9

9 Parts Selection and Management

To produce a product, there is usually a complex supply chain of companies that are involved directly and indirectly in producing and parts (materials) for the final product. Thus, to produce a reliable product, it is necessary to select the parts that have sufficient quality and are capable of delivering the expected performance for the targeted life-cycle conditions.

This chapter discusses parts selection and management. The key elements to a practical selection process are presented. Then, the practices necessary to ensure continued acceptability over the product life cycle are discussed.

9.1 Part Assessment Process

The parts (materials)[1] selection and management process is usually carried out by a multidisciplinary team, which develops part assessment criteria and acceptability levels to guide part selection. A part is selected if it conforms to the targeted requirements, is cost-effective and available[2] to meet the schedule requirements. If there are problems, the parts management team also helps to identify alternative sources of parts or ways to help the supplier produce a better part.

Many product design teams maintain a list of preferred parts of proven performance and reliability. A "preferred part" is typically mature, and has a history of successful manufacturing, assembly, and field operation, so it is usually the conservative approach to parts selection. Thus, in some cases, new technologies, processes, markets, materials, and price pressures make a mature part undesirable or obsolete. When a new product is being developed or a mature product improved, a new part may be required.

[1]In this book, the materials that comprise the product are also considered parts. This can include everything from structural materials, to added material ingredients, such as flame retardants.

[2]The availability of a part is a measure of the ease with which the part can be procured. Availability is assessed by determining the amount of inventory at hand, the number of parts required over the life of the product production, the economic order quantity for the part, the lead time between placing an order for the part and receiving the part, production schedules and deadlines, and part discontinuation plans.

Reliability Engineering, First Edition. Kailash C. Kapur and Michael Pecht.

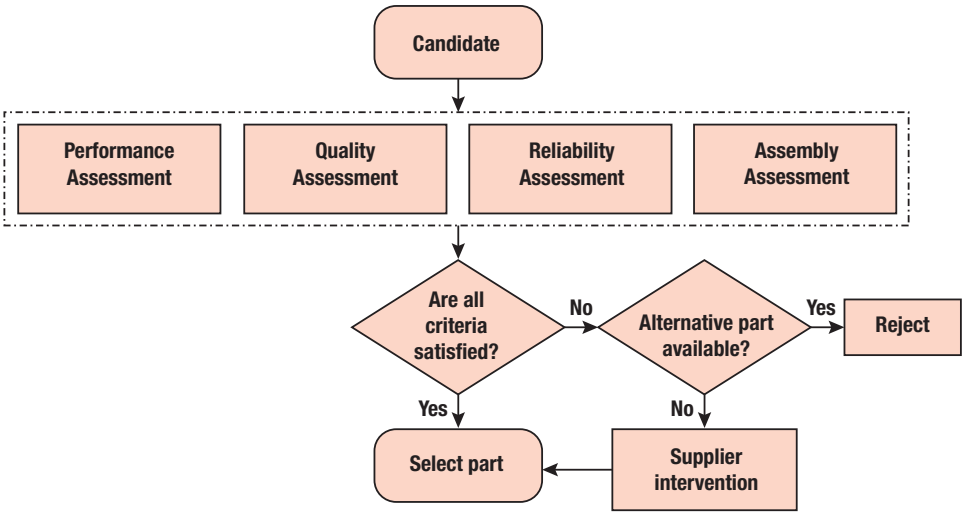

Figure 9.1 Part assessment process.

Because a company might make parts for many different customers, who have different target applications, it is not always possible for a customer of parts to dictate requirements. An "eyes-on, hands-off" approach may be needed to select parts with the required attributes. In some cases, the selection of a proper part might require an evaluation of the part, beyond that conducted by the part manufacturer.

Key elements of part assessment (see Figure 9.1) include performance quality, reliability, and ease of assembly. Performance is evaluated by functional assessment against the datasheet specifications. Quality is evaluated by process capability and outgoing quality metrics. Reliability is evaluated through part qualification and reliability test results. A part is acceptable from an assembly viewpoint if it is compatible with the downstream assembly equipment and processes.

