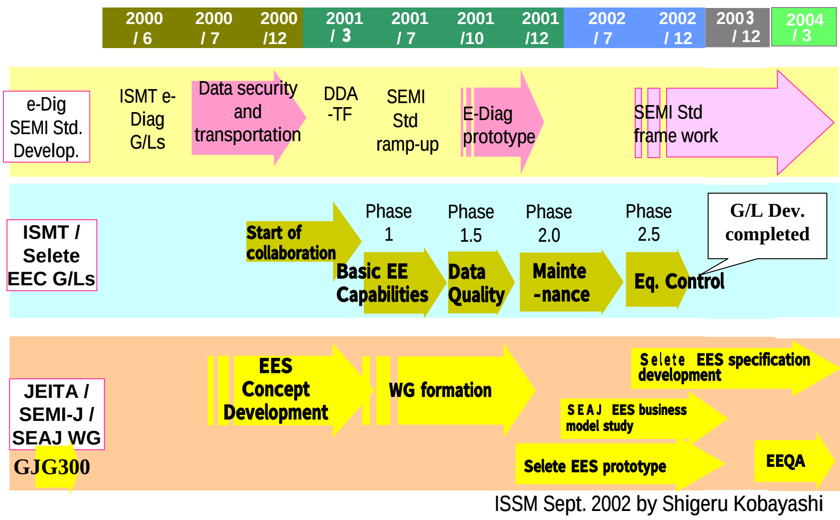


Fig. 2 EES Development Activity History

1.2.2. Expansion of EES Concept

In the conventional factories, the system called Manufacturing Execution System (MES) has supported products handling work which was done by the operators and conveyers facing with the front face of the equipment. The automation technology of process progress control and dispatch technology was the typical MES function. On the other hand, EES is a support system to equipment engineering including maintenance work and various works responding to conditions at the back face of the equipment. Originally EES was expected that it would contribute to raise the equipment operating ratio and the examination started.

However, a role of a platform on which various kinds of support functions can be put has come to be recognized as a main function of EES. Unlike the conventional system, in EES, utilizing of internet into the base technology is recognized as a direction from the start. EES is defined by not only its macroscopic function between the equipment in a micro factory but also among factories and over between companies. Therefore, EES came to be considered as a platform which enables to exchange detailed information widely as a hierarchical system. Various application contents such as arrangements for improvement of equipment operating ratio and delivery for materials, relation between equipment and facilities, cost calculation system, and a system that handles information of conditions and equipment performance are to be appeared on this platform, and are expected to bring the result.

At the same time, the importance of the platform of the information exchange which connects from design to mask manufacturing, and through wafer manufacturing in SoC has been recognized in Japan. This brought a new concept called Engineering Chain Management (ECM). This new concept and the concept of the platform of EES were combined, and the concept of new e-Manufacturing was born. The new e-Manufacturing concept became a hierarchical system which shows platforms divided by layers. It enabled to clarify function and relations of intra-equipment platform, inter equipment platform, and inter factories/inter companies/inter functions platform. The new e-Manufacturing concept came to be recognized as a unified platform which handles both micro and macro information as being related to.
Although it is the concept originally developed to build a new environment of Japan, it has been spread globally, now, advanced research is going on briskly not only in the U.S. but also in Taiwan and Europe.

1.2.3. Purpose of This Guidebook

The concept of EES spread much wider than previously thought and it surely helps to establish the original vision of EES at the beginning of development. However, in order to promote implementation of EES into system and to achieve the result at the earliest possible date, the necessity of specifying the field which concentrates the power of the industry came out. Then, JEITA tried to narrow down the application field to be carried out selectively for the time. The Figure 3 shows EES application service by industry.

As shown in the Figure 3, EES provides many application fields where the equipment suppliers and the device manufacturers use on both sides. Among those application fields, JEITA focused on the detection function of unscheduled equipment down time and applications at the time of equipment install to the factories. Furthermore, this guidebook narrows down to the requirements of quality assurance (QA) at the equipment installment. Although this guidebook summarizes the enhancement of equipment quality assurance at the time of the equipment installment with using EES , however the enhancement of quality assurance which does not use EES is also taken into consideration.

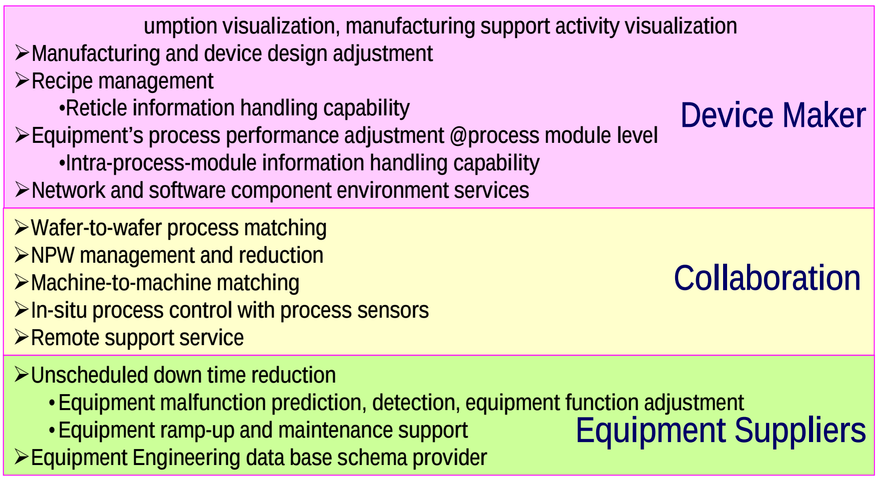


Fig. 3 EES Service Examples by Business Regimes

The requirements for enhancement of quality assurance are summarized by the following items at the time of equipment installation.

1. Qualified equipment without down time

- Extermination of initial failure
- Reduction of failure of maintenance time during operation.

2. Shortening ramp-up time (Reduction of process steps)
- Time before installation
- Time after installation (Ramp-up time at equipment suppliers side and basic process condition generation)

3. Reduction of difference among different equipment

- Difference between equipment and chamber

In order to guarantee cost effective quality assurance to supply equipment which satisfies those requirements, the new quality assurance method is needed to take over the conventional method, and it is necessary to develop the efficient quality assurance method. It is expected to establish win-win relation between device manufactures and equipment suppliers, to change the way of business to meet with the change of circumstance of a time, and to improve productivity of the factories.

1.3. Related Guidelines in Equipment Engineering Capabilities Guiidelines

This chapter introduces the EEC guideline of ISMT/JEITA/Selete, the current requirements of JEITA to EEC, and a relation with the contents of this guidebook. As the Figure 4 shows, there are 29 items of the guideline.

JEITA selected five items of guideline as the first priority for implementation for the time being. The aims for having extracted these five items include that all equipment engineering data (EE data) is taken out from equipment first, then the platform which utilizes EE data is established, and EE data starts to be used both by the equipment supplier and the device maker from the beginning of equipment life cycle by using at the initial stage of equipment installment. Further detail of the five items of guideline is described below. The outline of the requirements for advanced quality assurance at the time of equipment installment can be shown in the combination of these guideline items.
It is an extract from the guideline Japanese version text henceforth. The line with an underline is the main text of guideline, and the rest is incidental explanation.

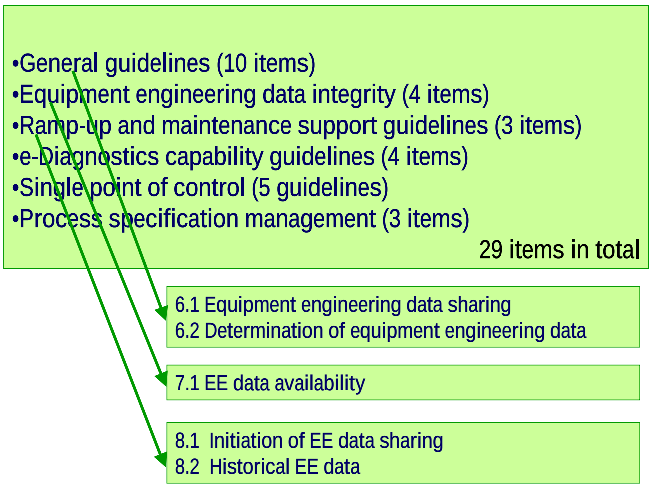


Fig. 4 Important EEC Guidelines for EES Start Up

(6.1) Equipment Engineering Data Sharing
(Extract of the text)
<u>Selected equipment engineering data must be shared between equipment supplier and device maker for equipment engineering operation purposes.</u>

Standards:
Standards are needed to define how to publish data from the equipment to an external system.
(Explanation)
The figure 5 shows the scheme of EE data sharing. The data taken out from equipment is used by both equipment supplier and device manufacturer. Moreover, the exchange of the information between equipment supplier and device manufacturer should be standardized for cost down of system development.

