Quality Handbook

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Semiconductor

Samsung Electronics Co., Ltd.

SAMSUNG

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Table of Contents

Figures

Tables

1. The Samsung Quality Policy

Samsung Semiconductor ("Samsung") has continuously enhanced the quality management system to achieve the best quality in all products and services.

Samsung's Quality Policy statement:
"We deliver, on the basis of an efficient quality system, the best products and services which conform to our customer requirements and expectations."

The quality objectives of Samsung's are measurable and consistent with quality policies. Quality objectives include key performance indicators by processes and joint quality improvement projects with customers and suppliers.

2. Samsung's Quality Management System (QMS)

2.1 Quality Management System Framework

Samsung has the world's best QMS based on international standards such as ISO9001 and IATF16949, and is continuously evolving to meet our customer requirements. Samsung manufacturing domestic and overseas sites have acquired the ISO 9001 or IATF16949 certification. For Samsung's international standard certification history, see https://www.samsung.com/semiconductor/support/quality-management/.

The ISO/IATF standard and customer requirements serve as the baseline for Samsung's QMS. Samsung's QMS implements the Plan-Do-Check-Action (PDCA) cycle of the ISO 9001 into the system to provide sufficient resources for the process and improve the overall performance continuously.

Figure 2-1. QMS Model-PDCA Cycle

2.2 Quality Audits

There are three types of audit program: third-party audit (by International standard certification body), second-party audit (by customer audit) and internal audit.
Samsung have obtained international standard QMS certifications such as ISO9001 and IATF 16949, and we maintain these through annual audit from an accredited certification body. Customer audits are conducted at planned intervals and any customer's requests.
If any nonconformity is found after the ISO9001/IATF16949 and customer audits, the Quality Assurance team conducts an internal audit. Samsung's internal auditing is performed as a preventive and monitoring tool to ensure compliance and effectiveness of the QMS, and to identify opportunities for improvements as well.

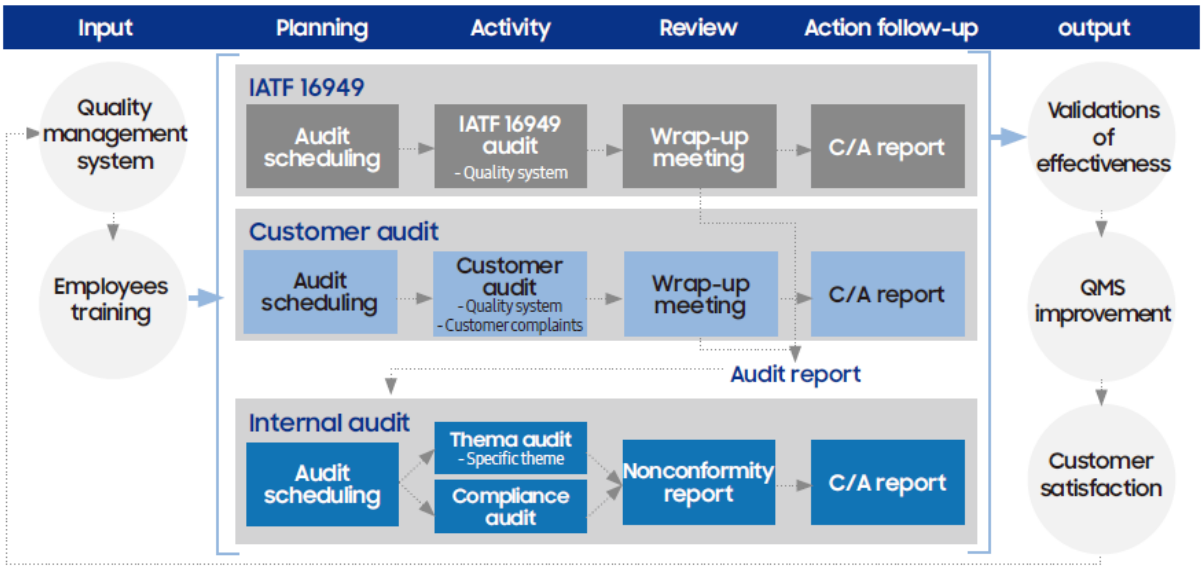

Figure 2-2. Samsung's Audit Program

2.3 Quality Documentation System

One of the objectives of Samsung's QMS is to establish and maintain a documented quality system which is defined to ensure that the products and processes conform to its specific requirements and meet the ISO 9001 and automotive requirements.
The procedure refers to "documentation of the most outstanding work at the given time". Here, 'the most outstanding work' means the method of producing products with the minimum variations due to external factors such as human, environment, methods, equipment, and materials.
Uniform application of the procedures helps enable productivity and quality uniformity across manufacturing sites.
All employees are committed to the concept of "NO SPEC NO WORK" (we don't work without standards) and perform all applicable quality improvement activities continually.
Samsung's quality documentation system is comprised of a document structure hierarchy as shown in the figure2-3.