Part assessment results may not remain valid if ingredients and process changes are made to the part. Even parts that are deemed acceptable may need to be reassessed periodically to ensure their continued acceptability.

If the part is not acceptable, then the assessment team must determine if an acceptable alternative is available. When no alternative is available, the team may have to pursue intervention techniques (e.g., work with the part manufacturer and conduct special screens) to mitigate the possible risks.

9.1.1 Performance Assessment

The goal of performance assessment is to evaluate the part's ability to meet the functional requirements (e.g., structural, mechanical, electrical, thermal, and biological) of the product. In general, there is often a minimum and a maximum limit beyond which the part may not function properly according to the datasheet specifications. These limits, or ratings, are often called the recommended operating conditions.

Manufacturers also typically set reliability limits for their parts, called absolute maximum rating. Companies who integrate parts into their products need to adapt their design so that the parts do not experience conditions beyond their absolute maximum ratings, even under the worst possible operating conditions (e.g., in

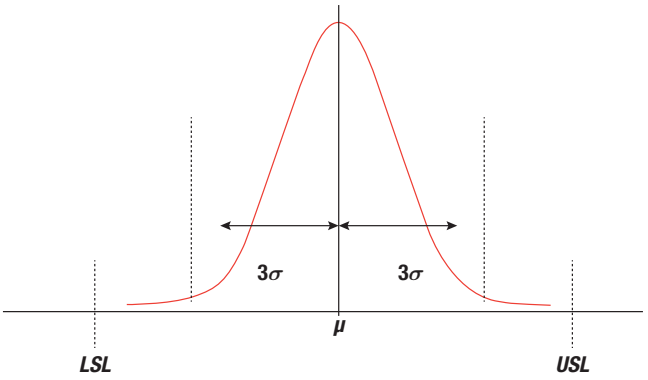

Figure 9.2 Distribution with 3σ process limits and upper and lower specification limits.

electrical products this would include supply voltage variations, load variations, and signal variations).[3]

9.1.2 Quality Assessment

Quality is associated with the workmanship of the product. Quality defects can result in premature (prior to that designed-for) failures of the product. To ensure designed-for reliability, it is necessary that the selected parts have acceptable quality. This is assessed by examining the control of the processes used to make the parts and the outgoing quality of the parts.

9.1.3 Process Capability Index

Statistical control of a process is arrived at by eliminating special causes of excessive variation one by one. Process capability is determined by the total variation that comes from common causes. Therefore, a process must first be brought into statistical control and then its capability to meet specifications can be assessed.

The process capability to meet specifications is usually measured by process capability indices that link process parameters to product design specifications. Using a single number, process capability indices measure the degree to which the stable process can meet the specifications (Kane 1986; Kotz and Lovelace 1998). If we denote the lower specification limit as LSL and the upper specification limit as USL, and if σ is the true value of the process, then the process capability index C_p is defined as:

$$C_p = \frac{USL - LSL}{6\sigma}, \tag{9.1}$$

which measures the potential process capability. It is obvious that Equation 9.1 does not have the process mean or expected value μ as well as any information about the target value T for the underlying quality characteristic. Figure 9.2 shows the normal

[3]Because the part might be used in a manner or in conditions in which it was not intended, a special process, called uprating, was developed. The term uprating was coined by Michael Pecht to signify the use of a part outside its recommended operating conditions (per the datasheet). The interested reader is referred to the book, Das, D., Pecht, M., and Pendse, N., *Rating and Uprating of Electronic Products*, CALCE EPSC Press, University of Maryland, College Park, MD, 2004.

distribution of a process, the 3σ limits from the mean, and the lower and upper specifications. In this figure, the process is centered between the specifications.

