EPSON
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Seiko Epson Semiconductor Product Quality Assurance Guidebook

SEIKO EPSON CORPORATION

Rev.1.5

NOTICE

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1. QUALITY MANAGEMENT SYSTEM CERTIFICATION

Seiko Epson's Semiconductor Operations Division has attained and maintain ISO 9001:2000 and ISO/TS 16949 certification.

Company	Certification	Attained
Seiko Epson, Corp. (Semiconductor Operations Division)	ISO9001: 2000	Initial certification: 10 October, 1993
	ISO/TS16949	Initial certification: 9 May, 2006

2. QUALITY ASSURANCE SYSTEM

Quality assurance for new product development

From planning and development to design, prototype production, mass production, and delivery, Seiko Epson has established a system to review quality at key points to precisely identify customer requirements and provide quality products in a timely manner. These quality reviews are incorporated into activities to maintain and improve product quality. The company's quality assurance system is illustrated on the following page.

- Planning and development stage

  Quality assurance starts with listening to customer comments at the planning and development stage. The product takes shape as the performance, reliability, and delivery schedule demanded or expected by customers and the market are promptly and accurately identified. Aspects such as circuit technology, manufacturing technology, manufacturing capacity, and quality assurance are all examined from various perspectives.

- Design stage

  In the subsequent design phase, we maintain close communications with the customer to ensure the incorporation of customer requirements into design work. Design work incorporates past circuit data, process data, quality data, and field information. To ensure high quality design, design rules play an ever-increasing role in each aspect of design, including circuit design, pattern design, process design, package design, and reliability design.

- Prototype production stage

  Once design is complete, work shifts to prototype production. But designs must be verified before the start of prototype production. This involves FMEA in the prototype phase to evaluate latent effects. A meeting is held to present and discuss analysis results, allowing the multi-functional team assembled from the various sections involved to examine them from various perspectives. The points and issues to be evaluated during prototype production are identified here before a decision to proceed with prototype production.

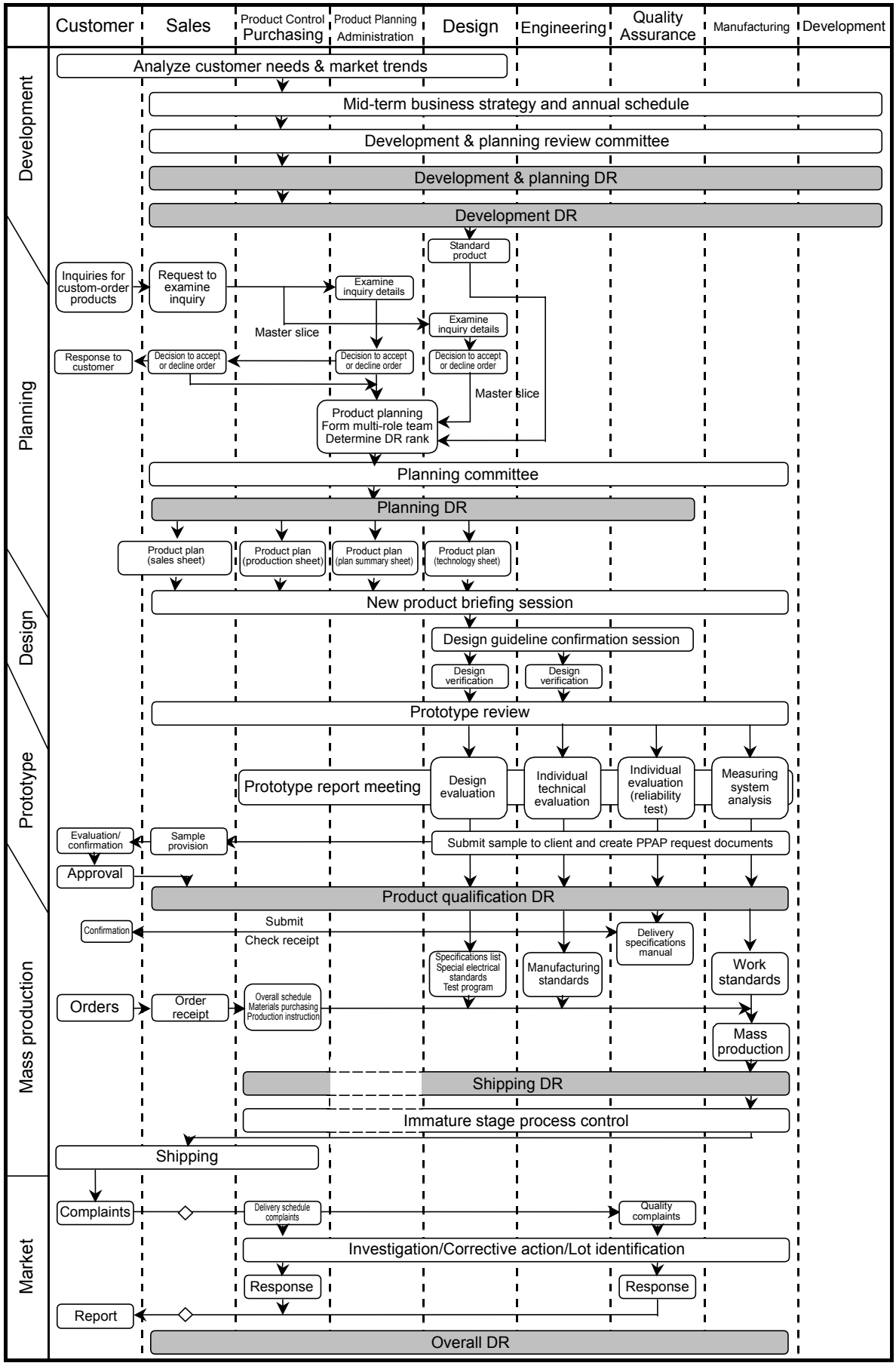
- Before mass production

  Products are subjected to approval review based on prototype evaluation results, in-house design verification, and reliability tests, etc., as well as the results of customer evaluations, when necessary. Mass production can begin once product qualification has been granted in the product qualification DR. Evaluations are performed at approved test facilities in accordance with Seiko Epson qualification criteria.

- Mass production stage

  The overall quality system is reviewed by monitoring and reviewing initial quality using immature stage process control where necessary during the mass production phase, ensuring continued improvements in the quality management system.

Quality Assurance System Diagram



The main points of the Seiko Epson quality assurance system are described below.

Design verification (FMEA)

To help prevent latent defects, FMEA is used in design verification for products with a significant proportion of new technology elements. FMEA is used in both process design (PFMEA) and product design (DFMEA) and helps build in-house knowledge while streamlining work procedures.

Design evaluation test facility control

Seiko Epson design evaluation is undertaken at approved test facilities. The equipment used in evaluations must be calibration controlled in the same way as equipment used in production. It's also subject to measurement system analysis (MSA). Evaluation staff are registered to ensure accurate evaluation results.