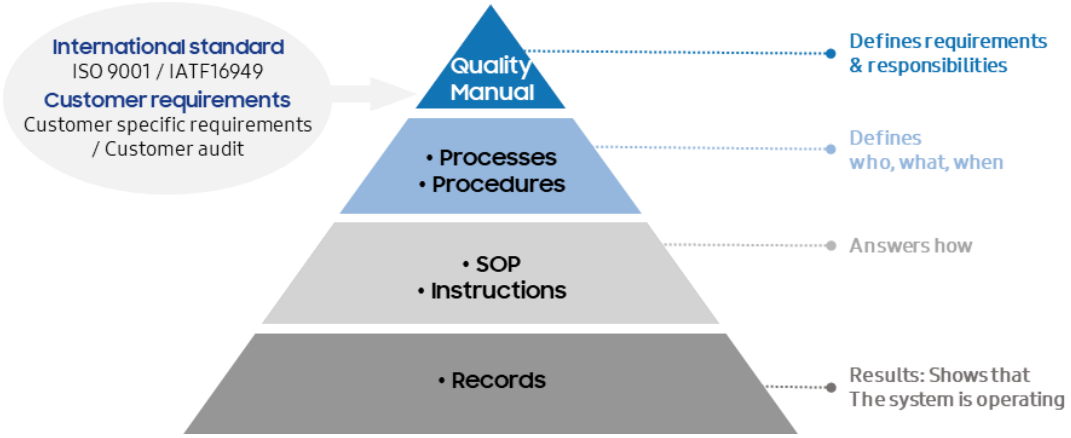

Figure 2-3. Quality Document Hierarchy

Quality Manual is the most significant document that defines Samsung's QMS. It represents major contents such as quality policy, quality goals, and organizational roles and responsibilities.
The objective of the Quality Manual is to specify the requirements for Samsung's QMS in order to satisfy the IATF 16949, statutory and regulatory requirements as well as consumer needs; and to ensure that all employees involve in the implementation of the quality policy via the QMS.

Processes/Procedures define each department's roles and responsibilities in practicing the core elements of Samsung's QMS.

SOP and Instructions outline detailed procedure of works, criteria, and technical methodologies to carry out specific operation or function.

Records are all kinds of data and documents for product traceability (Chapter 5.6). Samsung's document management system provides an efficient environment through sharing, collaborating and managing the records.

3. Product Development & Qualification

Increasing product design complexity and performance demands translate into key challenges to product development and certification. Samsung constantly improves test capability and capacity in development phase to meet these challenges.
Samsung assures product's quality and reliability performance with structured qualification and validation process throughout the product life cycle. The Samsung's Product Life Cycle (PLC) is defined in four phases as shown in Figure 3-1.

Figure 3-1. Samsung's Product Life Cycle (PLC)

Funnel image signifies that the PLC identifies market needs by adding as many ideas as possible at the Concept and Plan stages, and minimizes any problems arising from the Development and Production stages by identifying and resolving expected issues.

Concept's blue color symbolizes creation and freedom. In the Concept stage, new product requirements and business opportunities are evaluated based on the project proposal and market needs.

Plan's green color symbolizes precision and perfection. In the Plan stage, product design guidance and qualification plans are specified for use in Development stage. To meet these product development objectives, the resources (such as money, human and machine) are also planned and allocated.

Development's orange color symbolizes efforts, hard work, and achievements. In the Development stage, the product that meets its requirements is developed and verified its performance, reliability, and mass-producibility.

Production's red color symbolizes passions and proliferation. In the Production stage, product's launch is decided after product validation and manufacturability evaluation of mass production. This stage ranges from mass production to product discontinuance that have completed its life cycle.

4. Materials and Outsourcing Quality System

To be successful in satisfying business expectation, Samsung selects and develops reliable suppliers/ subcontractors (hereinafter referred to as ”suppliers”) . Each supplier’s performance is continuously assessed periodically (typically once a year) conducted in-depth audit in terms of technology, quality, delivery, cost, and finance. Suppliers are notified of the evaluation results and their improvement activities are driven systematically.