To measure the actual process capability for a noncentered process, we use C_{pk} that is defined as:

$$C_{pk} = \min\left(\frac{USL-\mu}{3\sigma}, \frac{\mu-LSL}{3\sigma}\right). \tag{9.2}$$

The measure of C_{pk} takes the process centering into account, by choosing the one side C_p for the specification limit closest to the process mean. The estimation of C_p and C_{pk} are obtained by replacing μ and σ using the estimates $\hat{\mu}$ and $\hat{\sigma}$ from the statistical control charts. To consider the variability in terms of both standard deviation and mean, another process capability index C_{pm} is defined as

$$\hat{C}_{pm} = \frac{USL-LSL}{6\hat{\tau}}, \tag{9.3}$$

where $\hat{\tau}$ is an estimator of the expected square deviation from the target, T, and is given by

$$\tau^2 = E\left[(X-T)^2\right] = \sigma^2 + (\mu-T)^2. \tag{9.4}$$

Therefore, if we know the estimate of C_p, we can estimate C_{pm} as

$$\hat{C}_{pm} = \frac{\hat{C}_p}{\sqrt{1+\left(\frac{\hat{\mu}-T}{\hat{\sigma}}\right)^2}}. \tag{9.5}$$

In addition to process capability indices, capability can also be described in terms of the distance of the process mean from the specification limits in standard deviation units, Z, that is

$$Z_U = \frac{USL-\hat{\mu}}{\hat{\sigma}}, \quad \text{and} \quad Z_L = \frac{\hat{\mu}-LSL}{\hat{\sigma}}. \tag{9.6}$$

Z-values can be used from a table of standard normal distribution to estimate the proportion of process nonconforming units for a normally distributed and statistically controlled process. The Z-value can also be converted to the capability index, C_{pk},

$$C_{pk} = \frac{Z_{\min}}{3} = \frac{1}{3}\min(Z_U, Z_L). \tag{9.7}$$

A process with $Z_{\min} = 3$, which could be described as having $\hat{\mu} \pm 3\hat{\sigma}$ capability, would have $C_{pk} = 1.00$. If $Z_{\min} = 4$, the process would have $\hat{\mu} \pm 4\hat{\sigma}$ capability and $C_{pk} = 1.33$.

Example 9.1

Find the fraction nonconforming items and the C_{pk} for a process with

$$\hat{\mu} = 0.738, \quad \hat{\sigma} = 0.0725, \quad USL = 0.9, \quad \text{and} \quad LSL = 0.5.$$

Also discuss various improvement strategies.

Solution:
Since the process have two-sided specification limits,

$$\begin{aligned} Z_{\min} &= \min\left(\frac{USL-\hat{\mu}}{\hat{\sigma}}, \frac{\hat{\mu}-LSL}{\hat{\sigma}}\right) = \min\left(\frac{0.9-0.738}{0.0725}, \frac{0.738-0.5}{0.0725}\right) \\ &= \min(2.23, 3.28) = 2.23. \end{aligned}$$

The fraction nonconforming p can be calculated as

$$p = 1-\Phi(2.23)+\Phi(-3.28) = 0.0129+0.0005 = 0.0134.$$

The process capability index using Equation 9.7 is

$$C_{pk} = \frac{Z_{\min}}{3} = 0.74.$$

If the process could be adjusted toward the center of the specification, the proportion of process nonconforming can be reduced, even with no reduction in σ, because we have

$$Z_{\min} = \min\left(\frac{USL-\hat{\mu}}{\hat{\sigma}}, \frac{\hat{\mu}-LSL}{\hat{\sigma}}\right) = \min\left(\frac{0.9-0.7}{0.0725}, \frac{0.7-0.5}{0.0725}\right) = 2.76,$$

and the proportion of process fallout would be:

$$p = 2\Phi(-2.76) = 0.0058.$$

The process capability index increases to

$$C_{pk} = \frac{Z_{\min}}{3} = 0.92.$$

To improve the actual process performance in a long run, the variation from common causes must be reduced. If the capability criterion is $\hat{\mu} \pm 4\hat{\sigma}$, ($Z_{\min} \geq 4$), the process standard deviation for a centered process would be:

$$\sigma_{\text{new}} = \frac{USL-\hat{\mu}}{Z_{\min}} = \frac{0.9-0.7}{4} = 0.05.$$

Therefore, actions should be taken to reduce the process standard deviation from 0.0725 to 0.05, or about 31%.