Problem experience

Details of past problems and experience in dealing with problems are maintained in a database to prevent recurrence. This database is used to determine check points when developing new products and launching similar products. Confirmation of check points extracted from this database is a DR requirement.

Immature stage process control

Immature stage process control is applied when necessary to monitor full productivity by confirming that the initial requirements are met in the early stages of mass production run. These activities ensure a stable run of mass production products at an early stage.

Product safety assurance

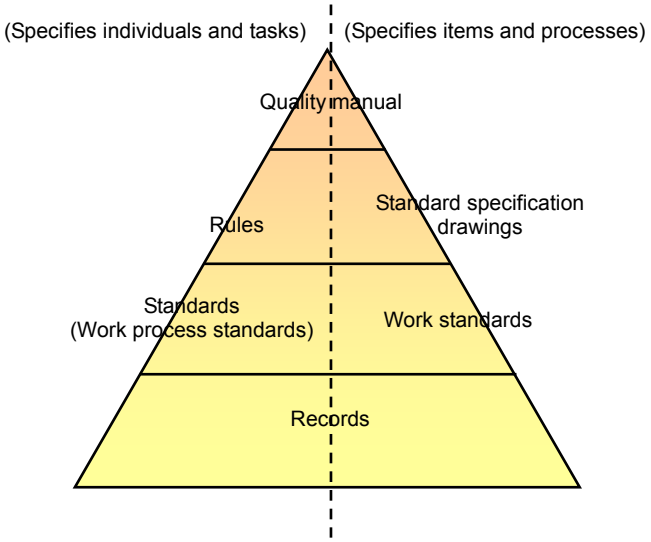
Safety and environmental regulations applying to product safety in the relevant destination countries are analyzed together with individual requirements from customers at each DR stage. These are incorporated into evaluation items to ensure compliance with laws and to resolve safety and environmental issues.

Technology Qualification

New technology elements at the time of product approval and 4M change approval are controlled by registration in a database publication within the division. These form materials for determining the newness at the new product planning stage and also form important points in determining subsequent evaluation guidelines.

3. STRUCTURE OF DOCUMENT CONTROL

Seiko Epson administers a system in which employee duties are clearly defined and work procedures specified and documented to ensure delivery of quality products that meet customer requirements.



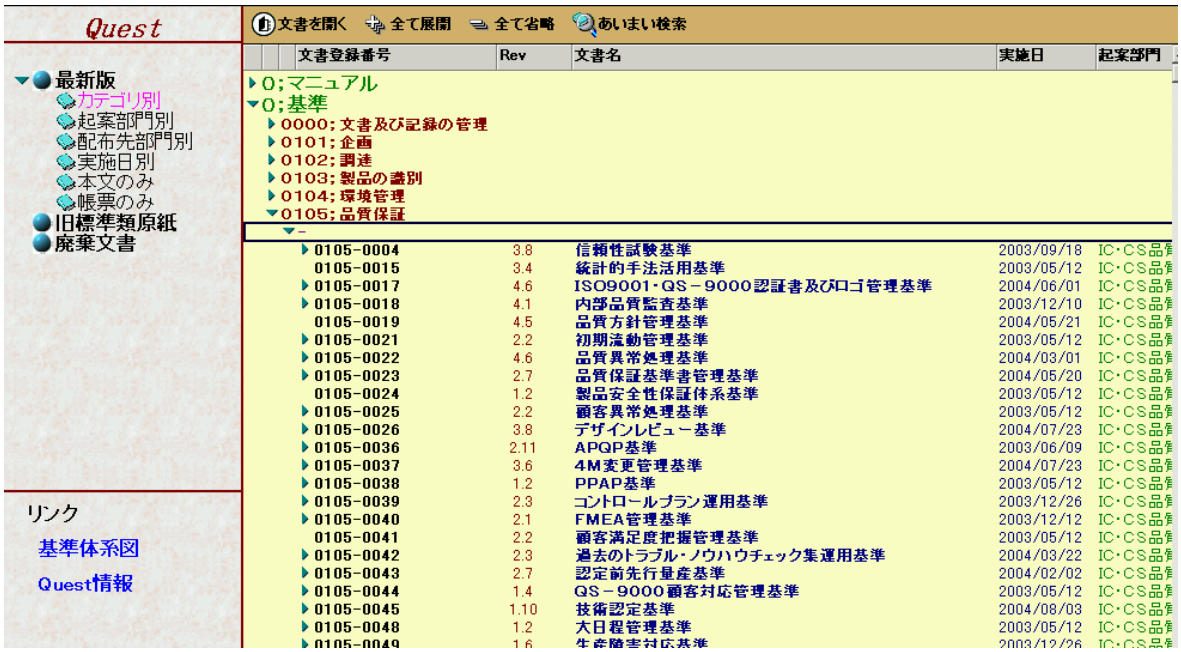
Rules: Specify specific task.

Standards: Specify work procedures or tasks and actions to satisfy standards based on rules.

Standard specification drawings: Specify items and processes based on rules.

Work standards: Stipulate detailed duties and work procedures prescribed in standards.

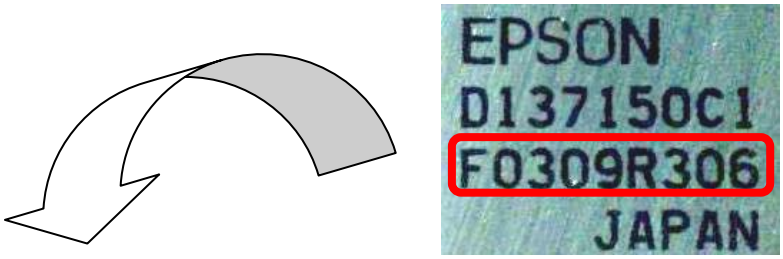
Standards are currently in the process of shifting to electrical control to ensure users can always reference current versions. This transition will also prevent accidental use of discontinued standards by immediately removing them following revisions. Revision histories are maintained for each standard to prevent changes without checking for later versions.



“Quest” digital standard control system

4. PRODUCT TRACEABILITY

Lot numbers are printed on the front of the package or included on chip tray labels. Note that lot numbers may be simplified if the package size limits the number of characters that can be printed. Tracing is still possible even with simplified numbers.