4.1 Materials Quality Control

Samsung ensures materials with stable quality and supply capability by following the certification procedure. The procedure is designed to validate product conformity, supply risk assessment and production capability through supplier self-checklist and manufacturing site audit.

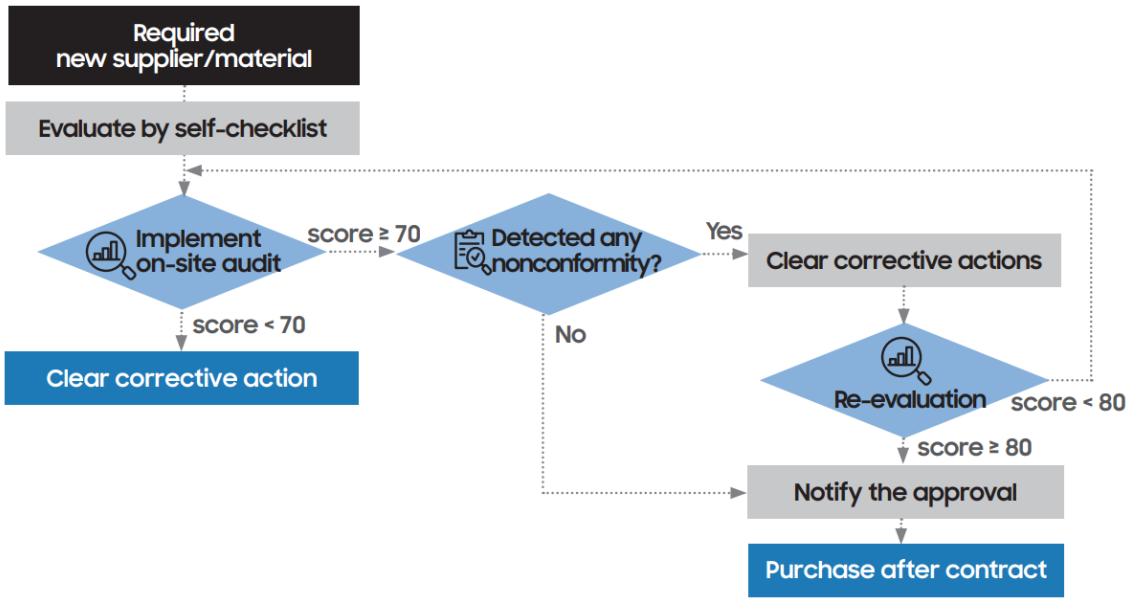

Figure 4-1. Procedure of Material Qualification

Samsung has multi management tools to maintain material quality and to address any material-related issues.

Table 4-1. Material management system elements

Prevention	• Change Control Board • Failure Mode & Effect Analysis (FMEA) • Audits • Technical Review Meeting (TRM)
Detection	• Supplier Statistical Process Control (SPC) • Supplier Outgoing Quality Control (OQC) • Samsung Incoming Quality Control (IQC) • Material Quality Monitoring
Reaction	• Supplier Corrective Action Request (CAR) • Material Review Board (MRB)

Prevention: Samsung operates several preventive measures against any material-related quality issues. The Material Change Control Board (MCCB) controls and evaluates any changes in suppliers. The Failure Mode and Effect Analysis (FMEA) can be used as a tool to define potential causes of quality issues and to design effective counterplans in advance. At this point, Samsung performs audits on each supplier's quality management system and manufacturing processes, including but not limited to Supply Chain Management (SCM) capacity, procurement, and storage management.

Detection: To detect and take control of excursions, Samsung uses detection tools such as the material inspection based on the statistical process control and the advanced metrology system. Suppliers should comply with the process control actions in any excursions, and, if necessary, Samsung offers consulting and/or training program that supports their technology development and utilization.

Reaction: Suppliers are responsible for performing corrective actions following material-related issues. Samsung runs the Material Review Board (MRB) to identify the root causes of the detected issues and implements corrective actions to prevent reoccurrence of the same issue.

4.2 Outsourcing Quality Control

Samsung follows the procedure of subcontractor qualification whenever package, equipment, process or materials are newly added and/or changed. The subcontractors' conformity to mass production process is validated by technical reviews and evaluations.

Nonconformity Product Handling (Subcontractor's duty): This procedure is designed for taking corrective actions for the lots with below-standard-yield due to the device's characteristics issues. Tests are conducted at Onyang Plant after the subcontractor's semi-finished products are assembled. Product's characteristics that may affect the reliability, the quality and the field due to the detected defects are evaluated.

