Quality Assurance Program for Purchased Parts

● Teruhisa Kitani ● Motoko Sazanami ● Masaru Seita

(Manuscript received July 10, 2007)

We continuously promote quality assurance activities to provide our customers with highly reliable, high-quality products in keeping with our company slogan of "Fujitsu reliability and creativity". The quality of individual parts used in our products is an essential factor for achieving high overall quality. Moreover, product recalls involving quality and safety issues have recently become a growing social concern, and are attributed to the inferior quality of such purchased parts as batteries. Based on our extensive experience, we have constructed an approval system for evaluating all parts used in products designed by Fujitsu. Through the evaluations made under this system, we clarify the impact of parts quality on product reliability and implement an ongoing quality improvement program based on a partnership with parts suppliers. In this way, we can prevent failure on the customer side. This paper introduces such a quality improvement program.

1. Introduction

Fujitsu hardware products consist of various parts and units (hereinafter collectively called parts). The quality of individual parts in our products is an essential factor for achieving high overall quality in Fujitsu products. We have constructed an approval system for evaluating all parts used in products designed by Fujitsu. Through the evaluations made under this system, we clarify the impact of parts quality on product reliability and implement an ongoing quality improvement program to ensure the purchase of parts offering stable quality based on a partnership with parts suppliers. In this way, we can prevent problems on the customer side. This paper introduces such a quality improvement program.

2. Procedures for approving parts

Common divisions independent of the product design division in Fujitsu have constructed an approval system for evaluating all parts. Under this system, we evaluate the characteristics and reliability of parts used in products designed by Fujitsu, and conduct supplier audits. Based on the results, we approve the parts for registration in the database and manage the parts suppliers (**Figure 1**).

This paper specifically describes "reliability evaluation" and "supplier management" of the part approval procedures.

2.1 Reliability evaluation

The purpose of evaluating reliability is to verify the reliability of parts (in terms of lifetime and expected failure rate during the product warranty period guaranteed for customers). More specifically, it includes the following procedures:

1) Cross-checking new parts with the database

We cross-check parts to be newly adopted using past evaluation records and a failure database, and primarily judge whether evaluation is required.

2) Evaluation review meeting

We analyze the physical structure of parts requiring evaluation. We also discuss concerns about parts at the "evaluation review meeting" attended by personnel from related divisions having the know-how necessary to develop methods of evaluating samples and reflecting evaluation rules.

3) Reliability test

Based on the results of the evaluation review meeting, we estimate the lifetime and failure rate of parts through accelerated testing where stresses stronger than in actual use environments at customer sites are applied to actual parts. Defective parts detected in such testing are analyzed for clarifying the effects on actual use.

2.2 Supplier management

Along with the reliability evaluation, we check the quality assurance system (including compliance with RoHS directive) and quality control system in place at the manufacturing processes of parts suppliers.

Then we discuss with parts suppliers the quality target and outgoing quality level. Details will be stipulated in the "Quality Assurance Agreement". Once purchases are made, product performance is mutually confirmed through "QC patrols", at "quality meetings", and other means. The results are then graded and arranged in order for the supplier performance review (SPR) from standpoints of quality, technology, price, production, and the environment load. The scores are reflected in the evaluation criteria and purchase policy.