At this point, the process has been brought into statistical control and its capability has been described in terms of process capability index or $Z_{\min}$. The next step is to evaluate the process capability in terms of meeting customer requirements. The fundamental goal is never-ending improvement in process performance. In the near term, however, priorities must be set as to which processes should receive attention first. This is essentially an economic decision. The circumstances vary from case to case, depending on the nature of the particular process in question. While each such decision could be resolved individually, it is often helpful to use broader guidelines to set priorities and promote consistency of improvement efforts. For instance, certain procedures require $C_{pk} > 1.33$, and further specify $C_{pk} = 1.50$ for new processes. These requirements are intended to assure a minimum performance level that is consistent among characteristics, products, and manufacturing sources.

Whether in response to a capability criterion that has not been met, or to the continuing need for improvement of cost and quality performance even beyond minimum capability requirement, the action required is the same: improve the process performance by reducing the variation that comes from common causes. This means taking management action to improve the system.

9.1.4 Average Outgoing Quality

Average outgoing quality (AOQ) is defined as the average nonconforming part lot fraction from a series of lots, based on sample testing. It represents the total number of parts that are outside specification limits, as determined from sample tests conducted during the final quality control inspection. This number reflects the estimated number of defective parts that will be received by the customer. AOQ is usually reported in parts per million (ppm).

AOQ reflects the effectiveness (or lack of it) of the part manufacturer's quality management system. An effective quality management system will minimize the total number of nonconformities produced, as well as the number that are shipped. High values of AOQ represent a high defective count, implying poor quality management. Low values reflect high part quality.

If all parts are tested prior to shipping, then theoretically, the AOQ should always be zero because all nonconformities should be removed. However, if a large volume of parts is produced, it is usually impractical to test all parts. Instead, a sample is tested, and an estimation of the AOQ is calculated from it.

The parts management team should establish threshold AOQ requirements to determine part acceptability. Limits should be defined to differentiate acceptable and unacceptable parts. Some factors to be considered include application, testability and diagnosability, production volume, reworkability, and the target cost.

9.1.5 Reliability Assessment

Reliability assessment is a means to obtain information about the ability of a part to meet the required performance specifications in its targeted life-cycle application for a specified period of time. If the parametric and functional requirements of the product cannot be met, then a different part may have to be used, or some product changes will be necessary, such as reducing the loads acting on the part, adding redundancy, or implementing maintenance.

Reliability assessment includes the evaluation of supplier qualification data, reliability life testing, and reliability monitoring tests. In some cases, failure models will be needed to assess the results of the tests against the target performance and reliability objectives. Once all the parts are selected and incorporated into a product, there will be additional tests to determine the reliability of the product as a whole. Product tests are necessary to assess the parts under the targeted conditions, and include the effects of assembly, the interaction of parts and the loads that the parts generate.

Most often, the suppliers of parts will not know, and may not want to know, the life-cycle usage profiles, load conditions, and reliability targets of the final product. As a result, suppliers generally follow guidelines and standards when they assess the reliability of their parts, to provide some standard level of assurance to potential customers, and to baseline the reliability of a part against that of previous parts and other parts accepted by the industry. The test results are generally published in a document or on the Internet. Most manufacturers provide test results in terms of the number of failures and the sample size tested.

Qualification tests are conducted prior to volume manufacturing. The purpose is to ensure that the nominal product will meet some standard level. The sample size may range from one to hundreds of parts, depending on the cost, volume to be sold, and risk. For example, some precision sensor parts are so expensive and only a few are ever sold, that only a few are normally tested. On the other hand, many hundreds of parts are qualified when producing a new semiconductor device.

Qualification tests usually employ a wide range of load conditions to assess reliability. These load conditions may include high and low temperature, temperature cycling, thermal shock, vibrations, mechanical shock, various humidity conditions, dust, and contamination. These conditions may be much more severe and exhaustive than those seen in the field. Generally, the tests are conducted for a specified time, number of cycles, step loading, and so on. In some cases, a company may wish to test to failure (called life tests) to determine the limits of the part, but again this depends on the time consumed, the costs, and the perceived risks.