<Typical lot number marked on package>

(1) (2) (3) (4) (5) (6) (7) (8) (9)

<Key>

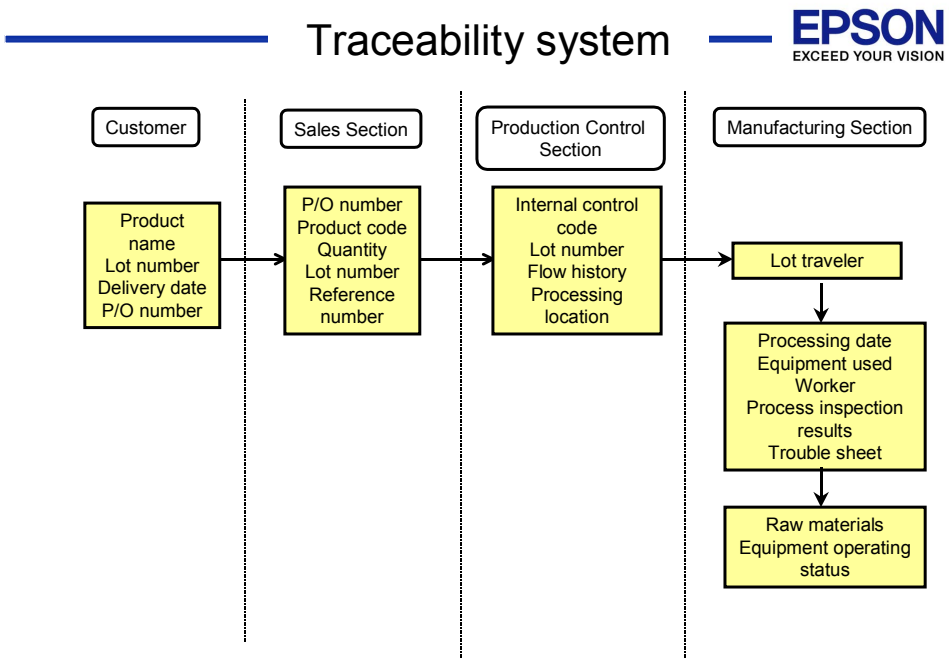
(1) Epson control code

(2) (3) Manufacture year code: Last two digits of year
(2003 in this example)

(4) (5) Manufacture week code: Week counted from first Thursday of manufacture year
(in accordance with ISO 8601)
(Week 9 in this example)

(6) (7) (8) (9) Epson control codes

This code allows tracing of manufacturing history and raw materials. The scope of traceability is shown below.



Scope of traceability

5. QUALITY CONTROL IN MANUFACTURING PROCESSES

Product quality and reliability is built in during the manufacturing processes. Quality is controlled by paying particular attention to the following points in order to prevent latent defects in devices.

Incoming inspection: Control of materials received
Process control: Control of manufacturing processes
Use of statistical methods
Operator certification

Each of these is explained below.

(1) Incoming inspection

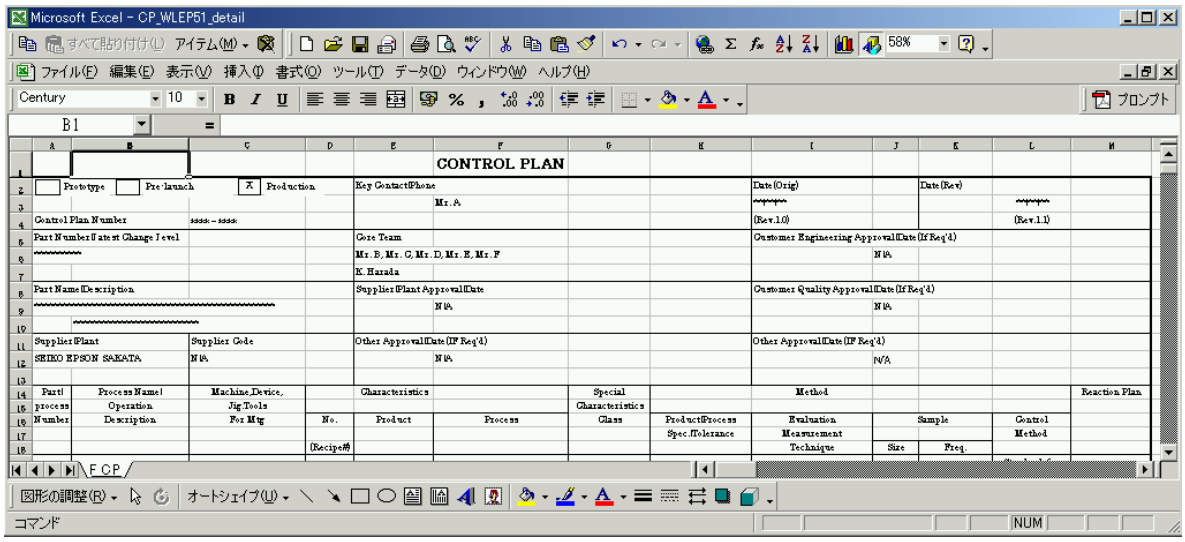
The quality of raw materials used in manufacturing processes must be confirmed to maintain product quality and reliability. The following activities are performed to ensure this.

- Selection of manufacturers of raw materials used in manufacturing processes together with regular meetings
  (See "10. Supplier Control" for detailed information.)
- Incoming inspection for all raw materials
  Materials that have not been inspected are not used in mass production. The main items subject to incoming inspection are shown below, together with inspection methods.

(2) Process control

Control points are determined within the actual manufacturing process to ensure that quality is an integral part of the process. Process control involves specifying these control points and control methods. The output is checked from key processes, and this data is subjected to variation control using statistical process control (SPC). The data is fed back continually to support improvement activities. (See “5. (3) Use of statistical methods (SPC)” for detailed information.)

Seiko Epson creates control plans to summarize these control items. One example is shown below.



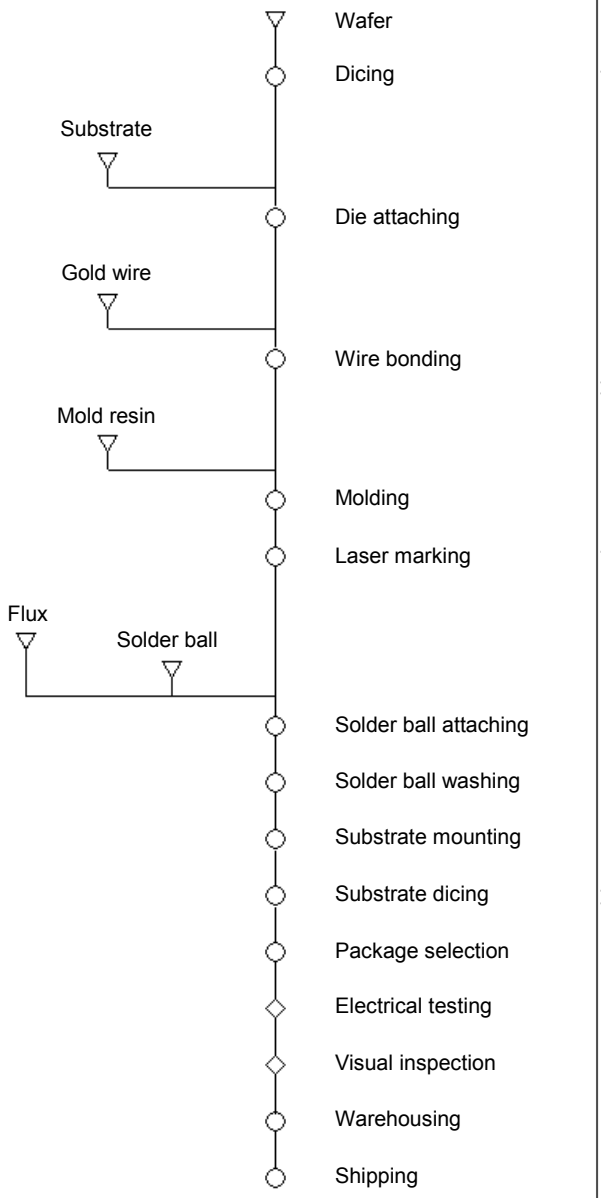
Another key element of process control is manufacturing plant control. Manufacturing plants are controlled through daily and periodic inspections, and the inspection results are used to implement continuous improvements that enhance preventive maintenance.