5. Manufacturing Quality Systems

Samsung's commitment to quality enables to sustain world-class competitiveness in the semiconductor industry. All employees take the responsibilities to improve product quality and share best-known practice across factories. In addition, fully automated production facilities and highly specialized continuous monitoring system allow us to ensure consistent product quality and reliability.

5.1 Environmental Management

Samsung is committed to minimizing the environmental impacts of our operations and products throughout their life cycle.
We innovate to design energy efficient products with durability for longer use. We also focus on resource efficiency with reuse and alternatives for chemicals at the manufacturing level. Our global manufacturing facilities are certified by the ISO 14001 (environmental management standards), OHSAS (Occupational Health and Safety Assessment Series) 18001, and ISO 50001 (energy management standards). We also take a proactive approach to environmental and social impact issues with our internal and external stake holders.

5.2 Process Change Management

There are many changes in products and the production processes for a variety of reasons including enhancing product's performance, adding manufacturing capacity, and changing suppliers. Changes in product and process are inevitable and necessary for improvements, and, without proper evaluation and verification, it may lead to unexpected failures.

The Process Change Control Board (PCCB) is a tool for controlling process changes in Samsung factories including materials and facilities. The PCCB requires clear implementation and verification plans to prevent the risk and verify the benefits following the changes. PCCB's objectives are to a) ensure an effective management of process changes, b) lead process improvement and product enhancements and c) maximize the accumulated technologies.

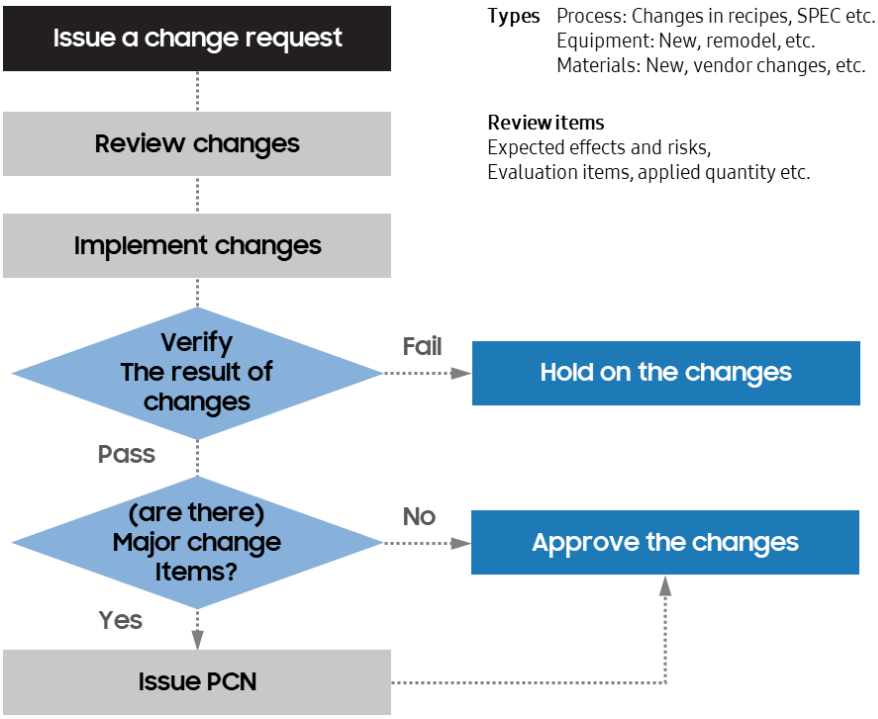

Figure 5-1. Procedure of Process Change Control

Once a change request has been made, the PCCB review and create an application plans with limited schedule that can minimize the impact on manufacturing process. After Implementation of such change, the results are verified. The PCCB tracks any in-line parameters that may affect the product's performance and finished products parameters such as yield and reliability. Final approval is granted only when all members of the PCCB reach a mutual agreement.

Samsung communicate critical changes that may affect a product's performance to customers through Product Change Notification (PCN). PCN is linked in the PCCB for any major changes. Please refer to PCN in Section 6.2 for details.

5.3 Manufacturing systems

Due to product's size reduction and complexity with the advancement of semiconductor technologies, the parameters of processes, equipment and materials are exponentially increasing.
Samsung's monitoring programs continuously evolve to maintain quality, prevent excursions, and reduce variability of key parameters.

Process & Production Monitoring

Samsung's monitoring program detects any unpredictable and subtle variations. It allows engineers to identify problems early and prevent excursions.