Qualification tests should be repeated if any changes to the materials, processes, structure and operation of the part, could possibly change the failure mechanisms. If the changes are not significant, then reliability monitoring tests are used to assess the ongoing reliability level.

Reliability monitoring tests are conducted at intervals in the manufacturing process, to ensure that the nominal product continues to meet some standard level, especially if there are continuous improvements being made to the materials, processes, structure, and operation of the part. For electronic parts, companies often conduct reliability monitoring tests at least twice per year, and sometimes quarterly.

Reliability monitoring tests are typically some subset of the qualification tests, which have been determined to be the most applicable to the specific part, in terms of the potential failure mechanisms that could be precipitated. However, the test conditions are still usually accelerated and will often be more severe and exhaustive than those seen in the field. Similar to qualification, the sample size may range from one to hundreds, typically depending on the cost, volume to be sold, and risk.

It is the responsibility of the company that selects the parts for use in the final product, to determine if the magnitude and duration of the life-cycle conditions are less severe than those of the reliability tests, and if the test sample size and results are acceptable, the part reliability should be acceptable. If the reliability test data are

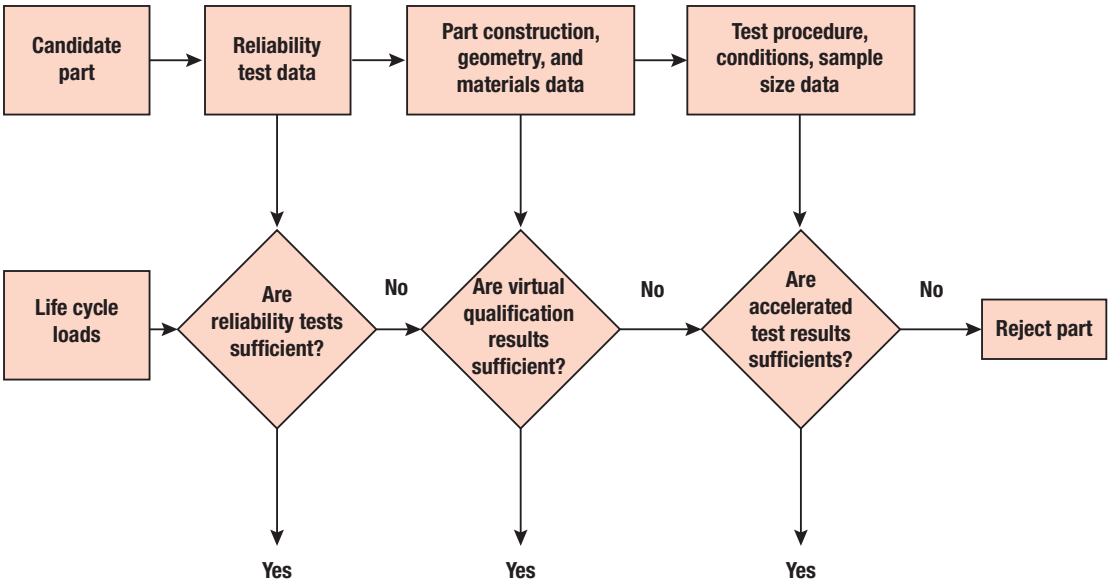

Figure 9.3 Decision process for part reliability assessment.

insufficient to validate part reliability in the application, then additional tests and virtual qualification should be considered. The process flow is show in Figure 9.3. Reliability monitor tests are also called life tests, continuous monitor tests, and environmental tests.

Results should include test types, test conditions, duration, sample size, and number of failures. Root cause analysis should be performed for all failures. If any failures are reported, parts manufactured during the same period as those that the data represent must be cautiously evaluated, and possibly rejected for use. In addition, the same kind of defect may exist in other nontested parts.