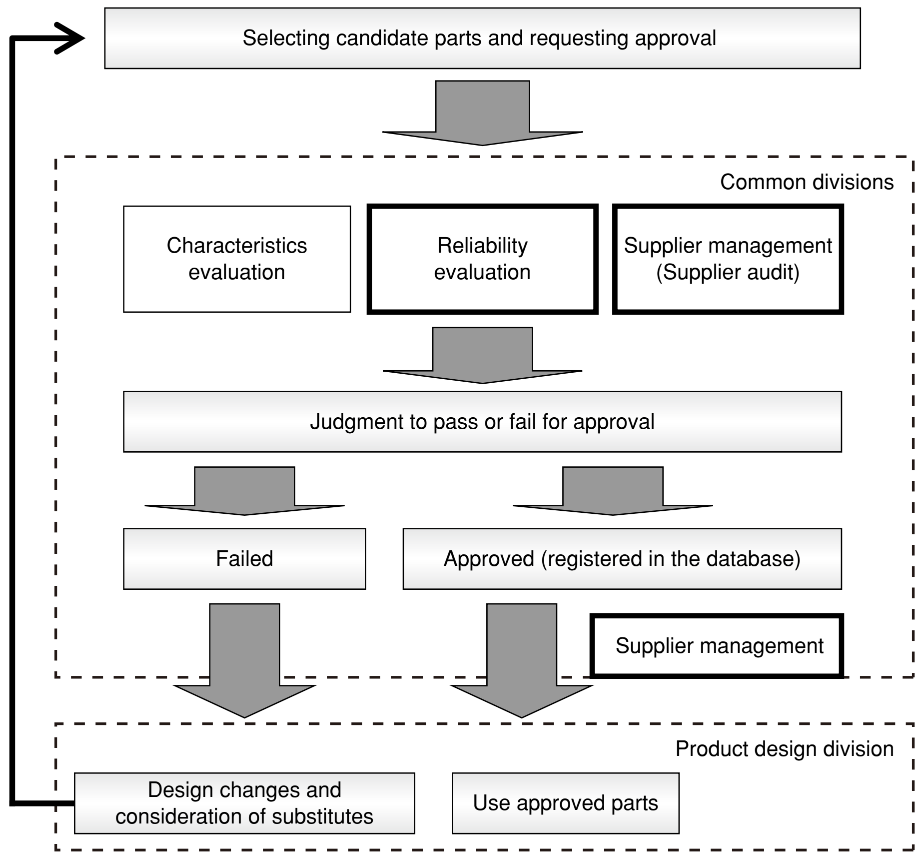

Figure 1
Approval flow.

3. Reliability evaluation

When purchasing parts, we reach agreement with the suppliers concerning the function, performance, and lifetime in the "specifications", and evaluate parts to verify contents of the specifications as required. Even when individual parts satisfy the specifications presented by suppliers, their specifications may prove insufficient for the operating conditions of the final products. Therefore, the agreement reached on specifications must be investigated in detail.

Electronic parts are often damaged by temperature and humidity. Given the four distinct seasons in Japan, there are large differences in temperature between summer and winter, such as the hot, humid weather during the rainy season, and the cold, dry winter. This represents one of the severest product environments in the world. Therefore, we consider such standard reliability test conditions defined by the Japan Electronics and Information Technology Industries Association (JEITA) to be inadequate. This is why we evaluate parts using temperature, humidity, and operating conditions based on such standards as a general guideline, and then by considering past evaluation results and failures claimed by customers.

More new materials have been recently adopted in order to comply with the RoHS directive (mentioned below), reduce costs, and enhance performance levels. We therefore focus on the materials themselves, precisely measure and analyze them in the nano realm to clarify the quality risks, and reduce the risks described below.

3.1 Evaluation of power supply modules

Power supply modules represent important parts that form the basis of product functions. These modules are subject to much higher safety risks, such as the generation of smoke and firing. Safety hazards attract a lot of attention from customers and have a very large effect on product images. Therefore, in addition to subjecting modules to elevated temperature, humidity, and electrical stress, we check the circuit diagrams of the modules to improve the precision of evaluations so we can identify circuits and structures that have insufficient safety or reliability. Based on the results, we improve the modules in order to establish the required levels of safety and reliability. Major evaluation items include:

1) Operations (when subject to input voltages, loads, and temperature changes) as specified in the specifications.
2) We verify the circuit diagrams to find circuits having problems relative to safety, current load, and other factors, and confirm those modules that do not generate overheating and the smoking mode (including fire retardancy) in case any part is damaged.
3) We investigate the effects of parts having a shorter lifetime (e.g., capacitors) mounted in the modules against the lifetime of modules.

3.2 Evaluation of LCD modules

LCD modules used for the displays of personal computers often have failure involving a Cold Cathode Fluorescent Lamp tube (CCFL tube) employed as a light source. In particular, such trouble includes overheating and the generation of smoke caused by inverter unit for cold cathode discharge tube, a shorter lifetime attributed to the structure of CCFL tubes, and heat and the generation of smoke attributed to assembled conditions.

We focus on investigating failure since heat and the generation of smoke in inverter circuits are related to safety. We also develop inexpensive circuits for use in detecting electrical noise generated when discharge phenomena generates heat.