Samsung's Interlock System: Throughout the manufacturing process, critical parameters are monitored and tracked by interlock systems. The critical parameters may include machine input(Equipment Control)/output(Fault Detection Control) and process input(Recipe) / output(CD, thickness, etc.). In wafer fabrication process, a three-stage protection system is operated as shown in Figure 5-2.

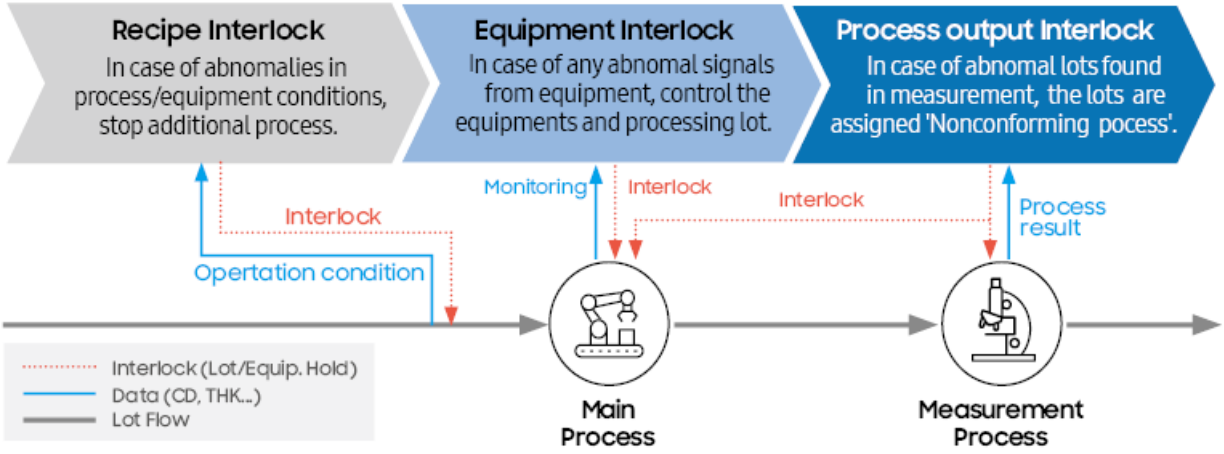

Figure 5-2. Samsung's interlock system

Statistical Process Control (SPC) and Advanced Process Control (APC) : SPC system allows to detect abnormalities in process and to take corrective actions before the quality failures. Samsung has highly advanced SPC program which is suitable for semiconductor manufacturing technologies. It includes small-change detection which is called EWMA (Exponentially Weighted Moving Average). Also APC system performs real-time, and controls equipment's inputs automatically by run-to-run variation.

Continuous Improvement Projects

Manufacturing engineers continually focus on variation reduction and process improvement. We believe that eliminating sources of variation may lead to product enhancements.

FAB Equivalency - "Copy Intelligently": The Samsung Equivalence Test checks the equivalency at all levels of physical inputs and outputs. It is derived from "Copy Intelligently" activities. The Samsung Equivalence Test enables consistency of product's performance between different manufacturing sites, lines, and(or) equipment.

Samsung's equivalency methodologies are applied to facility, materials, process input/output criteria, and product performance criteria. Both central tendency and variations of the parameters are statistically matched. It is possible to control deviation of process and pre-check the stability of process for any changes in Samsung factories.

Statistical Post Processing: Statistical comparisons of wafer test data to final product's quality allow not only to optimize test condition but also to predict product performance. With advanced statistical methods, wafers and(or) dies with potential risks can be effectively screened.

FMEA (Failure Mode and Effects Analysis) : The Failure Mode and Effect Analysis (FMEA) is a methodology for identifying potential failure modes, determining their effect on the product, and taking preventive actions in the product design and the manufacturing process. Based on FMEA, manufacturing process and control factors are divided into small units, and all possible failure modes are clearly defined and listed by each item. The effect on the product performance and the root cause of each failure are also identified. Then, corrective and preventive actions are implemented.

5.4 Control of monitoring/measurement equipment

Samsung ensure reliable and compatible monitoring and measurement system with minimizing variations caused by measuring and test equipment.
The Measurement System Analysis (MSA) is performed to quantify the uncertainty of the measurement system by measurement environment, sample and mechanical devices variation. Accurate and precise measurement systems are used to ensure that products are compliant to specification and customer requirements.