Virtual qualification is a simulation-based methodology used to identify the dominant failure mechanisms associated with the part under the life-cycle conditions, to determine the acceleration factor for a given set of accelerated test parameters, and to determine the time-to-failures corresponding to the identified failure mechanisms. Virtual qualification allows the operator to optimize the part parameters (e.g., dimensions and materials) so that the minimum time-to-failure of any part is greater than the expected product life.

Whether integrity test data, virtual qualification results, accelerated test results, or a combination thereof are used, each applicable failure mechanism to which the part is susceptible must be addressed. If part reliability is not ensured through the reliability assessment process, the equipment supplier must consider an alternate part or product redesign. If redesign is not considered a viable option, the part should be rejected, and an alternate part must be selected. If the part must be used in the application, redesign options may include load (e.g., thermal, electrical, and mechanical) management techniques, vibration and shock, damping, and modifying assembly parameters. If product design changes are made, part reliability must be reassessed.

Reliability assessment results provide information about the ability of a part to meet the required performance specifications in its targeted life-cycle application for a specified period of time. If the parametric and functional requirements of the system

cannot be met, then the load acting on the part may have to be lessened, or a different part may have to be used.

9.1.6 Assembly Assessment

Assembly guidelines are recommendations by the part manufacturer to prevent damage (e.g., defects) and deterioration of the part during the assembly process. Examples of assembly can include recommended temperature assembly profiles, cleaning agents, adhesives, moisture sensitivity, and electrical protection. Assembly guidelines could also include information regarding part compatibility with equipment or dependent technologies (e.g., heat sinks and paints). As new technologies emerge and products become more complex, assembly guidelines become more important to ensure the quality and integrity of parts used within the product.

9.2 Parts Management

After a part is accepted, resources must be applied to manage the life cycle of the parts used in the product. This typically includes supply chain management, obsolescence assessment, manufacturing and assembly feedback, manufacturer warranties management, and field failure and root-cause analysis.

9.2.1 Supply Chain Management

In supply chain management, one of the key risks is associated with change. Changes occur for many reasons. For example, there may be shifts in consumer demand, new market challenges, advances in technology, and evolution in regulatory requirements and standards. All these changes affect supply-chain interactions.

Changes of concern to product reliability include a change in the companies that comprise the supply chain, a change in any of the materials and processes used to make the part and control quality, a change in any of the processes in which the part is assembled into the product, and a change in any other assembly process (not directly associated with the part) that could affect the reliability of the part.

A change in a company or a company's practices must be considered a risk in the production of a product. In general, no two companies make a product exactly the same way. Furthermore, a common company name does not ensure the same quality system and policies at each of the manufacturer's different locations. A part can be fabricated and assembled at multiple locations around the world and subjected to different company quality policies. In fact, companies may have different quality certifications from site to site. Different certifications can cover different areas of a quality system, and certification audits may examine different criteria (see Table 9.1). Because a part may be manufactured at different sites, and these sites may have different quality policies and certifications, the actual manufacturer of a candidate part should be identified and assessed.

In the manufacturer's supply chain assessment, the manufacturer's quality policies are assessed with respect to five assessment categories: process control; handling, storage, and shipping controls; corrective and preventive actions; product traceability; and change notification (Figure 9.4). These categories contain the minimum set of criteria necessary to monitor the supply chain.

Table 9.1 Example of Fairchild semiconductor corporation certifications[a]

Site	Certificate type	Certifying body
Cebu, the Philippines	ISO-9001 and QS-9000	DNV
	Qualification of Transistors & Diodes for Delco Electronics	Delco Electronics
Penang, Malaysia	ISO-9001 and QS-9000	DNV
	Stack Level 2 Supplier Certification	Stack International
	AEC-A100	AEC
	QSA Semiconductor Edition	
Puchon, South Korea	ISO-9001 and QS-9000	BSI
South Portland, Maine	ISO-9001 and QS-9000	DNV
	Stack Level 1 Supplier Certification	Stack International
Wuxi, Jiangsu, China	ISO-9001 and QS-9000	TÜV Cert

[a]Fairchild Semiconductor, "Fairchild Semiconductor Quality Certificates," South Portland, ME, http://www.fairchildsemi.com/company/quality.html, accessed November 16, 2013.