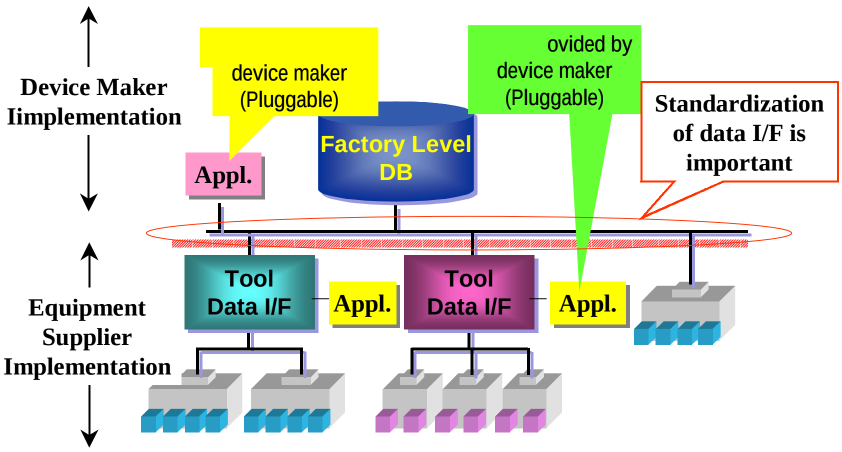


Fig. 5 Scheme of EE Data Sharing

(6.2) A Determination of Equipment Engineering Data
(Extract of the text)
The equipment supplier shall determine all the data related to equipment engineering with relevant documentation. It is the equipment supplier's primary responsibility to understand the scope of equipment engineering in order to maintain and improve equipment performance. The device maker will collaborate with equipment suppliers on the equipment engineering data list.

Remarks:
equipment engineering data may be used for at least the following capabilities: maintenance and improvement of basic equipment performance and process performance, improvement in maintenance operations, and prediction of required.

(Explanation)
It is described that the determination of EE data is a primary responsibility for equipment supplier and device manufacturer should cooperate to make EE data listing. This chapter summarizes the business flow based on the above flow.

(7.1) EE Data Availability
(Extract of the text)
-Product and process outcome objectives and equipment process condition set points.

-The actual values achieved by the equipment including; measured process conditions, measured process end results, and calibration values, and;
-Time-varying "actuator" control signals, measured controller outputs, and controller coefficients used by any embedded controllers.
(Explanation) This chapter required about the kind of data. Data required for quality assurance at the equipment installment is requested to be structured.

(8.1) Initiation of EE Data Sharing (extract of the text)

- EE data collection, analysis and distributions shall begin prior to shipment.
- Equipment suppliers and device makers shall initiate EE data sharing prior to the time the equipment is shipped from supplier to the user.
- The equipment supplier shall make EE data and any derived analysis/reports from each individual equipment available to the device maker prior to shipment of the equipment.

(8.2) Historical EE Data
(Extract of the text)

- EE data collected during acceptance and ramp-up will be used as an historical baseline for equipment.
- The equipment supplier shall define and provide data to show detailed equipment performance through the ramp-up period and at the time of acceptance.
- The device maker may also choose to collect and analyze detailed equipment performance data for their own purposes, at their discretion and at any time before or after shipment of the equipment.

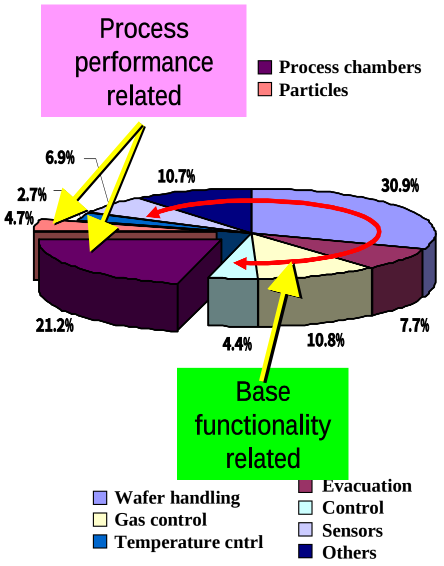
(Explanation)
The guideline of the above (8.1) (8.2) is the background of this guidebook. They requests data collection and indication before and after the equipment installment.

This guidebook is written based on the above EEC guideline. This guidebook can be used as further detail contents of requirements with operation image attached to the guideline.

2. Purpose of Enhancement in Equipment QA

Figure 6 analyzes mean time trouble repair (MTTR) of equipment in a factory. The chart shows that MTTR caused by the process performance related factor is not major factor and base functionality related factor accounts for a larger proportion of MTTR.

At the semiconductor manufacturing factory, the monitoring data about process state taken from the equipment is used to eliminate the production of scrap wafers through monitoring the data. The another important indication of figure 6 is that it is easily understood that the above effort of monitoring data about process state is mainly spent for detecting failure of equipment base functionality related.



Source: “ Device maker’s expectation to EES and e-Diagnostics” by Tadashi Kiriseko in SEMI Workshop on e-Manufacturing & APC/FDC ,

Fig. 6 MTTR Analysis for Process Tools on Factory Floor

Therefore, it is still important to detect the failure and breakdown at the based of factory operation, however at the same time, it is essential to improve the reliability of the base functionality of equipment. In order to improve the reliability of equipment base functionality, it is an inevitable measure to improve in the completeness of equipment by activating feedback to equipment design and assembly & packaging field.

The prioritized purpose of equipment engineering system is to improve equipment fundamentally described above. The result will be expected only when the industry-wide activities to improve equipment base functionality instead that only equipment suppliers

Table 1 Purpose of EEQA Upon Equipment Ramp-Up

Primary Goal	
1	Reliable and consistent verification of equipment base functionalities
2	More efficient and rapid equipment's ramp-up
3	Reduce ***Machine-to-Machine*** or ***Chamber-to-Chamber*** difference in terms of equipments' base functionalities

Secondary Goal	
Share equipment's base line data;	
1	in order to allow reuse for efficient troubleshooting
2	so as to confirm the base functionality performance
3	so as to reduce ***Machine-to-Machine*** difference in terms of equipments' process performance
4	so as to encourage more efficient energy and consumables consumptions and maintenance

collaborate to improve just process functionality of the equipment.
It is essential that the first step of equipment improvement at any functionality is to expose and visualize the failures. It is important to check that the performance of both process and base functionalities have come out as correctly as possible when starting to use the equipment newly introduced. It will be a precious and important opportunity for both device manufacturers as users, and the equipment suppliers who deliver equipment to their users to analyze the data of functionality with a serious interest and to expose the failures if any.

It comes near to stating the obvious that both device manufacturers and equipment suppliers pursuing the opportunity are able to share the purpose described in Chart 1. The quality control with advanced functionality of equipment with shared purpose between user and supplier is hereinafter called as “Enhanced Equipment Quality Assurance”(EEQA).

3. Common Focus Areas in EEQA

The focus areas for equipment functionality and performance can be classified into three categories. (Fig. 7) The upstream category is user own process performance, the second area is vertical standard process performance executed, then the last one is process set-up capability performance.

Although the process set-up capability performance as basic equipment functionalities relates directly to the performance of devices, in the limited range of the information which is available to the equipment operators usually, the operator can hardly explain the reason of the change of performance.
However, the device performance can be more efficiently analyzed by correct understanding of the process set-up capability performance.

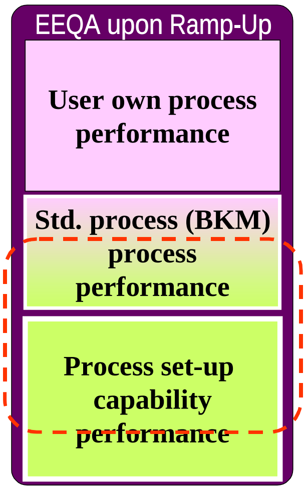


Fig. 7 Focus Area for EEQA Upon Equipment Ramp-up

The purpose of this guideline is to share EEQA through the industry wide using electronic data information related to equipment. It is desired to make it enable to collect precisely the reaction on right above or on the wafer and serve the data into mass production as it is being developed, or to develop ad-hoc observation sensing technology for making collectable information to be closer to the performance. Those capabilities are in the competitive technology area. It is expected to use those equipment information obtained by sensing technologies and to understand the equipment functionality more precisely. However it is out of the object range of this guidebook.

Moreover, the performance of devices depends on the process technology used in equipment. The process technology differs by each device manufacturer and it may fully be unable to be acquired by process set-up capability performance, therefore, the process technology in almost cases is out of the scope range of this guidebook.
Since the equipment is made based on the assumed virtual standard process, this guidebook can cover a partial functionality performance that determines user performance.

As mentioned above, the scope of EEQA in this guidebook is the equipment functionality performance in the range enclosed with the dotted line of Figure 7. Since the device maker is manufacturing the device on the assumption that a process set-up capability operates normally, a device manufacturer's concern inclines toward right-hand side by a diagram as shown in Figure 8.