Flowcharts are shown for a wafer process and typical FCBGA/PFBGA package assembly process to illustrate manufacturing process quality control more clearly. The flowcharts are used to create flow forms for each product, which are then used for control and manufacture.

Wafer process

Process	Control point
Wafer	
Washing	Resistivity, thickness, flatness, scratches
Oxidation	Surface washing extent
Nitride film formation	Temperature, atmosphere, time
Mask	
Film inspection	Pattern dimensions, defect density
Photoresist	External appearance, film thickness
Photolithography	
Inspection	Resist thickness, deformation, focus check
Gas	External appearance, dimensions
Ion injection	
Heat treatment process	Accelerating voltage, injection amount
Gas, Sputtering Target	Temperature, atmosphere, time
Diffusion inspection	
Metallization	External appearance, sheet resistance, C-V test
Conductive layer inspection	
Passivation	Vacuum, temperature
Device parameter measurement	External appearance, film thickness, step section inspection
Wafer probe test	External appearance, debris
	Electrical properties (e.g., Vth, β)
	Circuit electrical properties

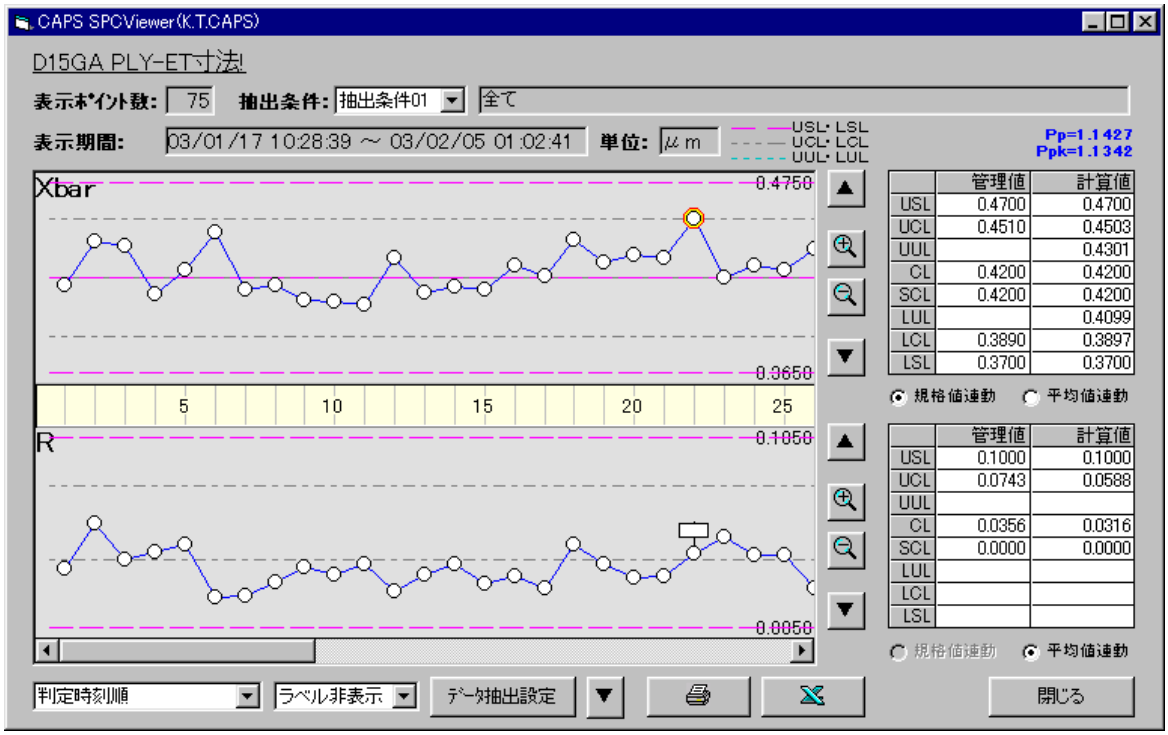
PFBGA product

Process	Control point
	Blades wear control, purified water External appearance Temperature, US power, wire bonding appearance, bonding strength Temperature, pressure, visual appearance Visual appearance of marking Temperature, visual appearance, bond strength Visual appearance Visual appearance Number of cut lines, purified water control Storage orientation, visual appearance Electrical parameters, functions Visual appearance

(3) Statistical process control (SPC)

SPC control is applied to special characteristics to determine the extent of variation within manufacturing processes and to identify fluctuations in the early stages. The data obtained is then fed back to the process to assist with process maintenance control.

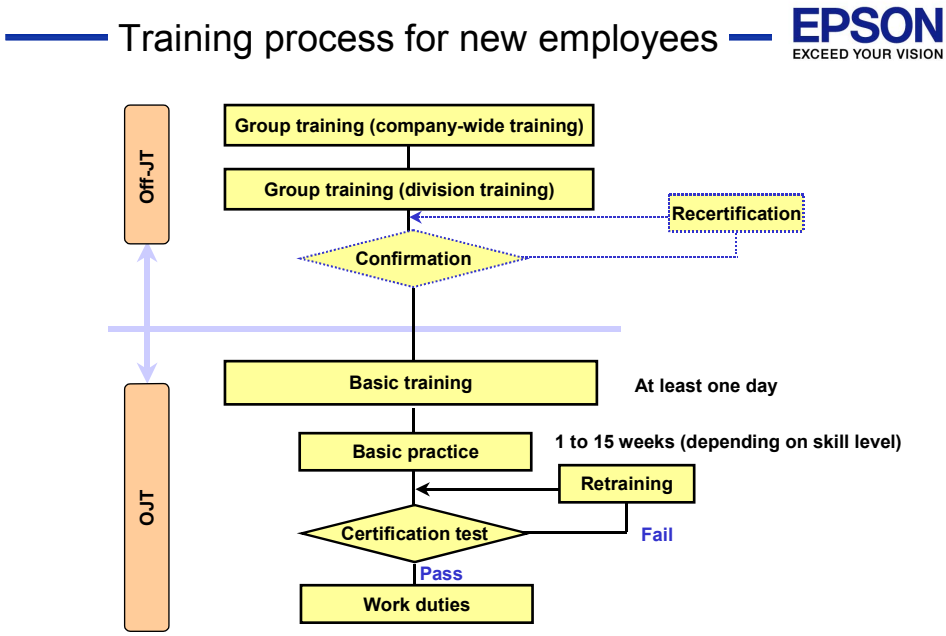
SPC optimizes individual processes and process types to achieve consistent product quality. A typical control chart is shown below.