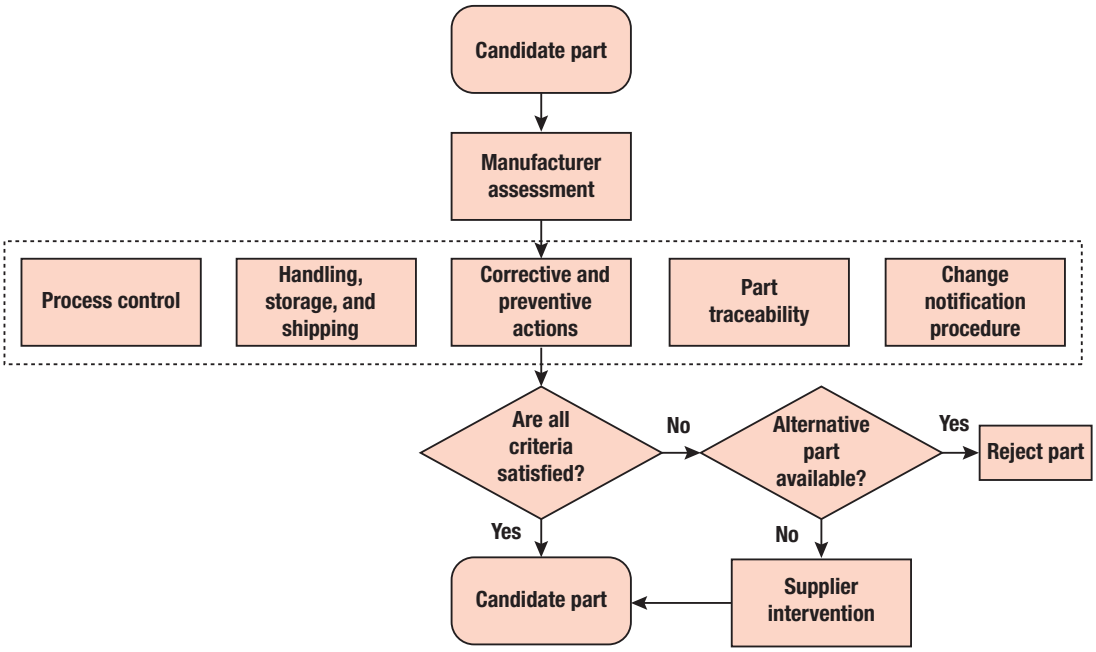

Figure 9.4 Manufacturing assessment process flowchart.

9.2.2 Part Change Management

Changes to parts are made throughout the life cycles of the parts. These changes are usually managed by a manufacturer's change control board. The policies of these boards generally vary from one manufacturer to another.

The types of changes that are made to parts, as well as the motivations for making changes, depend on the life-cycle stage of the parts. For example, a typical semiconductor part goes through sequential phases of introduction, growth, maturity, decline, and obsolescence (see Figure 9.5).

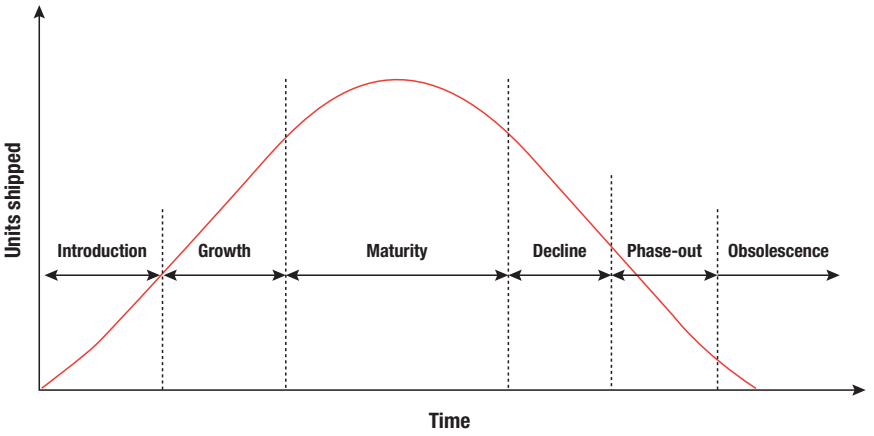

Figure 9.5 Typical life-cycle of an electronic part.