A device manufacturer requests very much to equipment manufacturer to maintain process set-up capabilities or to improve in reliability being made radically shown at the left side in Figure 8.

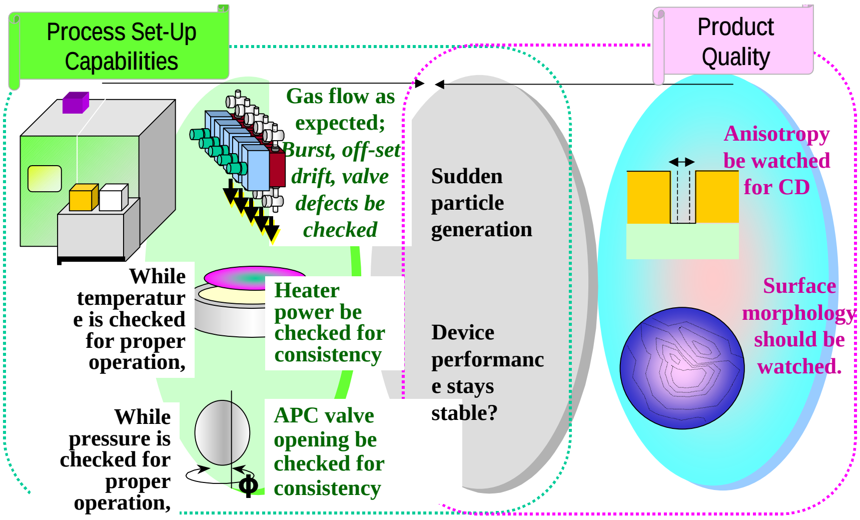


Fig. 8 Two Regimes of Interest; Process Set-up Capability Performance and Product Quantity Performance

Table 2 summarizes the expectation about the equipment QA enhancement. It is indispensable that the return loop of equipment information for improving the reliability of equipment by utilizing the electronic data from equipment perfectly is initiated from users through equipment supplier. Since there is almost no experience in our industry to share the necessary equipment information to build the new information flow, sufficient examination is indispensable.

Performance confirmation	Example	Until now	Direction
Device fabrication results	Pattern definition Morphology Step coverage		No so much to change but with quantitative confirmation of basic equipment capabilities
Direct process condition generation capabilities	Reactant supply Wafer heating	Confirm process condition value ranges No quantitative recognition of M-to-M differences Paper based report	Quantitative confirmation of recipe contents Statistically verified confirmation of process condition repeatability Quantitative M-to-M difference visualization
Indirect process condition generation capabilities	Wafer transportation Cryogenic pump compression	Criteria such as "No wafer breakage in 1000 wafer dry run"	Quantitative mechanical stability confirmation Recipe sequence confirmation with quantitative data

Table 2 Equipment QA Enhancement Expectations

4. Process Set-up Functionality

There are two categories in process set-up functionality as follows;
(1) Direct process condition generation capabilities
eg.
- Function of energy required for a reaction
- Function of light irradiation
- Function of wafer temperature
- Function of thermodynamic conditions set-up
- Function of supplying reactive gas

(2) Indirect process condition generation capabilities
- Function of wafer transport to reactive chamber
- Function of automation correspondence
- Function of exhaust gas
- Function of temperature control for exhaust gas piping

Both the functions of these are equally important, and are considered as a scope of the QA enhancement. It is necessary to decide how far functionality performance should be checked.

In most cases there are two or more functions are existing behind one direct process set-up. Furthermore, there may be another function in the back again. Probably, the subsystem is purchased in many cases from the outside of the equipment supplier, when assembling equipment. This guidebook does not carry out being aimed at all the functions that carry out a chain. The evidential data of QA which a device manufacturer can use in a positive attitude is expected to be offered. A device manufacturer's concern becomes stronger as it is closer to manufacturing semiconductor products. Therefore, EEQA area covers the function at one back as supporting function of the process set-up capability for the near term. However, if it is a complicated function, a function in back will increase a certain degree, and it will be thought that generalization is difficult (Fig. 9).

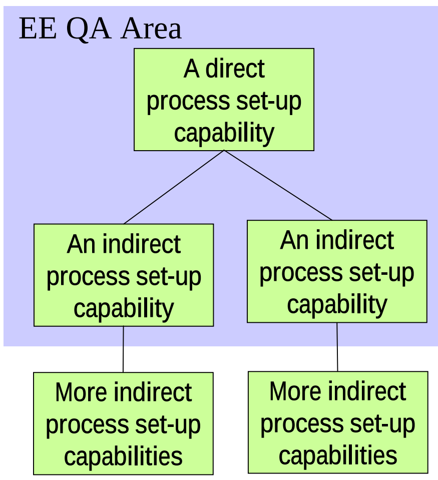


Fig. 9 Focus Area for EEQA Upon Ramp-Up

5. Agreement Formation Procedure of Details of EEQA

There is not an existing industry rule agreed upon about what kind of EEQA should be proceeded or what kind of data should be used. However, the Equipment Engineering Capabilities (EEC) guidelines have described the equipment engineering data as follows;

1) Shall be determined by Equipment suppliers
2) Shall be agreed with device manufacturers

The sequence flow of the equipment engineering data of EEQA and determination of data collection procedure along with EEC Guidelines is shown in Figure 10.

The sequence shows that a device manufacturer first shows its high level requirement about which function capabilities needed to check by the disclosure of QA enforcement data, then an equipment supplier considers QA work in which it can succeed with the equipment concerned of its company and proposes concrete QA operation, and finally comes to the consensus of both parties about details of EEQA. The high level requirement from a device manufacturer is to be expressed in a function unit. Although it is natural, depending on the target QA item, it may not be at such a sequence.

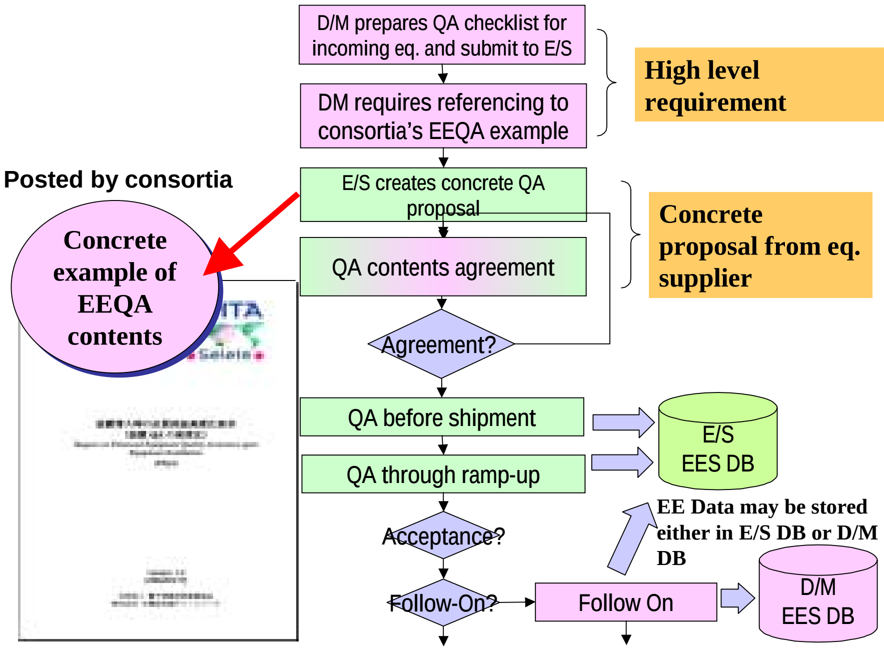


Fig. 10 Business Flow Assumed

It is important that the equipment supplier should propose the concrete details of QA offering the data which shows rationally that the equipment function capabilities have enough performance and reliability as for mass production equipment. The design performance value of equipment and the function capability of standard equipment etc. can be referred to at this time. Moreover, the reliability data in the field may also be referred to.

A device manufacturer needs to tell equipment supplier what QA data they expect to be disclosed as a user. Because, as a user, device manufacturers have suffered from many experiences of the failures of equipment at their factory, there is a demand for thoroughness of a performance check as a way stage for reducing the failures generating to a rational level, or delaying it. The demand is not necessarily in agreement with the contents of QA which the equipment supplier is carrying out now.

It is not the purpose of this guidebook to get into the details of each equipment function nor the concrete method of QA enforcement shown in the Figure 10. Technology has many peculiar aspects and technology also evolves quickly. This guidebook aims at transmitting generally summarized expectation of device manufacturers to equipment suppliers. When the concrete example is shown, it should be considered as an example of many cased and equipment suppliers are required to understand common users expectation through the example.

6. Contents of QA Enhancement

6.1. Check List as a Media for EEQA Collaboration

In order to request high level requirement for in what function capabilities a device manufacture to receive and check QA data, it is desirable to have a template form covering all QA items of device manufacturers' interest so that it avoids mistake of drop behind about QA items. Moreover, it is also important that the common checklist make it easier for equipment suppliers to perform comparison and analysis what difference to be in the demand item among device manufacturers. It should be emphasized that this request does not refer to individual specification of each device manufacturer.