Clicking on this alarm point in the system allows inspection of the defect status. This defect status is retained as a record. The display can be switched from time-based to machine number display, reducing the time required to detect and resolve problems and ensuring consistent process control.

(4) Operator certification

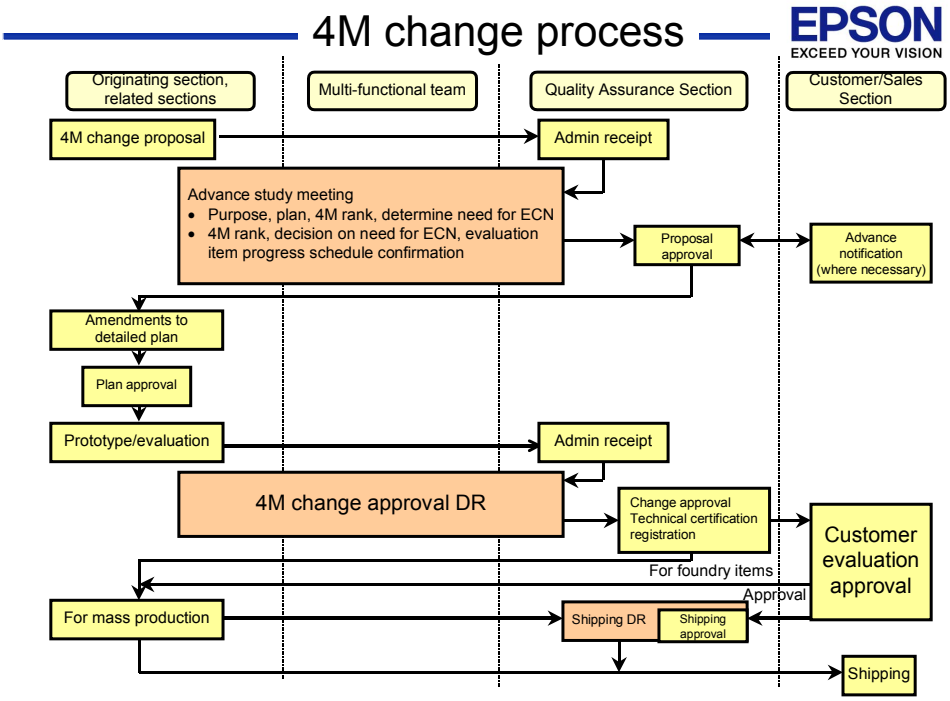
Employees involved in manufacturing processes are subject to operator certification. Workers undergo training in various operational details and are allowed to participate in actual operations only after certification and confirmation for the specified level of the certification test. Workers are recertified annually to maintain worker skills.



6. PROCESS CHANGE CONTROL

Process improvements are performed on a daily basis in the mass production phase to achieve even better product quality and reliability and to improve productivity. Accordingly, process changes are unavoidable in such cases. Process change plans are prepared in advance by the originating section, after which the plan and evaluation details are examined by the multi-functional team, which determines whether the customer must be notified. The change is implemented following evaluation and confirmation that there are no effects on the product. This enables process control and quality.

Process changes deemed to affect quality and reliability for the customer are reported in advance to the customer for approval.



7. PLANT AND MEASURING EQUIPMENT CONTROL

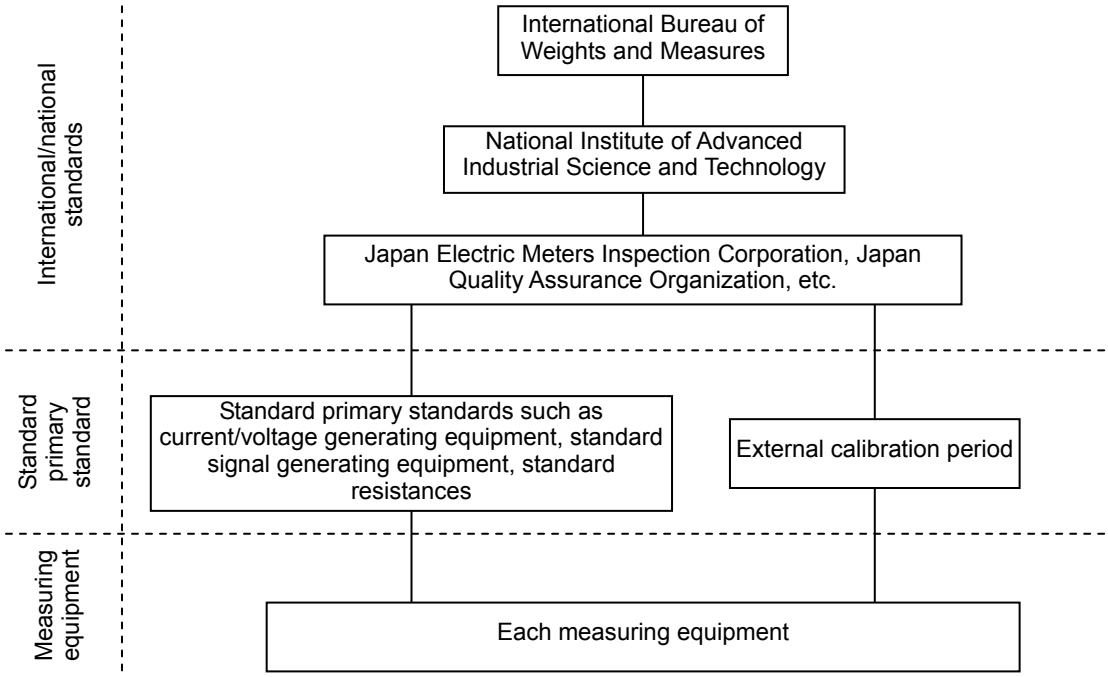
(1) Plant control

Equipment used in manufacturing processes is rigorously inspected following selection for the relevant process. Equipment accuracy is checked in daily or periodic inspections following approval for mass production use.

(2) Measuring equipment control

- Ensuring traceability

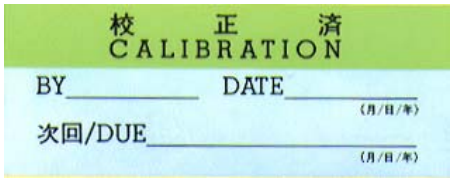
  Measuring equipment used for measurements to check built-in quality and measuring equipment used in design validation and testing/inspection is calibrated. The calibration process ensures traceability in accordance with national standards. Calibrations are performed both in-house and by external calibration organizations. In-house calibration is performed to in-house primary standards whose traceability to national standards has been confirmed by certified employees with calibration training. External calibration is carried out by contractors subject to control similar to suppliers or manufacture contractors using quality systems confirmed to be appropriate for traceability and calibration work.