The problem of short lifetime of CCFL tubes, on the other hand, occurs through the mechanism described as follows: The distribution of temperature in the CCFL tube initially lacks uniformity due to its structure and assembled conditions. Vaporized mercury eccentrically locates at the cold areas, which results in lower brightness and electrode wear out. Finally, the tube does not light up because of electrode falling and perforation of the glass wall. We must evaluate the movement of mercury in the same assembly condition as in the final product to detect these problems.

3.3 Evaluations of hard disk drive (HDD)

We consider the HDD a very important module, given its special characteristics relative to the storage of customer information. We conduct the following evaluations in close cooperation with suppliers to understand trends in technology, changing use conditions of the final products, and past incidents of failure.

1) Evaluation considering high density recording

The amount of head flying height in HDDs decreases as the bit density increases. This amount is now approaching the design limits. We cannot judge the stability of head flying height by evaluating standard running operations; instead, we should check the margin of head flying height at high temperature and low pressure condition.

2) Evaluation of operating stability in the Japanese market

HDDs have a higher failure rate in the Japanese market due to climatic conditions specific to Japan (i.e., dependence on temperature and humidity). We analyze incidents of past failure and evaluate products by setting evaluation conditions under which such cases can be detected.

- High temperature, low humidity, and short-term mode/high temperature, high humidity, and long-term mode
- First writing operation assurance just after power up at low temperature

3.4 Analysis at the material level

Various materials are used in purchased parts. Consequently, materials pose many problems relative to reliability. In particular, high-polymer materials, adhesives, adhesive tape, rubber, and similar materials pose such problems as deterioration due to aging, plasticizing deformation, and the generation of gas. Because it is important to judge the physical properties of materials, we make it a point to analyze the materials. We use precise analysis equipment for more precise evaluations of reliability.

3.5 Compliance with RoHS

Manufacturers are replacing parts with those that include no banned substance in complying with the RoHS (Restricting the use of Hazardous Substances) directive enforced in Europe on July 1, 2006. We consider these replacement materials to pose higher quality risks due to inferior physical properties and a limited record of past use. Fujitsu evaluates these replacement materials by focusing on the "moisture sensitivity in assembling" and the "formation of whiskers".

We review the applicable criteria of moisture sensitivity level test to comply with lead-free assembling. We also evaluate materials by focusing not on the formation of whiskers during a certain period, but the growth potential corresponding to lapsed time in order to prevent serious failure.

4. Failure analysis

This section describes the process for investigating the causes of failures detected in the evaluation of reliability. It is essential to investigate the causes of failures detected in the reliability tests and clarify the factors that accelerate failures, in order to improve the precision of evaluation and ensure the reliability of Fujitsu products.

4.1 Flow of failure analysis

The flow of failure analysis is explained here by using the example of LSI chip, which failed in a system (**Figure 2**).

We first confirm the state of a failure

through non-destructive inspection. Then we de-cap the suspected part and investigate the cause of failure.

In the initial non-destructive inspection, we conduct an external visual inspection, V/I curve tracing, an X-ray transmission investigation, and a Scanning Acoustic Tomograph investigation in this order. We judge whether there is any trouble with the package and the input/output sections of silicon dies. The V/I curve tracing is a method of electrically investigating the connection between external terminals and silicon dies in the package, and damage to the input/output sections of built-in silicon dies by utilizing the protection diode characteristics in those devices. The X-ray transmission investigation is used to check for any trouble involving abnormal shapes of the lead frame and lifted bonding wires. The Scanning Acoustic Tomograph investigation is a method of checking any interface delamination between the silicon die and mold compound that encapsulates it at the interface.