It is also required for each device manufacturer to standardize their requirement within each company. Moreover, it is also required to maintain the demand at a long period of time. From the above-mentioned viewpoint, this guidebook has proposed sharing a common list for the demand about equipment QA data indication among device manufacturers. The item "QA checklist for incoming equipment" in Figure 10 refers to this list. This will be henceforth called EEQA checklist. In summary, the purpose of an EEQA checklist includes;

1) Standardization of requirements on EEQA data indication/disclosure from device manufacturers
2) Maintenance of uniformed requirement among device manufacturers and within each device manufacturer
3) Easy comparison among requirements from device manufacturers and emphasis on common requirements.

6.2. Outline of EEQA Checklist

It is necessary to have the function and performance of equipment rationally in the outline EEQA checklist. There are many common functions among equipment suppliers and at the same time many specific functions only available to each equipment also between equipment suppliers. For this reason, it is necessary to decompose all functions of the whole equipment into "module", to assemble the modules, and describe the function to many equipment types (Fig. 11).

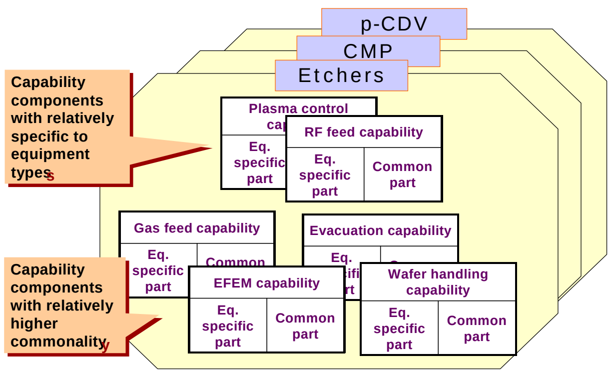


Fig. 11 Equipment Capability Representations

In the EEQA checklist, it separated structurally between the function capability items and the performance items within capability in which QA dated is requested. The figure 12, as two-dimensional list, shows a horizontal axis refers capability items, and the vertical axis refers performance metrics.

The usual equipment user engineers grasp the function capability as a portion (site) of equipment in their operation. If the categorization of equipment function into modules is not proceeded along with equipment portion concept, it would make difficult for the equipment user engineers to show their requirements. Therefore, the capability axis is described relating to the categories by equipment portion or combined portions.

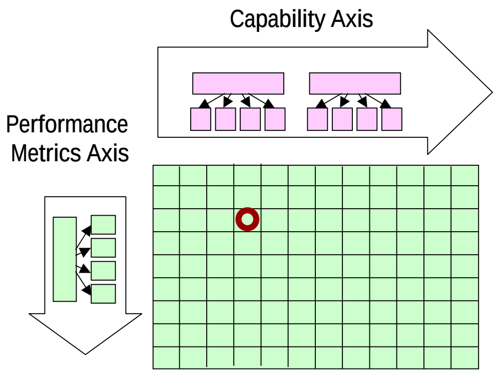


Fig. 12 Capability Axis and Performance Metrics Axis

Table 3 is an example of a capability axis. The horizontal column called “High level capabilities” refers module combination of equipment function capabilities and the column called “Subsystem level equipment portion” refers the portion of the equipment where the function is carried.

High level capabilities	EFEM capabilities Load Port Wafer handler			Wafer handling capabilities (including whole equipment)								Vacuum Evacuation Capabilities			Gas Supply Capabilities			Process Pressure Control Capabilities
Subsystem level eq. portion	Load Port	Wafer handler	ID reader	Door	Load Lock	Gate	Transfer chamber	Gate	Process Chamber	Process Chamber	Whole equipment	Load Lock	Transfer chamber	Process chambers	Load Lock	Transfer chamber	Process chambers	Process Chambers

Table 3 Example of Capability Axis (1)

Table 4 shows details though function part level. Assume the case where there is a demand about QA data requested from a device manufacturer on the level of the details described in Figure 3. In this case, the equipment suppliers are expected to disclose the QA data in function part level for the relevant equipment.

High level capabilities	Subsystem level eq. portion	Function level eq. portion
EFEM Capabilities Load Port Wafer Handler	Load Port	Loader
		FOUP Opener
	Wafer handler	Arm
	ID reader	FOUP ID reader
		Wafer ID Reader
Wafer Handling Capabilities (including whole equipment)		Door
	Load Lock	Wafer positioning sensor
		Gate
	Transfer chamber	Arm
		Folk
		Gate
	Process Chamber	Push Pin
		Stage
	Process Chamber	Hoist
	Whole equipment	
Vacuum Evacuation Capabilities	Load Lock	Pressure Gauge Check
		Leakage Check
	Transfer chamber	Pressure Gauge Check
		Leakage Check
	Process chambers	Pressure Gauge Check
		Leakage Check
Gas Supply Capabilities	Load Lock	Mass Flow Controller
		Gas Manifold
		Venting Function
	Transfer chamber	Mass Flow Controller
		Gas Manifold
	Process chambers	Mass Flow Controller
		Gas Manifold
		Wafer stage
Process Pressure Control Capabilities	Process Chambers	Automatic Pressure Control
		Pressure Gauge Check

Table 4 Example of Performance Metrics Axis (2)

In this guidebook, it is assumed that there is hardly necessary for device manufacturers to describe their requirements in EEQA checklist into this detail level into function part.

Table 5 is an example of the performance metrics (vertical axis) showing performance items. It is used for device manufacturers to indicate their requirement for QA data by function capability.

Group items include equipment base functionality, process set-up capability, and process execution capability. For the sub items, refer to the explanation below for the open loop characteristics and closed loop characteristic

The open loop characteristics refer so-called bare characteristics of equipment function capabilities.

For example, in the vacuum processing equipment, the characteristics include the characteristics for vacuum achievement degree and evaluation time for the vacuum achievement. In the wafer thermal processing equipment, although operation which heats, carries out the monitor of the temperature of a wafer, and is adjusted to the target temperature is usually performed, the behavior without feedback of heating mechanism is the open loop characteristic. The most fundamental example of the open loop characteristics is the temperature rise characteristic at the time of beginning to switch on fixed electric power, indicial response characteristic.

On the other hand, an example of the closed loop characteristics is shown in the characteristic with the temperature control in temperature adjustment functional-related area. The most popular characteristics for gas pressure adjustment functional-related case is APC (Automatic Pressure Control). For example, the degree of fidelity to setting pressure, the range for set up, and response to disturbance etc. are typical closed loop characteristics.

Any sub item is described in almost same concept from a performance metrics-criteria viewpoint. That is, fidelity, stability, repeatability, calibration, a control range, etc.

The items on horizontal may need to be replaced or to be changed for combination depending on equipment type. The performance metrics axis has aimed to be used without being exchanged by the equipment type. It is because it is important to show the similarity of the requirement of device manufacturers about performance data items and data granularity which get strong interest from device manufacturers. The interest of device manufacturers regarding QA data submission is expressed by the table mentioned above, and can be shown to equipment suppliers.

Equipment Functionality Confirmation	Mechanical Performance	Fidelity
		Stability
		Repeatability
		Transient Response
		Calibration
		Zero adjustment
		Control Range
	Electrical Performance	Fidelity
		Stability
		Repeatability
		Transient Response
		Calibration
		Zero adjustment
		Control Range
Process Set Up Capability Performance Confirmation	Process Set Up & Execution Performance (Open Loop Characteristics)	Fidelity
		Stability
		Repeatability
		Transient Response
		Calibration
		Zero adjustment
		Control Range
	Process Set Up & Execution Performance (Closed Loop Characteristics)	Fidelity
		Stability
		Repeatability
		Transient Response
		Calibration
		Zero adjustment
		Control Range
Process Execution Capability Performance	Response to parameter settings (equipment internal constants)	Response over entire range
		Fidelity
		Stability
		Repeatability
		Transient Response
		Calibration
		Zero adjustment
		Specification Achievement
	Response to parameter settings (Recipe Settings)	Response over entire range
		Fidelity
		Stability
		Repeatability
		Transient Response
		Calibration
		Zero adjustment
		Specification Achievement

Table 5 Performance Metrics Example

7. EEQA Checklist Example

An equipment supplier will start with the execution plan proposal of QA data responding to the interest of device manufacturers mentioned above as well as their original proposal. The final QA proposal from equipment suppliers do not need to be shown in the EEQA checklist format described above, The correspondence state to the demand. However, since it is necessary for device manufacturers to check the response from suppliers by the EEQA checklist format, in the process which reaches agreement between a device manufacturer and an equipment supplier, EEQA checklist concept will be used inevitably.