- Measuring equipment identification tags

  Measuring equipment subject to calibration is identified using one of the tags shown below to ensure that everyone uses only the correct equipment. Measuring equipment available for use is identified by tags 1 and 2. These are used to maintain and control the calibration status under the periodic calibration system.

1. Calibration equipment control tag
   Indicates the calibration control number.



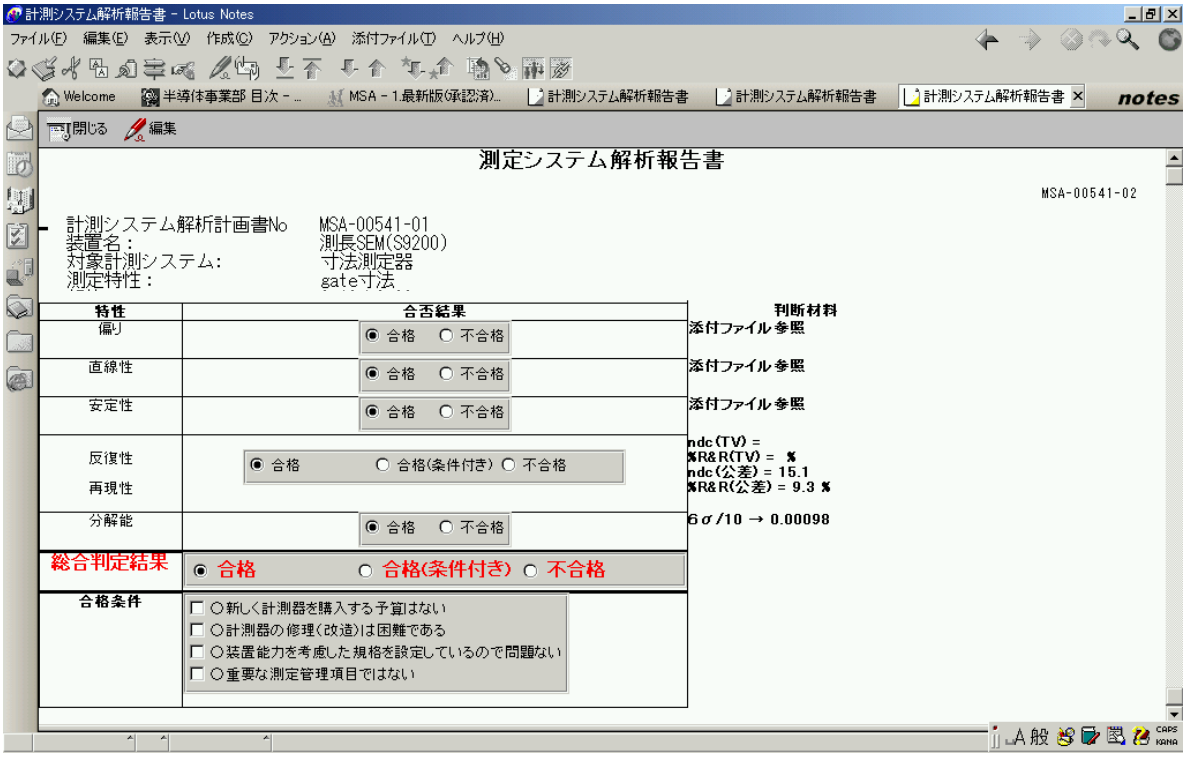
2. Calibrated tag
   Indicates the calibrator, date calibrated and next scheduled calibration date.

3. Engineering use only tag
   Indicates use is prohibited for mass production.

4. Do not use tag
   Indicates use is prohibited due to calibration non-conformance.

(3) Measurement system analysis (MSA)

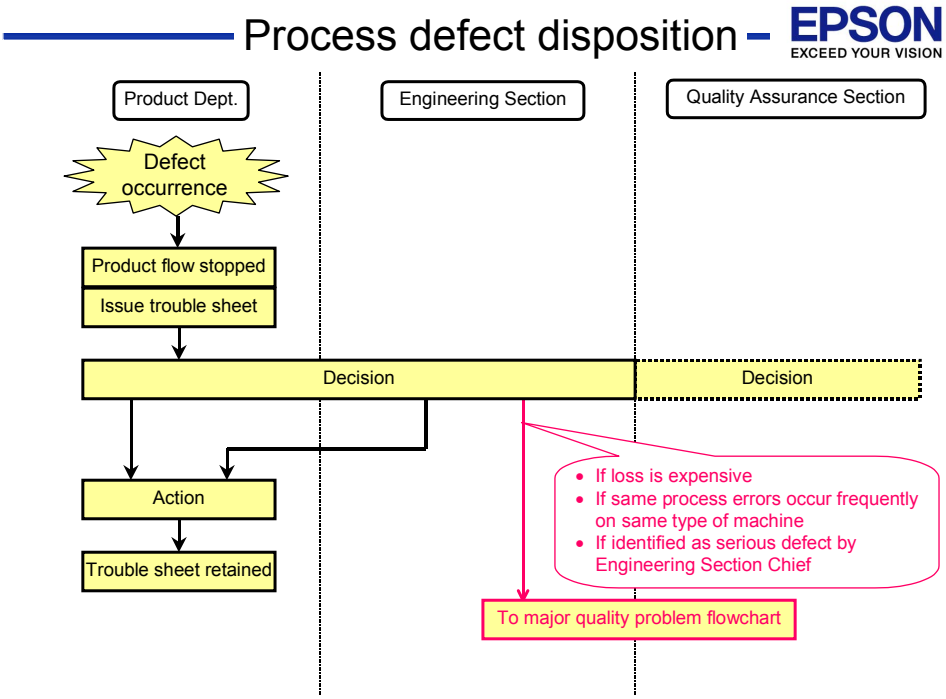
Even measurement systems that have been calibrated with confirmed traceability to national standards can still produce variations in results obtained due to different measurers and ambient conditions. Measurement system analysis (MSA) is therefore used to minimize these factors and ensure the high reliability of measurement systems used. This analyzes bias, linearity, consistency, repeatability, and reproducibility to statistically evaluate measurement equipment.