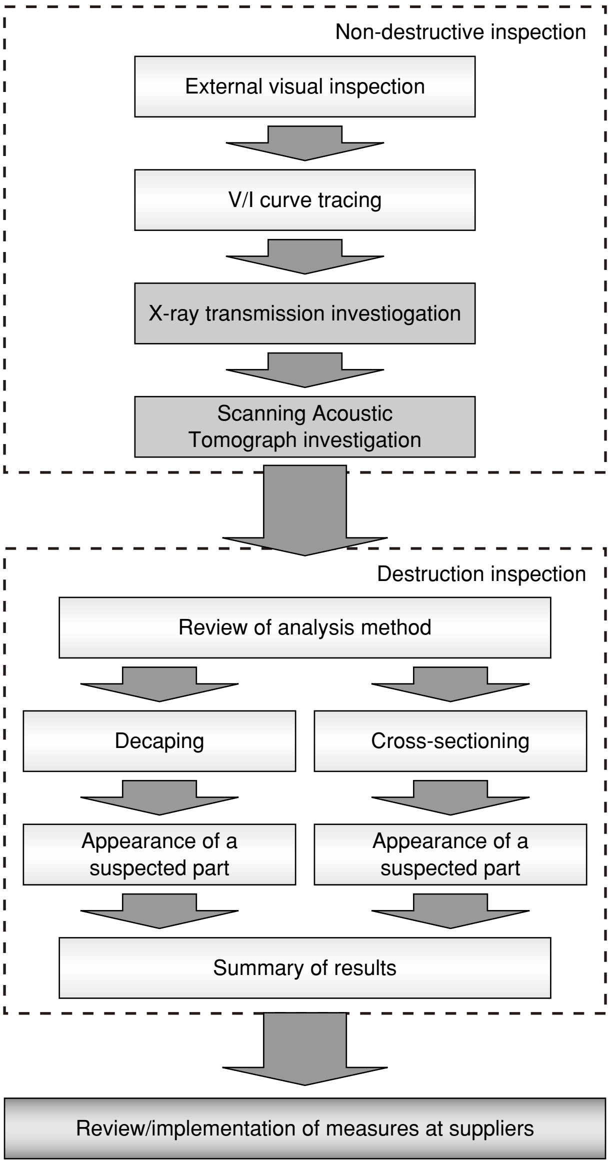

Figure 2
Failure analysis flow.

The mold compound includes much silicon filler so that the thermal expansion coefficient has a value similar to that of the silicon die, thus preventing delamination due to reflow thermal stress when mounting the LSI on a printed-circuit board. The bearing forces differ significantly depending on the LSI structure, silicon die size, and type of mold compound. The thermal stress at mounting may cause delamination and broken bonding wires in weak LSIs. Therefore, this analysis must confirm that there are no problems.

After identifying a failure in the input/output sections of a silicon die through non-destructive inspection, we de-cap the part by using chemicals and observe the suspected package under a microscope.

If a package-related problem such as delamination has been detected, we polish the cross-section of the package with a grinder. Then we observe the suspected part under a stereoscopic microscope and scanning electron microscope (SEM). We report the test results to parts suppliers, allowing them to reduce the period necessary to investigate causes and devise countermeasures.

4.2 Examples of analysis equipment

Fujitsu analyzes the causes of failures and identifies contamination material through detailed material analyses by using the following analyzer:

- SEM-EDX (Energy Dispersive X-ray spectrometer)
- Emission microscope
- Scanning Auger microprobe (**Figure 3**)
- FIB (Focused Ion Beam)
- EPMA (Electron Probe Micro Analyzer)

5. Supplier management

To ensure we purchase parts having the quality required for Fujitsu products, it is indispensable not only to perform the reliability evaluations and failure analyses described above but also enhance our cooperative relationships with suppliers. For that purpose, we do the following:

1) Conclusion of a Quality Assurance Agreement

We include a Quality Assurance Agreement in written documentation, set the same objectives and quality targets, promptly exchange information, and conduct effective improvement activities on an ongoing basis.

Stipulations include the quality targets, providing quality information in manufacturing processes and improvement information, cooperating in analyzing the causes of failures, failure analysis turn around time, engineering and process change notice, and providing information about the quality assurance system.

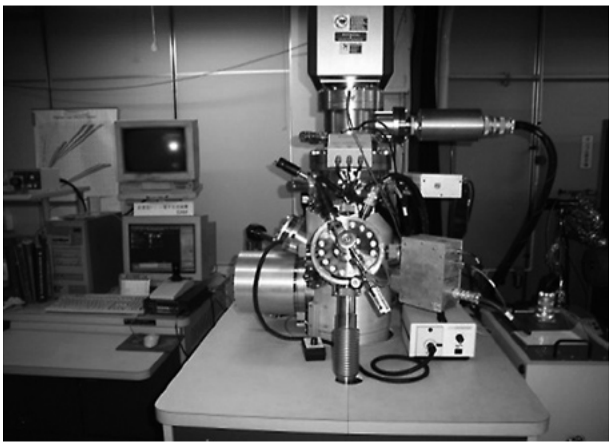

Figure 3
Scanning Auger microprobe.