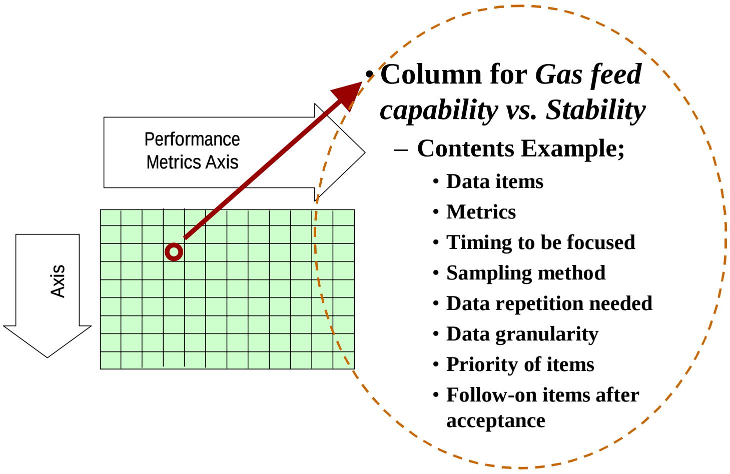


Fig. 13 EEQA Checklist as a Jump Table for QA Contents

Since the users' interest shown in their request for QA data need to related with the execution proposal of QA, in this case, EEQA checklist plays the role of the "jumb table" for QA. (Figure 13)

7.1. Characteristic Metrics Example

Figure 14 to figure 16 show the example of the QA contents corresponding to the sub items and further. It corresponds to evaluation function, temperature control function (electrostatic wafer chuck function), and equipment front end module function (300mm fixed buffer type), respectively. Each figure describes concrete contents for the categories of "electrical performance", "open loop performance", "closed loop performance" etc so that readers can easily understand.

- Electrical performance
  - Valves operate as instructed
  - Vacuum gauges are calibrated
  - Pumps operate as instructed
  - Check interlock action
- Mechanical performance
  - Valves are confirmed to open and close
  - Pumps are installed not to generate vibration
- Open loop performance
  - Evacuation speeds to be confirmed
  - Leak rates to be confirmed
  - Ultimate vacuum pressures to be confirmed
  - Cryogenic panel temperature rise upon gas loading to be confirmed within the specified range
- Closed loop performance
  - Automatic pressure control
    - Check fidelity of measured pressure values against setting values along with valve opening value
  - Gas pressures
    - Gas pressures against gas flow rates for linearity and fidelity
- Confirmation of equipment constants (outside of recipe control)
  - Fidelity of control point values
    - Check control point value for the rough and high vacuum cross-over
    - Check build-up rate critical value for cryogenic pump regeneration procedure
- Fidelity to recipe
  - Check if gas pressure changes as the recipe specifies

Fig. 14 QA Contents Example (1)

- Electrical performance
  - Resistivity check of heater elements
- Mechanical performance
  - NA
- Open loop performance
  - Temperature response under a constant condition
    - In functions of time, installation, electrical power, ambience
    - Step response
  - Confirmation of indications, meters, gathered data
- Closed loop performance
  - Step response between setting points
    - Test wafer with T/Cs
  - Step response upon backside gas introduction
  - Wafer temperature profile repeatability and fidelity
- Confirmation of equipment constants (outside of recipe control)
  - Check fidelity to the equipment constants
    - such as deposition shield temperatures
- Recipe control performance
  - Fidelity to recipe description, transient characteristics repeatability
    - Under plasma energy bombardment condition

Fig. 15 QA Contents Example (2)

•EFEM case (*300mm Fixed Buffer* type)

- Electric characteristics
  - Motor runs
  - Fluorescent lamp shines
  - Wafer sensors sense wafers
  - Down flow sensors sense down flow
  - Interlock functions accordingly (such as E84)
- Mechanical characteristics
  - Teaching done accordingly
  - Operation speeds confirmed specification
  - Wafer placement accuracy confirmed
  - FOUP opener speed confirmed
  - Wafer orientation function confirmed
  - No wafer breakage
- Open loop function
  - N/A
- Optional functions
  - Orientation On/Off selection confirmed
  - Wafer ID read On/Off selection confirmed

Fig. 16 QA Contents Example (3)

7.2. Detailed Example of EEQA Contents

Table 6 is an example showing the detailed methods of execution QA data about high level equipment functionality performance with practical data collected. The contents of Table 6 in evaluation capability shows the detailed conditions at the time of measuring some of the function performances, precondition, data granularity, etc. The table also shows data form and the number of measurement time.

Table 6 Details of EEQA Contents Example

Capability Performance		Measurement Items	Precondition or ambience	Measurement Methods		Data Form			Data Referred				Points of Interest					
Category	Contents			Methods, instrument or referenced data	Data granularity and like	Numeric	Graph	# of data points	Standard Eq. at eq. supplier	Same model eq. at device maker	Design values	Part's specification	Stability	Repeatability	Fidelity	Machine-to-Machine difference	Chamber-to-Chamber difference	Individual part difference
Evacuation Capability	Pressure gauge calibration such as vacuum gauge	Environment temperature	Ambient temperature			√		N>=2	√			√	√					√
		Display value fidelity to measured values		Instrument used for calibration	Mating data granularity to the gauge	√		N>=1							√			
		Exported data value fidelity to measured values			Mating data granularity to the display	√		N>=1							√			
	Vacuum Gauge Stability	Zero point drift	Ambient temperature	Zero pressure set-up, measurement period			√	N>=10	√			√	√					√
Evacuation Capability	Evacuation speed characteristics in each evacuation subsystems	Gradient of logp/logt at time=0 to be measured	Installation such as exhaust pipe line	Chamber volume and vacuum gauge	Better than 0.5 sec resolution Data precision in accordance in vacuum gauge	√	√	N>=5 > 1	√	√	√					√	√	
	Vacuum pump dynamic characteristics	Electric current	Previous maintenance date	Measure pumping down from atmospheric pressure	Better than 0.5 sec resolution Data precision in decimal digit number		√	N>=5 > 1	√	√	√							√
Evacuation Capability	Ultimate pressure	Pressure	Atmospheric exposure time and any parts replacement in the vacuum chamber	Chamber volume and vacuum gauge	10 sec resolution Data precision in accordance in vacuum gauge	√	√	N>=5 > 1	√	√	√					√	√	
	Pumping cross over pressure	Confirmation of set value for cross over	Normal predefined sequence	Read from pump down urves	Data precision in decimal digit number of 2	√	√	N>=5 > 1	√	√	√					√	√	

It is also shown what data should be compared as QA data in the column of data referred. The most important comparison reference value is a design value. Even if the provided value is within the permitted range of the characteristic value, when the same type equipment has been already supplied to the device manufacturer, the new characteristic value comparison with the existing equipment is important for a device manufacturers in many cases.

It is also significant in many cases to compare EEQA data with the characteristic value of the standard equipment which the equipment supplier owns. EEQA enables equipment suppliers to grasp the equipment capability performance numerically, and to understand precisely about design improvement, and the change of the characteristic by equipment installation status.

The table 6 also includes points of interest column at the right side to show the relation with purpose at performing measurement. The most important message appears in the particle granularity and data points in Table 6. It is important that the equipment function capability is supported by the scientific data along with the purpose of QA, i.e. data granularity and data points. In many cases the QA data of equipment capabilities achieved through sufficient number of times of electronic measurement methods precisely is highly marked than the current running equipment. Also it is a common requirement of the device manufacturers that the data of equipment capability performance without equipment failure needs to be submitted. An equipment supplier confers with a device maker about EEQA to the last, Table 6 should be created based on the consensus on EEQA between equipment manufacturer and device manufacturer and measurement items should be selected corresponding to the actual equipment, and the measuring methods also should be practical ones.

Other detailed QA contents are to be referred in “EE Data Practical Use during Equipment Operation" in Chapter 9.

8. EEQA Checklist

8.1. EEQA Item Checklist for Equipment Purchasing (issued by users)

This chapter explains further about the EEQA checklist described in Chapter 7. The EEQA checklist is first disclosed to equipment suppliers as users requirements of enhanced equipment QA.
This form is distinguished from the one proposed by equipment supplier for the agreement with device manufacturers (refer to Chapter 8.1). The former checklist may be called "EEQA Item Checklist for Purchasing Equipment (issued by users)" and the latter may be called "EEQA Item Checklist for Delivery Equipment (issued by suppliers)".

The EEQA check list described in the foregoing paragraph is related to the process condition set-up capabilities. However, the process set-up capability/ execution function of equipment is also the object of the enhancement equipment QA. The process capability performance which depends on the process condition of device manufacturers is also the object of QA although this guidebook does not include it as a scope. It is necessary to get a consensus between device manufacturers and equipment suppliers on what QA should be done for process capability performance.
Table 7 summarizes total QA demands for the performance of process set-up capability/execution function of equipment collectively. This list is used as a supplement to the purchase order specification form which is prepared by device manufacturers and given to equipment suppliers at the new equipment purchase. With this form the device manufacturers request equipment suppliers about the concrete confirmation items and the way of data submission in detail.
.
The horizontal axis of the table shows the example of the function of equipment. The 2nd line and the 3rd line are expected to be filled in about function parts and further detail items by parts respectively. The equipment suppliers are expected to fill in those items specifically with their decomposition of items, determination, and concrete description of the contents.
A vertical axis is categorized into three major items in order to check the basic performance metrics of equipment in phases. The three major items include; equipment base functionality confirmation, process et-up capability performance confirmation, and process execution capability performance. These major items are subcategorized by function.