8. NON-CONFORMANCE CONTROL, CORRECTIVE ACTION, AND PREVENTIVE MEASURES

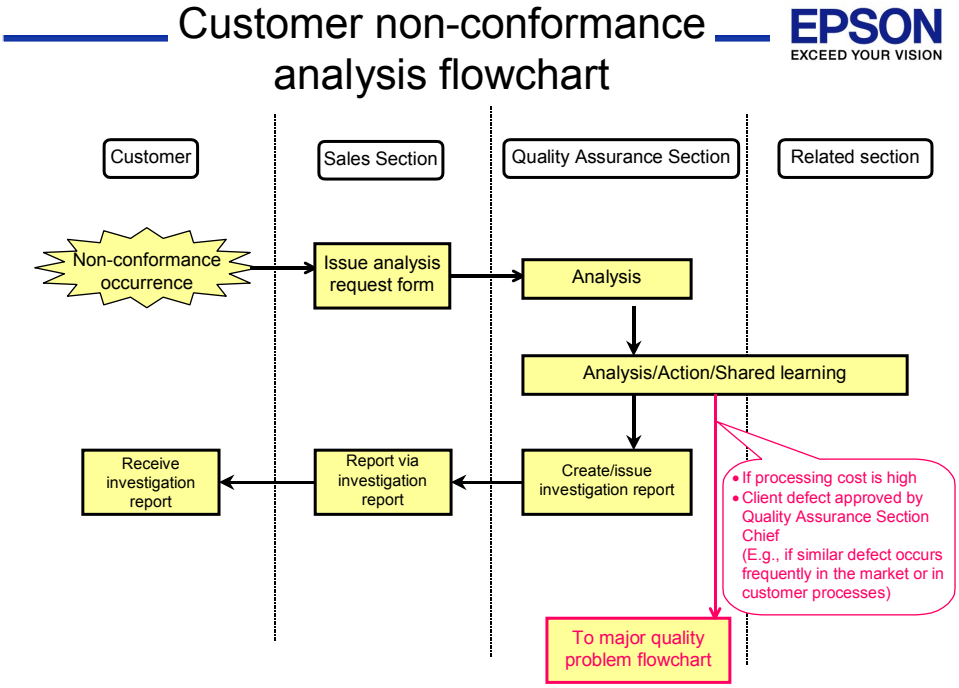
(1) Non-conforming product control in manufacturing processes

Products in manufacturing processes that fail to meet the specified standards are classified as non-conforming and are handled as shown below using product labeling and trouble sheets.



(2) Control of non-conforming products identified at customers or on the market

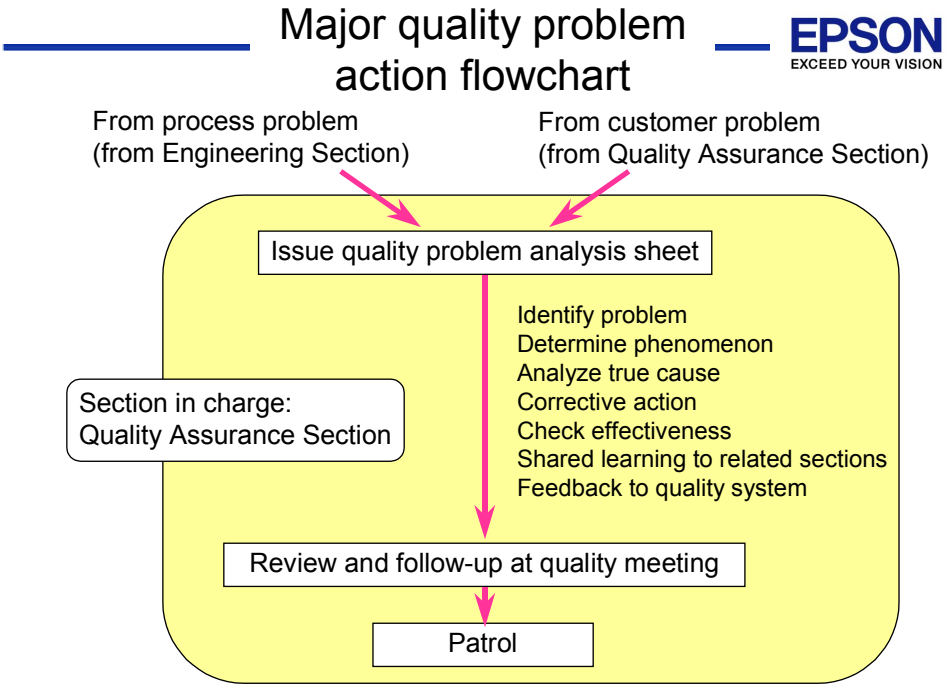
Please contact the Seiko Epson Sales Section if non-conformance is detected by customers after shipping. Problems are promptly analyzed as shown in the flowchart below before reporting the results to the customer.



Conducting analysis using FIB

(3) Corrective action

Problems arising in manufacturing processes or at customer sites identified as posing the risk of large amount of loss, as constituting serious problems, or as problems requiring shared learning, are subjected to separate registration control as major quality problems. The details recorded for major quality problems includes not just causal investigation and action, but also shared learning throughout the related section to confirm corrective action status and confirm completion.

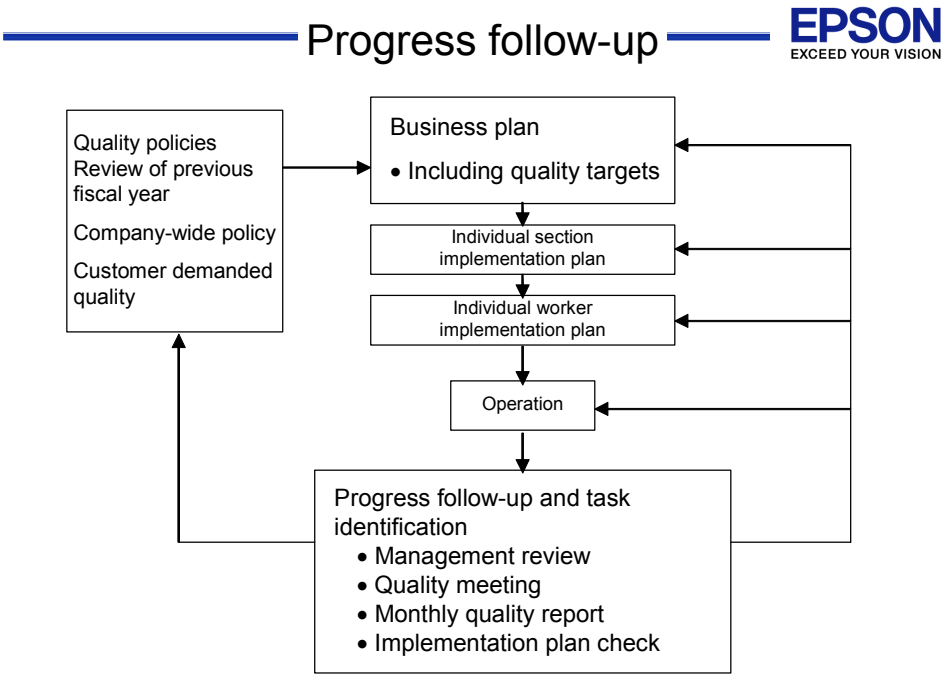


(4) Preventive Measures

One preventive measure involves collating the analysis results of past problem cases and adding these to check points highlighted in reviews for examination by the multi-functional team. Another major activities is the use of FMEA. These activities are used to prevent problem recurrence.