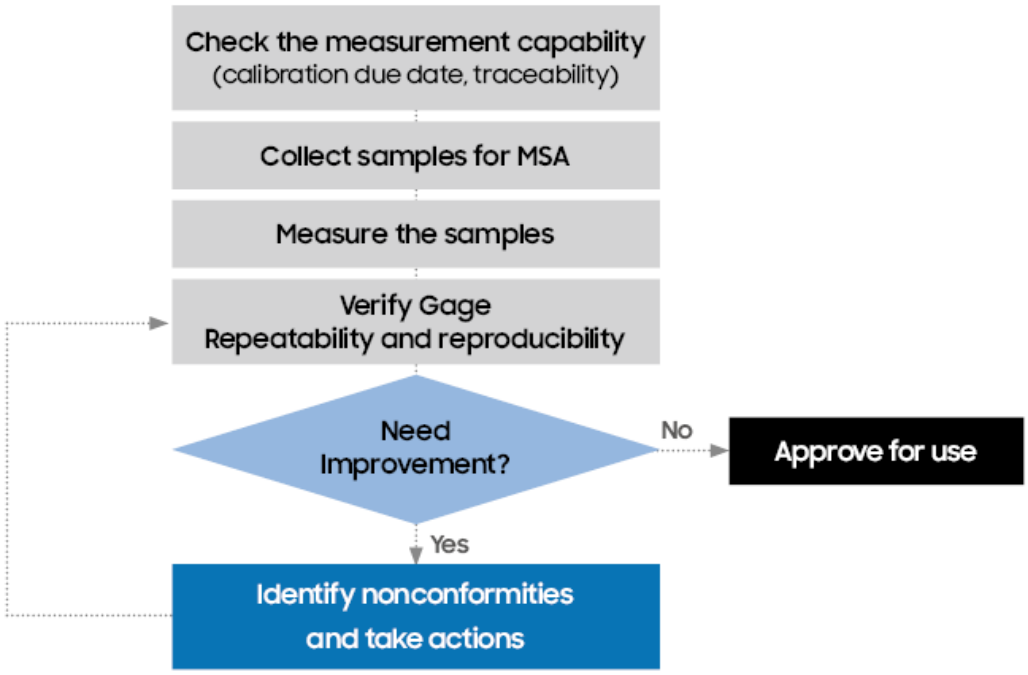

Figure 5-3. Procedure of Samsung's Measurement System Analysis (MSA)

5.5 Control of Nonconforming Product

Samsung identifies and controls nonconforming products, which do not conform to the specification and criteria. All nonconforming products are identified and segregated from normal products.
The Abnormal Lots Processing System (ALPS) is used to manage the nonconforming products.

ALPS is composed of four stages:

- Notification of nonconforming product occurrence
- Identification of the root cause
- Establishment of permanent corrective and preventive actions
- Disposition affected products

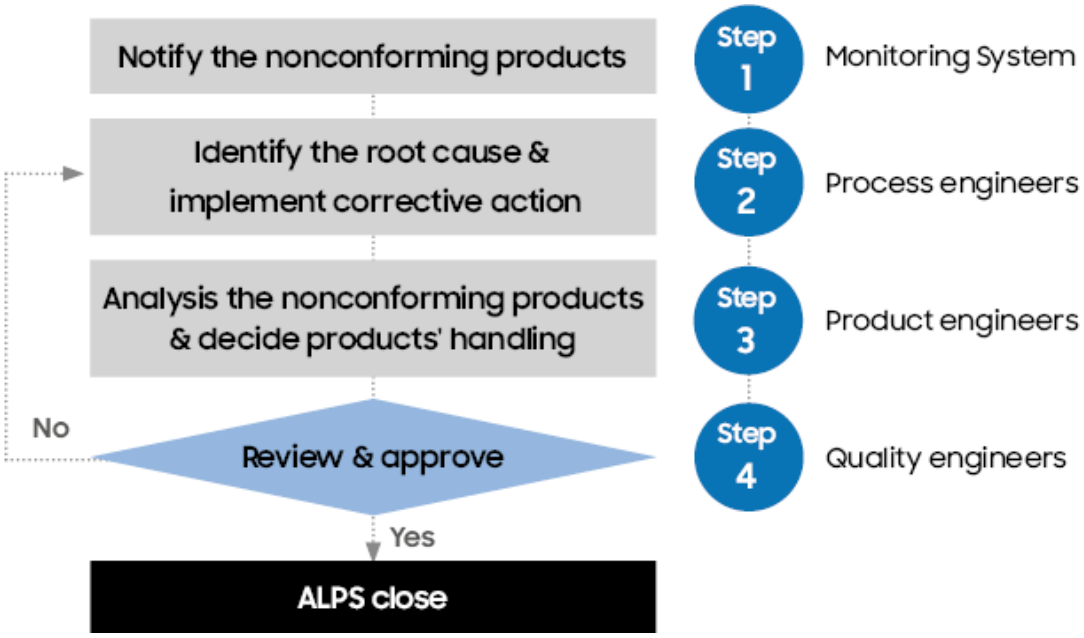

Figure 5-4. Procedure of Abnormal Lot Processing System (ALPS)