- The equipment base functionality confirmation is divided into mechanical performance and electrical performance.
- The process et-up capability performance confirmation is divided into process set-up & execution (open loop characteristics) and process set-up & execution (closed loop characteristics).
- The process execution capability performance is divided into response to parameter settings (equipment internal constants) and response to parameter settings (recipe internal constants)

Table 7 Example of EEQA Item List Presumably Issued by Equipment User

		Capabilities and Services	EFEM capabilities incl. load ports and wafer handler	Wafer handling in process and transfer modules	Vacuum generation	Process gas supply	Process pressure generation	Process temperature generation	RF energy supply	Material supply	Miscellaneous capabilities	Fail-Safe func.
		May be used for equipment functional portions										
		May be used for further categorization										
Base functionality confirmation	Mechanical performance	Fidelity										
		Stability										
		Reproducibility										
		Transient characteristics										
		Calibration										
		Zero adjustment										
		Control coverage confirmation										
	Electrical performance	Fidelity										
		Stability										
		Reproducibility										
		Transient characteristics										
		Calibration										
		Zero adjustment										
		Control coverage confirmation										
Process condition set up capability confirmation	Performance as open loop characteristics	Fidelity										
		Stability										
		Reproducibility										
		Transient characteristics										
		Calibration										
		Zero adjustment										
		Control coverage confirmation										
	Performance as closed loop characteristics	Fidelity										
		Stability										
		Reproducibility										
		Transient characteristics										
		Calibration										
		Zero adjustment										
		Control coverage confirmation										
Processing execution capability confirmation	Response characteristics to equipment constants	Fidelity										
		Stability										
		Reproducibility										
		Transient characteristics										
		Calibration										
		Zero adjustment										
		Achievement of designed performance										
	Response characteristics to recipe settings	Fidelity										
		Stability										
		Reproducibility										
		Transient characteristics										
		Calibration										
		Zero adjustment										
		Achievement of designed performance										

Overall Equipment Performance	Equipment physical size	Physical sizes and utility joint locations to specification	
	Equipment physical configuration	Appearance and physical organization of equipment	
	Production performance	throughput	
	Cleanness	Particle generation	
	Metallic contamination	Contamination by concentration of Al, Fe, Na, Cr, ...	
	Reliability	MTBF	
		MTBI and else	
	Installation environment dependent performance	Evacuation speed, cooling performance, ...	
		Noise immunity and else	
	Utility	Electric energy consumption, gas, chemicals, etc....	
		Coolant consumption and else	

In each subcategory action for equipment is reviewed by the following perspectives and the confirmation items are expected to be indicated in the table.

- Fidelity
  Difference with a setting value (time function)
- Stability
  Variation to the time-axis to the value in a stable state
- Repeatability
  Variation to the value(time function) when the same processing is repeated)
- Transient response
  Action in the transient state which can not be set up
- Calibration
  Correction added on purpose to adjust performance from outside
- Zero adjustment
  Adjustment of a staring point position
- Control range
- Confirmation of control range when equipment adjustment is done

Moreover, in the columns of overall equipment performance and process performance at the bottom of the table, it is expected to fill in the items for check and measurement after equipment design or equipment manufacturing.

Based on this list, "EEQA Item Checklist for Purchasing Equipment (issued by users)" and "EEQA Item Checklist for Delivery Equipment (issued by suppliers)" are created. After the equipment suppliers and device manufacturers agree on the lists, the actual QA work will be executed.

8.2. EEQA Item Checklist for Equipment Delivery (issued by suppliers)

This checklist is attached to the delivery equipment specifications from equipment supplier to device manufacturer at the time of equipment delivery with detail information about confirmation items by equipment manufacturers when they manufacture and install the equipment.

The draft checklist will be discussed between equipment supplier and device manufacturer and the equipment manufacturer is expected to submit the final version of the checklist based on the agreement through the discussion with device manufacturer. QA work will be done for the items marked in the checklist and the request and availability of actual data, reference values, data acquisition method will be filled in “EEQA Item Checklist for Delivery Equipment (issued by suppliers). Table 8 is an example for dry etching equipment with the description of the parts module and parts detail.
The equipment supplier indicates the items of this table which should be checked, fills “EEQA Item Checklist for Delivery Equipment (issued by suppliers)” form, then execute QA work both before the time of delivery and at the delivery /installment of the equipment to device manufacturer.

Table 8 Example of EEQA Item List Presumably Issued by Equipment Supplier (Etcher case)

Capabilities and Services			EFEM capabilities incl. load ports and wafer handler					Wafer handling in process and transfer modules									Vacuum generation						Process gas supply								Process pressure generation	
Location on equipment			Load port		Wafer handler	DID reader			Load lock		Transfer chamber			Process chambers			Load lock		Transfer chamber		Process chambers		Load lock chambers			Transfer chamber		Process chambers			Process chambers	
Detailed location on equipment / Performance Metrics			Loader	FOUP opener	Wafer handling arm	FOUP ID reader	Wafer ID reader	Door	Wafer position sensor	Gate valve	Wafer handling arm	Wafer folk	Gate valve	Wafer pusher pin	Process stage	Process stage hoist	Vacuum gauge	Leak check apparatus	Vacuum gauge	Leak check apparatus	Vacuum gauge	Leak check apparatus	Mass flow controllers	Gas manifold	Venting apparatus	Mass flow controllers	Gas manifold	Mass flow controllers	Gas manifold	Gas showering apparatus	Automatic pressure control	Gas pressure gauge
Base functionality confirmation	Mechanical performance	Fidelity																														
		Stability																														
		Reproducibility																														
		Transient characteristics																														
		Calibration																														
		Zero adjustment																														
		Control coverage confirmation																														
	Electrical performance	Fidelity																														
		Stability																														
		Reproducibility																														
		Transient characteristics																														
		Calibration																														
		Zero adjustment																														
		Control coverage confirmation																														
Process condition set up capability confirmation	Performance as open loop characteristics	Fidelity																														
		Stability																														
		Reproducibility																														
		Transient characteristics																														
		Calibration																														
		Zero adjustment																														
		Control coverage confirmation																														
	Performance as closed loop characteristics	Fidelity																														
		Stability																														
		Reproducibility																														
		Transient characteristics																														
		Calibration																														
		Zero adjustment																														
		Control coverage confirmation																														
Processing execution capability confirmation	Response characteristics to equipment constants	Fidelity																														
		Stability																														
		Reproducibility																														
		Transient characteristics																														
		Calibration																														
		Zero adjustment																														
		Achievement of designed performance																														
	Response characteristics to recipe settings	Fidelity																														
		Stability																														
		Reproducibility																														
		Transient characteristics																														
		Calibration																														
		Zero adjustment																														
		Achievement of designed performance																														

8.3. EEQA Contents Captured in EEQA Checklist for Equipment Delivery

It is necessary to decide on concrete items, reference values, and data acquisition method for the items marked in "EEQA Item Checklist for Equipment Purchasing (issued by users)". The attribute for actual check items is decided by the equipment function. The attribute is categorized, for example, into equipment related, vacuum related, gas related, temperature related, RF related, subsystem related etc. Through the continuous examination about the attribute, it is expected that concrete items, reference values, and the data acquisition method will serve as common contents for equipment suppliers and will be accumulated as operating knowledge for equipment supplier. It is expectable that the knowledge of the QA method corresponding to improvement in equipment reliability etc. is accumulated at the device manufacturers through enhancement of QA by EEQA simultaneously. This will bring an improvement of business advances on a scale of the industry.

The table 9 is another example of EEQA detailed contents.