9. CONTINUOUS IMPROVEMENTS

At the start of each fiscal year, a business plan is established based on the review results for the previous year, customer demands, and the company-wide policy. This plan includes quality policies and quality targets. This business plan is then used to draw up individual section plans and individual worker objectives.
To achieve quality targets, current conditions are identified at yield improvement meetings and quality meetings with follow-up on the status of corrective action. This information is reported to management. These overall activities to attain quality targets are used to promote continuing improvement and to increase product quality.



10. SUPPLIER CONTROL

Suppliers are generally categorized into suppliers of materials and components and manufacturing subcontractors. In both cases, maintaining quality is of prime importance, and suppliers are subject to the following three types of control.

Supplier selection
Daily control
Periodic control

(1) Supplier selection

When a request is issued to use a new supplier, selection is made by checking the technical capabilities of the supplier and determining whether it has a quality assurance system in place to ensure delivery of products of consistent quality. Following selection, products are evaluated and the factory is audited from a number of perspectives by the related sections to evaluate the supplier.
Following confirmation that the supplier meets standards of adequacy, a quality assurance standard is prepared and used to establish a quality assurance system.

(2) Daily control

The occurrence of quality problems or process changes are reported by the specified forms in accordance with the quality assurance standard. The number of problems is a major point considered in the supplier evaluations incorporated into periodic control procedures, as mentioned below.

(3) Periodic control

Suppliers are evaluated at each fiscal year based on QCD (quality, cost, delivery) results. These results are used to determine the supplier control level for the current year, and guidance is administered when necessary, including audits. In addition, periodic meetings, etc. are held at frequent intervals to ensure cooperation from suppliers to improve quality.

11. INTERNAL AUDITS

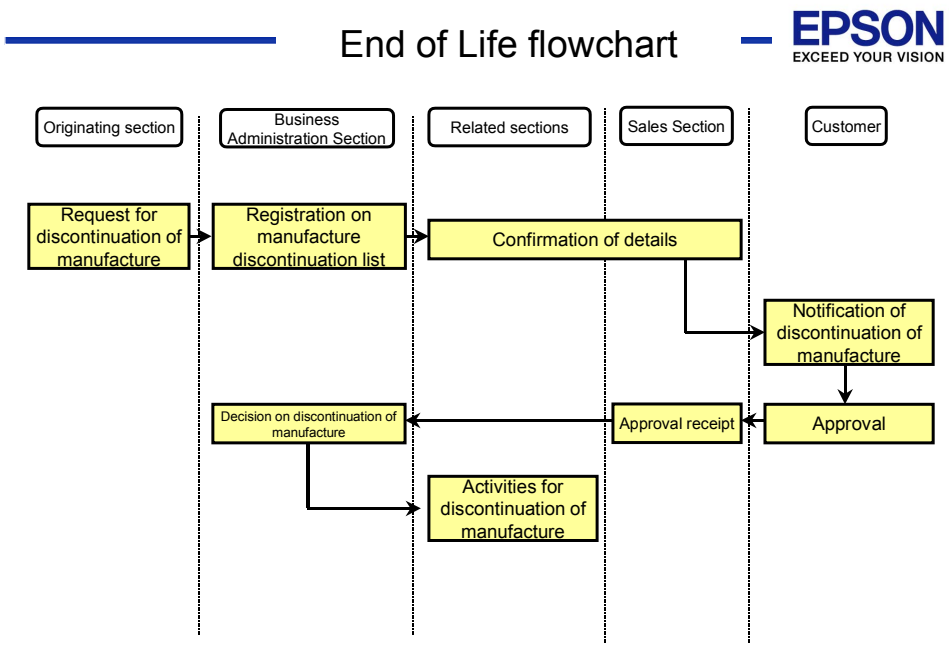
Internal audits are performed to confirm that the quality management system is being operated effectively and to create an even better quality system. Regular audits are performed annually, covering all shifts for manufacturing processes. Partial or total audits may also be implemented from time to time when deemed necessary by the quality system manager.

The results of these audits are used to improve the quality management system. The internal audit results are one of input to management review.

12. DISCONTINUATION OF MANUFACTURE

The manufacture of existing products may be discontinued due to manufacturing facility reorganization or product quality improvements. In these cases, the customer is generally notified approximately one year in advance.

The flowchart for the discontinuation of manufacture is shown below.



13. CLEANLINESS ACTIVITIES

Support for cleanliness activities also forms part of the duties of the Quality Assurance Department. These activities are described below.

(1) Importance of cleanliness activities

Seiko Epson products have achieved an outstanding reputation among our customers for performance and reliability. The most important factor for integrating this reliability and quality is maintaining and controlling cleanliness in the environment in which products are made. Activities that ensure cleanliness in the factory will become even more important in the future, with the ever-increasing precision of products and demand for higher levels of quality control. Cleanliness activities for semiconductor manufacturer are particularly important, since particles or impurity ions encountered during the manufacturing processes can greatly affect product yield rates and reliability.

(2) Cleanliness goals

The four points below constitute the goals of cleanliness activities and support the production workfloor.

1) Increase quality (eliminate quality problems and complaints attributable to foreign matter)

This is treated as a major cleanliness item that helps prevent any direct inconvenience to the customer.

2) Increase yield rates and contribution to F costs reduction

Reduce foreign matter and impurities to avoid generating non-conformances or products requiring reworking. While this also reduces failure costs for Seiko Epson, the primary goal is to enable provision of products to customers at low cost and with short lead times.

3) Preventive maintenance and life extension of production plant

The emphasis is on tackling problems at the source from the early stages, with daily inspections performed to avoid effects on production and delivery schedules caused by plant stoppages when problems arise. Intensive maintenance extends the life of plant equipment and allows sustained production with depreciated plant equipment, which in turn makes it possible to continue providing low-cost products to customers.

4) Improve Customer Satisfaction

In addition to the importance of maintaining a clean manufacturing environment, winning esteem from our customers helps boost our own levels of satisfaction. Creating products from the customer’s perspective is important for ensuring reliability and long-term use with peace of mind. This is why all divisions within Seiko Epson incorporate cleanliness activities into their daily

production activities, always aware of their vital nature.

(3) Cleanliness activity support details

The following multi-faceted support is provided to ensure high quality product manufacture:

1) Training (New employee training and basic training)

Good quality products require both a good manufacturing environment and a workforce with high awareness and knowledge of cleanliness.

Product quality reflects workforce quality. Training is vitally important.

- New employees receive cleanliness training as part of the training program for new employees.
- Cleanliness training is also provided at the appropriate intervals for every employee.

2) Cleanliness support in each production line

Instruction and support is provided for semiconductor manufacturing lines through cleanliness diagnosis and patrols.

3) Supplier cleanliness support

Cleanliness training, instruction, and advising is also provided when necessary at the manufacturing lines of subcontractors.

Cleanliness guidance session

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