5.6 Product Identification and Traceability

Product is identified and tracked from raw materials through all manufacturing process to shipment to the customer. The unique identifier is assigned to each material, equipment and product and managed by the Code Information System (CIS) according to the operation of master code.
Processed information (product code, lot number, manufacturing history, etc.) is systematically managed by identification process, and actual or alleged nonconforming product are immediately isolated and discarded.

Products can be tracked when an abnormality is discovered or upon customer's specific requests. Samsung's traceability enables us to quickly identify the source of any nonconformities, and determine which customers may be affected.

6. Customer Support

Samsung has a comprehensive set of customer quality support system that encompasses technical support, quality issue resolution, return managements and quality cooperation. The customer quality support system responsibilities include:

- Understanding customers' requirements on the quality and reliability of products
- Providing customer assistance by resolving customer quality issues
- Performing the periodic internal quality diagnosis to satisfy customer's quality needs
- Measuring and improving customer satisfaction for Samsung's key customers

6.1. Customer Quality Support Network

Samsung has established a worldwide network in order to provide speedy customer support for inquiries and qualities issues covering both consumer (B2C) products and business (B2B) products. In the case of the business products, we have assigned quality experts (failure analysis engineer, quality engineer) in Samsung's local site for in-depth customer support of quality issues. In the case of the consumer products, specialized consultation/service centers work for troubleshooting the quality issues that customers raise.
For B2B products, the worldwide regional headquarters are specified at http://www.samsung.com/semiconductor/support/global-network/.
For consumer products, Internet access and customer Support Hotline phone numbers are specified at http://www.samsung.com/semiconductor/minisite/ssd/support/cs/.

6.2 Customer Quality Support System

Samsung provides a comprehensive set of customer quality support system that includes resolving quality issues, returns, and quality cooperation, including:

- Product Regulation Certifications
- PCN (Process Change Notification)
- Order Fulfillment Quality
- Technical Support
- Claim Management
- RMA (Return Material Authorization)
- VOC Management (Voice Of Customers)

Through the above customer quality support systems provided by Samsung, customers can reduce the cost of their business operation. We, Samsung, are also continuously improving and enhancing our services to understand customer needs and to provide customers with important information on our products and services.

Product Regulation Certifications

Samsung complies with the environmental and safety regulations in all stages of product life cycle (development, manufacturing, usage and disposal). We comply with regulations demanded by the global societies and endeavor to design and produce products that minimize their adverse impacts on the environment. Please visit the following website for additional information regarding Environment Compliance: http://www.samsung.com/semiconductor/about-us/global-compliance/.

PCN (Process Change Notification)

Product and process changes allow Samsung to improve product quality and manufacturing efficiency as well as customers' flexibility. These changes include adopting new or different types of materials, designs or processes. Samsung has a PCN procedure for major or critical changes in processes. By following this procedure, customers can be notified before such changes.

Order Fulfillment Quality

Samsung's logistic processing is executed in the following order: receiving purchase orders (P.O.) from customers, creating delivery orders (D.O.), granting good issues (G.I.), products entering the customers' warehouse, and lastly, obtaining a proof of delivery (POD).

Table 6-1. Types of accidents during order processing

Types	Definitions
Theft/Loss	Theft, loss, out of stock, attempted theft
Damage	MBB (Moisture Barrier Bag) damage, oil stain, wet, damage (e.g. pallet, wafer, scratch, wrinkled, torn, compressed, squashed, dropped)
Shipment/Delivery	Wrong delivery, wrong shipment, wrong transportation, no packing list, no POD

Technical Support

Samsung provides various technical supports in order to maintain a stable quality level for customers and to make continuous improvements. Samsung's unique quality management provides a wide range of technical support for customers by enabling Samsung to predict the expected quality level of the customers, provide manpower and material resources to resolve quality issues promptly, and simultaneously reflect the customers' requests on the products and quality level.

Claim Management

Figure 6-1 demonstrates procedures of the failure analysis for the maximization of customer satisfaction which cover receiving quality claims, analyzing them, devising countermeasures and taking corrective actions via the precise identification of customer dissatisfaction with the products. Thus, the claims are effectively handled while the recurrence of the same issues is prevented, ensuring outstanding product quality and credibility.