Table 9 Example of EEQA Detailed Contents

Function/Performance				Measurement method		Form of data			Referencing									
Category	Item	Measurement items	Measurement conditions/environmental conditions	Instrument and/or combined data	Data granularity	Data values	Graph	# of data points	E/S owned calibration standard equipment	D/M owned same type equipment	Design value	Subcomponent specification	Stability	Repeatability	Fidelity	M-to-M difference	Ch-to-Ch difference	Individual difference
Evacuation Capability	Calibration of pressure (vacuum) measurement devices (such as vacuum gauge)	Pressure (all ranges)	ambient temperature	Calibration history and instrument	Data granularity that matches to that vacuum gauge under			N>5					:-(					:-(
		Fidelity of data displayed on the panel			Data granularity that matches to that data display device			N>=1										
		Fidelity of data transmitted out of equipment			Data granularity that matches to that vacuum gauge under QA			N>=1										
	Stability of pressure measurement	Zero drift characteristics	ambient temperature	How zero pressure is made in what measurement term	Same as above			N>10					:-(					:-(
	Evacuation speed characteristics in each of evacuation systems	Extrapolated from log P / t gradient at time=0	Installation condition	Chamber volumes, vacuum gauges	Time domain: better than 0.3sec granularity Pressure values: granularity that matches the vacuum			1<N<5										
	Pump dynamic characteristics	Electric current		From onset of atmospheric pressure	Time domain: better than 0.5sec Current: better than 2 decimal			1<N<5										
	Ultimate evacuation pressure	(Vacuum) pressure	Previous chamber condition: such as atmospheric pressure exposure time	Chamber volumes, vacuum gauges	Granularity that matches to the pressure measuring device	:->	:->	1<N<5										
	Pumping cross over pressure	Cross over pressure set point confirmation	Normal sequence	Read from pumping curve	2 decimal digits			1<N<5									:-(	
Pressure control capability	Calibration of pressure measuring	*omitted*																
	Stability of pressure measurement device	*omitted*																
	Open loop characteristics (valve opening linearity	Valve opening angle and/or control setting vs. chamber pressure relation	Installation condition, exhaust , MFC status	equivalent at 10%FS, 50%FS, 90%FS	Time domain: better than 0.3sec granularity Pressure values: granularity that matches the vacuum gauge	:->	:->	N>=1	:-(	:-(	:-(						:-(	
	Closed loop characteristics (Indetial response)			equivalent at 10%FS, 50%FS, 91%FS with gas flow levles as		:->	:->	N>=1	:-(	:-(	:-(		:-(				:-(	
	Robustness to disturbance			Supply gas pressure variation	Dynamics needs to be captured within 0.3 sec granularity	:->	:->	1<N<5	:-(	:-(	:-(							
Gas flow control capability	Flow controller valves operation timings (if applicable)	Valve opening and closing timings vs. MFC control timings	Assumption be made appropriate MFC operation is being done as quoted in the left column					N>10	:-(	:-(	:-(							
	Closed loop characteristics (Indicial response)	Valve opening angle and/or control setting vs. chamber pressure relation	Supply gas pressure needs to be kept constant For low vaporization pressure gases, vaporization needs to be	Calibration curves '@10%FS, 50%FS 90%FS vs. gas flow levels Indicial response needs to be predefined @zero start and intermediate flow	granularity Pressure values: granularity that matches the vacuum gauge	:->	:->	1<N<5	:-(			:-(	:-(	:-(	:-(			:-(
	Robustness to disturbance	Gas flow rate		Supply gas pressure variation	Dynamics needs to be captured within 0.3 sec granularity						:-(	:-(	:-(					

9. Practical Use of EE Data during Equipment Operation

The time of equipment operation covers from the production start through operation cessation in the life cycle for semiconductor process equipment as shown in Figure 17. It is expected that EE data is utilized in various stages of semiconductor device manufacturing the equipment was handed over from the equipment suppliers to the device manufacturer. Although considerable EEQA efforts already starts from the equipment designing stage in the equipment supplier regime, this chapter focuses on the role of equipment suppliers during above-mentioned period for the utilization of EE data from a device manufacturer's viewpoint.

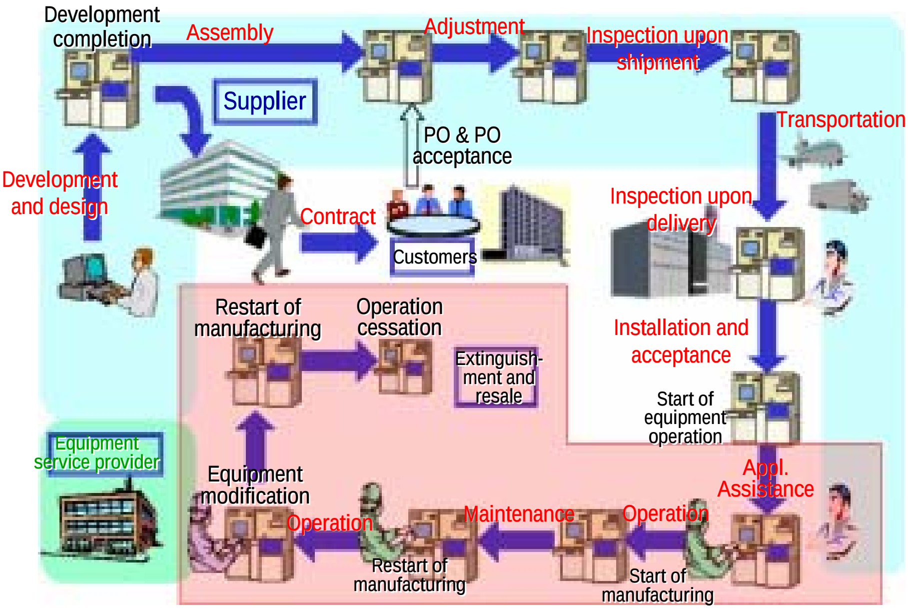


Fig. 17 Life Cycle for Semiconductor Process Equipment (translation version of SEAJ's EES Business Model Study Report)

9.1. Utilization of EE Data during Equipment Production Period

The equipment supplier can accumulate the basic EE data of each part of the equipment by the continuous EE data acquisition through regular maintenance during semiconductor device manufacturing period even after the equipment is handed over to the device manufacturers. The utilization of EE data brings the equipment suppliers the information of the exchange time / life information on a component and spare parts. By feeding this back to an equipment design, it enables to develop equipment with more high reliability and performance.

9.2. Utilization of EE data at the time of equipment maintenance / repair

At the regular equipment maintenance and expected or unexpected repair, EE data can be utilized. The conventional equipment heavily depends on experience of a maintenance executor and the restoration state of equipment is not necessarily uniformed.

Moreover, repair works sometimes require the skill of design levels, including the machine state of equipment, internal state of software, and check of log-in information such as event information.
This procedure may cause longer repair time because of different level of maintenance operator's skill or fall of reliability because of the repair of equipment by misjudgment. By utilizing EE data, the analysis of troubles and the quality of finished maintenance work can be judged with fixed quantity data. Thereby, these kinds of work can be standardized and it leads to shortening and load reduction of working hours.

9.3. Utilization of EE Data at Modification of Equipment

The utilization of EE data at modification of equipment is similar to the method of EE data at the time of new equipment installment. The variation of equipment performance and the change in characteristics of equipment parts with time are perceived quantitatively from difference by comparison of the collected data with reference data or comparison of EE data between each equipment.

The improvement and modification of equipment based on this information, the reliability and mechanical performance can be achieved. Moreover, it is applicable also to verification of the equipment performance after improvement by comparing EE data acquired after the improvement with reference data.

9.4. Utilization of EE Data at Disposal of Equipment (Relocation)

Due to the increase of equipment cost along with advanced performance and function of equipment, the demand for used equipment is increasing. The cases which the increase

The hardware / software specification as well as the current situation of used equipment is able to confirm, however it is not possible to know how the equipment has been used and how good performance is.

Then, by utilizing EE data accumulated during equipment operation at the time of equipment disposal or relocation, EE data will play the role like a chart of equipment, and will point to the history of an equipment state, or the present state. Moreover, if the current status of equipment is merged with reference data, the equipment can be back to its initial state, therefore, equipment supplier will be able to sell the used equipment as value-added equipment.

10. Appendix

10.1. Glossary

Automation technology
In manufacturing, “automation” refers to replacement by equipment which substitutes for human work except for the portion for which needs advanced judgment and advanced technique by human. Automation technology refers to necessary methods or the development of the methods to materialize the automation.

Closed loop characteristics
Characteristics of a system that has an output variable measured and compared with the target value in order to acquire the deviation from the target value and that deviation is fed back to the system so that the system adjusts the output value with the minimized deviation. The system characteristics may be described as a response to the stepwise change in the target value or in the measured value; such response is called the indicial response.

Direct process condition preparation function
In this guidebook, the function which creates processing conditions acting to a wafer directly in a process preparation function.

ECM: Engineering Chain Management.
The management method which applied to the management method of supply chain management (SCN) to the flow of thinking or skill using the model replaced with functional ability.

e-Diagnostics
The remote diagnostic solution for semiconductor manufacturing equipment operation improvement.

EE data: Equipment Engineering Data
The data used in EEC in a broad sense. Generally refers to the data obtained from equipment. There are three kinds of categories, DEE (Detail equipment event), trace data (analog collection data), and context data (setting data on equipment including static data and dynamic data), and it has a close relation mutually respectively.

EEC: Equipment Engineering Capabilities
A function or capability required for the various equipment management and operation improvement which are realized using EES.

EEQA Checklist
The information medium which carried the items of the EEQA and contents.

EEQA: Enhanced Equipment Quality Assurance
Quality assurance (QA) of equipment performance lined with electronic data in this guidebook.