2) Supplier audit

We should confirm that newly recruited suppliers have a sufficient quality assurance system and properly manage their manufacturing processes.

3) QC patrol

We should visit the manufacturing sites of suppliers on a regular basis, confirm that they are maintaining a quality assurance system, and exchange information about quality. We should also establish a strong commitment with the manufacturing sites and build up a trustful relationship in order to ensure that parts offering stable quality are supplied.

4) SPR

We should evaluate major suppliers from the standpoints of quality, price, technology, production, and environment load, and notify them of evaluation results on a regular basis. We ask suppliers to recognize their strengths and weak points based on these results, and cooperate in supplying parts offering stable quality.

These evaluation results are also reflected in purchasing activities for helping to enhance the cooperative relationship as directly linked to quality.

5) Supplier audit regarding compliance with RoHS

RoHS prohibits the use of six certain hazardous substances (lead, mercury, cadmium, hexavalent chromium, PBB, and PBDE) in products exported to Europe.

Fujitsu bans the use of 24 substances in accordance with its own Green Procurement Specification. We are now strictly controlling the use of those substances, beginning with the origin of the supply chain.

6. Future tasks and activities

The quality assurance activities for purchased parts have been previously explained. However, it is also true that there are many factors that inhibit stable evaluation and assurance activities. This section describes those factors and countermeasures.

1) Correspondence to new technologies (shift to higher performance levels and densities)

The purchased parts used in Fujitsu products are rapidly evolving. These parts often adopt new technologies. Therefore, we should consider the possibility of having to deal with new and previously unknown failures.

It is insufficient to evaluate already determined items against such unknown failures. Fujitsu has adopted a mechanism for accumulating related know-how at the evaluation review meetings previously described.

2) Sharing and exchanging know-how

This issue is related to the previous section. We should understand the properties of materials that constitute a part and the stresses (including special conditions) applied to the part under conditions of use by customers, in order to expose failures in parts that may cause other failures. This technique is akin to the skill of a craftsman. We have concerns about this challenge as we have encountered the year 2007 problem.

For this challenge, we utilize Fujitsu's characteristics in manufacturing products in multiple fields, unify the use conditions and failures of products in common divisions, list the problems and know-how concerned, and reflect them in evaluating parts.

7. Conclusion

In this paper, we described the concept of quality assurance for parts purchased by Fujitsu and some of Fujitsu's quality assurance activities. The quality of parts is directly linked to the quality of our products. We should improve the quality of parts, even if only slightly; reflect the improvements to the products that contain them; and adapt to the expectations of our customers. We can achieve these goals by enhancing the systems used for evaluating parts and strengthening our collaborative relationships with parts suppliers.

Teruhisa Kitani, *Fujitsu Quality Laboratory Ltd.*
Mr. Kitani graduated from the Industrial Engineering Department of Osaka Prefecture University in 1980. He joined Fujitsu Ltd., Kawasaki, Japan in 1980 and has been engaged in Quality Assurance of component part for computer system. He moved to Fujitsu Quality Laboratory Ltd. by company split-up of October, 2007.

Motoko Sazanami, *Fujitsu Quality Laboratory Ltd.*
Ms. Sazanami graduated from the Industrial and System Engineering department of Hosei University. She joined Fujitsu Ltd., Kawasaki, Japan in 1986, and has been engaged in quality assurance of IC/LSI for any information processing system. She moved to Fujitsu Quality Laboratory Ltd. by company split-up of October, 2007.

Masaru Seita, *Fujitsu Quality Laboratory Ltd.*
Mr. Seita graduated from the fiber faculty system engineering department of Shinshu University. He joined Fujitsu in 1989, was assigned to the incoming inspection section of the semiconductor, and developed the inspection equipment. Afterwards, He worked on the start-up of the reliability evaluation system of the file unit in 2001. He moved to Fujitsu Quality Laboratory Ltd. because the belonging section became independent in 2006. He takes charge of the reliability assessments of the module parts such as LCD and power supplies now.