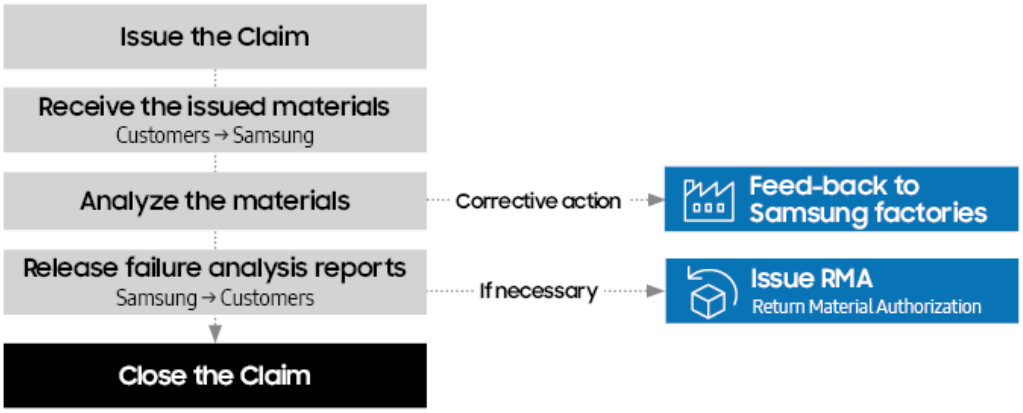

Figure 6-1. Procedure of Claim Management

RMA (Return Material Authorization)

This is a series of steps by which any quality issues with Samsung's products that have already been shipped to customers or warehoused for shipping are identified and handled promptly. The objective is to minimize quality issues by responding to customers' quality-related requests quickly and in a timely manner.

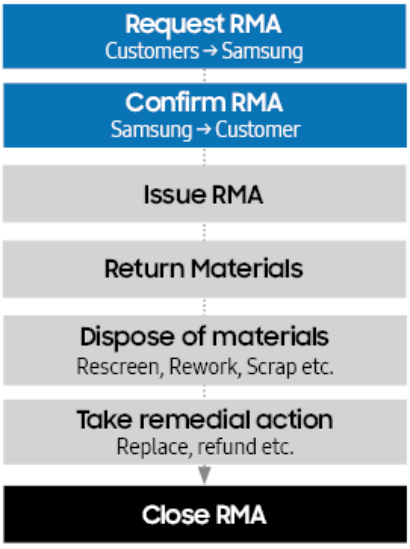

Figure 6-2. Procedure of RMA

VOC Management

Samsung actively listens to customers through various channels and analyzes the obtained data in an effort to provide customers with products and services of the highest quality by driving a sustainable quality innovation movement. The types of VOC management for customers include surveys or interviews for specific customers, Ranking & Rating, and periodic quality review meetings, etc.

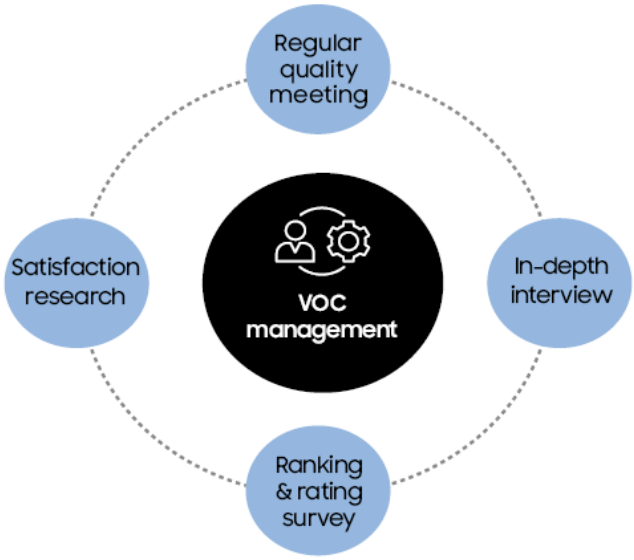

Figure 6-3. Elements of Samsung's VOC management

Revision History

Date	Version	Remark
20.04	04	Updated chapter 2.2 & modified Figure 2-3
18.10	03	Add chapter 2~3, 4.1, 5.1, 5.2, 5.6 & updated other chapter with minor revision
17.06	02	Renewal semiconductor website and quality handbook
14.02	01	Updated Quality training curriculums
08.06	00	Initial release