EES Applications:
Equipment management and quality control applications using EE data. APC, equipment / process FDC, an equipment failure detection function, etc. are included.

EES: Equipment Engineering System
The system of the equipment management proposed by JEITA and Selete as a system which improves operation of equipment suppliers, and semiconductor device

manufacturing by freeing from the conventional technique of performing equipment management based on equipment information with much restriction collected by host system, and grasping and managing the original function of equipment based on the data in which various equipment states are shown.

Electronic data
Data recorded on a computer or data formatted to be reused about the equipment operation and management report recorded on the paper conventionally. EE data etc

e-Manufacturing
The manufacturing system that enables enhanced production management, quality management, and performance management in product manufacturing by utilizing advanced information technology.

Equipment
All equipment related to semiconductor manufacturing process, inspection, and transport, etc.

Equipment basic performance
Performance of the fundamental function of equipment.

Equipment difference
Generally it refers to the difference between the equipment of the same model and the same function. With Equipment QA, it also may refer to the difference between the modules (process chamber etc.) of the same specification in equipment and the same function.

Equipment failure detection function
The application function which fixes the unusual state or unusual part of equipment, making full use of EE data, especially equipment detailed event, and analog trace data, etc in this guidebook. One of the equipment FDC functions.

Equipment life cycle
Generally it refers to a cycle from the time of products coming into market till sales stop. In this book, it refers to a concept which includes even the improvement cycle to design development stage and the next generation equipment by the feedback from a market further.

Equipment QA
The assurance about the quality of semiconductor manufacturing equipment itself (hardware, software) in this guidebook.

Equipment QA Enhancement
The activity which performs objective QA for quality assurance of equipment based on the scientific basis rather than on the present condition in this guidebook.

Evaluation axis
The axis of an index in which the data acquired for EEQA is evaluated objectively.

Evaluation of performance
It refers to evaluation work after processing work for devices finish to check how much correctly the process is done to meet with requested specification.

FDC: Fault Detection & Classification.

Detection and classification of abnormalities. Originally, FDC meant detection of abnormalities in semiconductor process manufacturing. Since the abnormalities in process closely relates to equipment hardware and control system, the scope of the FDC has widen to cover whole semiconductor device manufacturing instead of limit to process insufficiency. Since C can read it as "Control" and may be used, cautions are required.

Fidelity
Generally, defined as "carrying out truly and correctly". In this guidebook it refers to the degree of how much differences there are to the directions value or the fixed setting value the candidate for observation in the recipe etc. (Refer to Fig. 18).

Functional ability
Refers to the performance of function in this guidebook.

Functional axis
The axis in the table that enumerates the equipment functions required to be inspected for EEQA data collection in this guidebook.

Functional parts
The structure / mechanism parts which bring about a certain action alone.

Fundamental function of equipment
Equipment functions other than processing function such as transport of wafer and maintenance of vacuum degree of processing room. (= equipment basic function).

GJG: 300 mm Global Joint Guidance.
GJG related to automation in semiconductor device manufacturing. Originally GJG was developed by International 300mm Initiative (I300I) and J300 of Japan collaboratively as guideline of equipment automation in 300mm wafer factories. GJG also refers to the guidelines developed by International SEMATECH(ISMT), Japan Electronics Information Technology Association (JEITA), and Semiconductor Leading Edge Technologies (Selete) based on the original GJG.

Hypothetical standard process
The standard process which serves as a basis for common phenomenon does not necessarily match the actual handling process of device manufacturing.

International SEMATECH/JEITA/Selete Collaboration Guideline
As international cooperation after GJG, the guideline about communication control of 300mm equipment basic function developed by JEITA, Selete, and International SEMATECH.

MES: Manufacturing Execution System.
The computer system which performs manufacturing progress management of a semiconductor device manufacturing process.

MTTR: Mean Time Trouble Repair.
The average failure return time. MTTR is usually used with MTBG(Mean Time Between Failure) which means average failure interval in many cases.

Open loop characteristics
Refers to the characteristic in case return control of the specific function in equipment is not performed.

Performance
Generally it refers to good thing of completion. In this book, it comprehensively refers how much the device manufactured with the equipment satisfy specification.

Performance capability
The capability which determines performance in this guidebook.

Platform
The base-environment using computer related to both hardware and software in this guidebook.

Preparation
Refers to comprehensive work/operation which prepares the process environment required for semiconductor processing such as preparatory plans and product process preparations (seasoning etc.) of equipment, and also refers to the work/operation which carries a wafer into such an environment.

Preparation function
The function which should be loaded in equipment or related system in order to realize "preparation".

Process execution functions
The functions or complex of functions that are used to perform semiconductor fabrication process execution.

Process progress management
It checks in what state the target product has set to the production schedule, and judges what disposal should be carried out based on the state based on the manufacturing flow. One of the typical functions of MES.

QA: Quality Assurance

QA Contents
The concrete methods and results of the items carried out for quality assurance of the relevant equipment.

QA data (Equipment QA data)
The data related to quality assurance of semiconductor manufacturing equipment in this guidebook.

QA item
The management items required for quality assurance of equipment in this guidebook.

QA operations
Overall operations related to quality assurance of equipment.

QA proof data (QA performed data)
The real acquisition data which supports QA performance.

QA works
The operations and activities for quality assurance such as data acquisition carried out with the actual equipment.

Recipe
Recipe generally refers to a prescription or a recipe. In semiconductor manufacturing, it refers to the process execution conditions of processing equipment.

Repeatability
Generally defined as "A certain state appearing again". It refers to the variation in a value (time function) when the action for observation repeats the same processing (Refer to Fig. 18).

Running base
The state grasp based on real operation state in this guidebook.

SOC: System on Chip.
The concept to load the high value added system such as communication tools and information appliances directly on a silicon chip, and complete as a unit of device instead of set.

Spot observation sensor
Sensor for observing the "state of a place" where the reaction for wafer processing, such as inside of process chambers at the time of process execution, has occurred.

Stability
The variation over the time-axis to the value in the stable state for observation.
Refer to Fig.18.

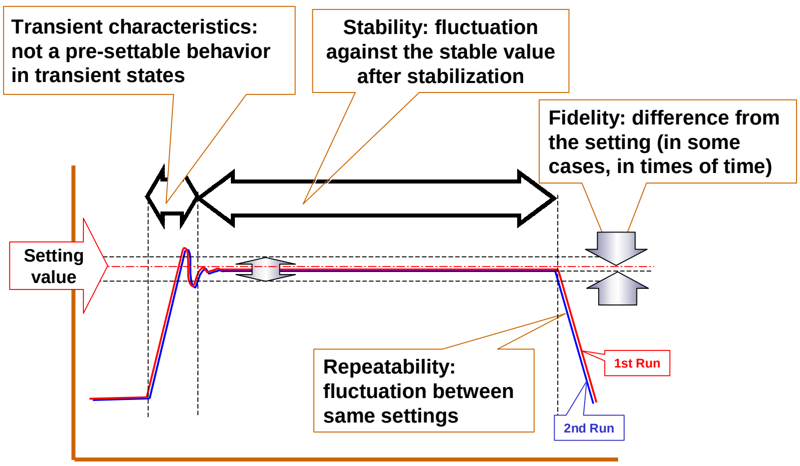


Fig. 18 Transient/Stability/Repeatability/Fidelity

System Implementation of EES
The phenomenon carried as a functional node of a factory management system or a function on equipment by using EES as a functional system in this guidebook.

The dispatching technology
The technology of performing optimal delivery management of not only semiconductor manufacturing process but the general manufacturing processing. Technology indispensable to the physical distribution optimization for delivery assurance and product manufacturing.

Transient characteristics

Refers regularly to the state change during transition. In this book, it refers to the action for observation in the transitional state where it cannot set up. (refer to Fig. 18).

Visualization
Refers to changing what is concealed and unable to be recognized under the usual state into the situation where it can be recognized by a certain technique.

10.2. Acronyms (as of March 2004)

ASPLA: Advanced SoC Platform Corporation
URL = http://www.aspla.com/

FITWG: Factory Integration Technology Working Group

ISMI: International SEMATECH Manufacturing Initiative, Inc.
URL = http://www.ismi.org/

ISMT: International SEMATECH
URL = http://www.sematech.org/

ITRS: International Technology Road Map for Semiconductors

JEITA: Japan Electronics and Information Technology Industries Association
URL = http://www.jeita.or.jp/

SEAJ: Semiconductor Equipment Association of Japan
URL = http://www.seaj.or.jp/

Selete: Semiconductor Leading Edge Technologies, Inc.
URL = http://www.selete.co.jp/

SEMI: Semiconductor Equipment and Materials International
URL = http://www.semi.org/

STRJ: Semiconductor Technology Road Map technical committee of Japan
URL = http://strj-jeita.elisasp.net/strj/

10.3. Contact Information (as of March 2004)

For more information about this guidebook or referenced material, please contact the following.

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Selete: Semiconductor Leading Edge Technologies, Inc.

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