During the introduction stage, the changes implemented are mostly design improvements and manufacturing process adjustments. The part may be continuously modified so that it can meet datasheet requirements, achieve economic yields, and meet reliability and quality requirements.

During the growth and maturity stages, a part is in high volume production. Changes are implemented both to enhance the part and to minimize costs. Feature enhancements may be made to maintain competitiveness and generate new interest in the part. Material, fabrication, and assembly and testing locations may change to reflect changing business needs and capacity. Changes to improve yields and minimize costs may be necessary to maintain competitiveness in the marketplace.

During the decline stage of the part, sales levels start dropping, and manufacturers try to transition customers to newer parts and technologies. Part discontinuance usually occurs when the volume of sales for a part drops to the point where the part can no longer be profitably manufactured. However, it could also occur when a semiconductor company transitions its facilities to a new manufacturing technology.

After the part has been discontinued, it is in the obsolescence stage. Parts are no longer available for purchase, and costumer of parts must utilize stockpiled parts, obtain parts from an aftermarket source, find an equivalent substitute parts, or redesign their products.

9.2.3 Industry Change Control Policies

For most part manufacturers, the change process starts with the submission of a proposal to a change control board, sometimes called an engineering control board This board is usually composed of people from all major divisions within the company, including marketing, manufacturing, product engineering, and reliability engineering. Any division within the company can propose a change to the board.

Upon receipt of the change proposal, the board classifies the change according to some internal classification process. This classification involves deciding how significantly the form, fit, or function of the part would be affected by the change. Part characterization and reliability test results, contractual agreements with customers, and the number of parts affected by the change are also considered. If the

board determines that the benefits of the change outweigh the risks, the change is approved.

Change classification systems and change control policies vary widely from one company to the next. Many companies have policies detailing the amount of testing that needs to be conducted to propose a change to a change control board. Many companies also have policies on how quickly the changes are phased into production. The change control process for IBM Microelectronics is illustrated in Figure 9.6. When, all changes go through a single standardized review process, regardless of the type of change.

Change is an inevitable aspect of part manufacturing. The development of new technologies and manufacturing processes, constantly changing business forces, and the emergence of new environmental regulations all necessitate change for a manufacturer to remain competitive. The manner in which a manufacturer manages change can have a large impact on economic success and customer satisfaction. If changes are not implemented in a controlled manner, changes that adversely affect part reliability are more likely to be inadvertently made, damaging the reputation of a manufacturer and increasing the risk of liability. If changes are made frequently or if insufficient notice or reason is provided for changes, manufacturers can also receive negative reactions from customers.

Effective change notification requires manufacturers to communicate with their customers frequently and openly, so that a bond of understanding can develop. The complete effects of changes are often unknown, and the distinction between major and minor changes is often fuzzy. Change control is therefore not only a science but also an art.

For original equipment manufacturers (OEMs), change tracking is becoming increasingly complicated. As captive parts suppliers are divested, the amount of control OEMs have over the change control process has diminished. An increasing number of companies are also purchasing through distributors and contract manufacturers, increasing the number of paths for the flow of change notification information through the supply chain. OEMs must therefore take an active role in the change tracking process and establish contractual agreements with the manufacturers, distributors, and contract manufacturers from which they purchase parts to ensure that they receive the change notifications they need. Larger OEMs that have the benefit of being able to work directly with part manufacturers should clarify what types of changes result in notifications and make special arrangements to address any omissions from this list that may affect their products. A request to be included on advance notification lists allows the most advance warning of impending changes to be received as soon as possible, often early enough so that feedback to the part manufacturer that may influence the implementation of the change can be provided.

9.3 Risk Management

The risks associated with incorporating a part into a product fall into two categories:

- *Managed Risks.* Risks that the product development team chooses to proactively manage by creating a management plan and performing a prescribed

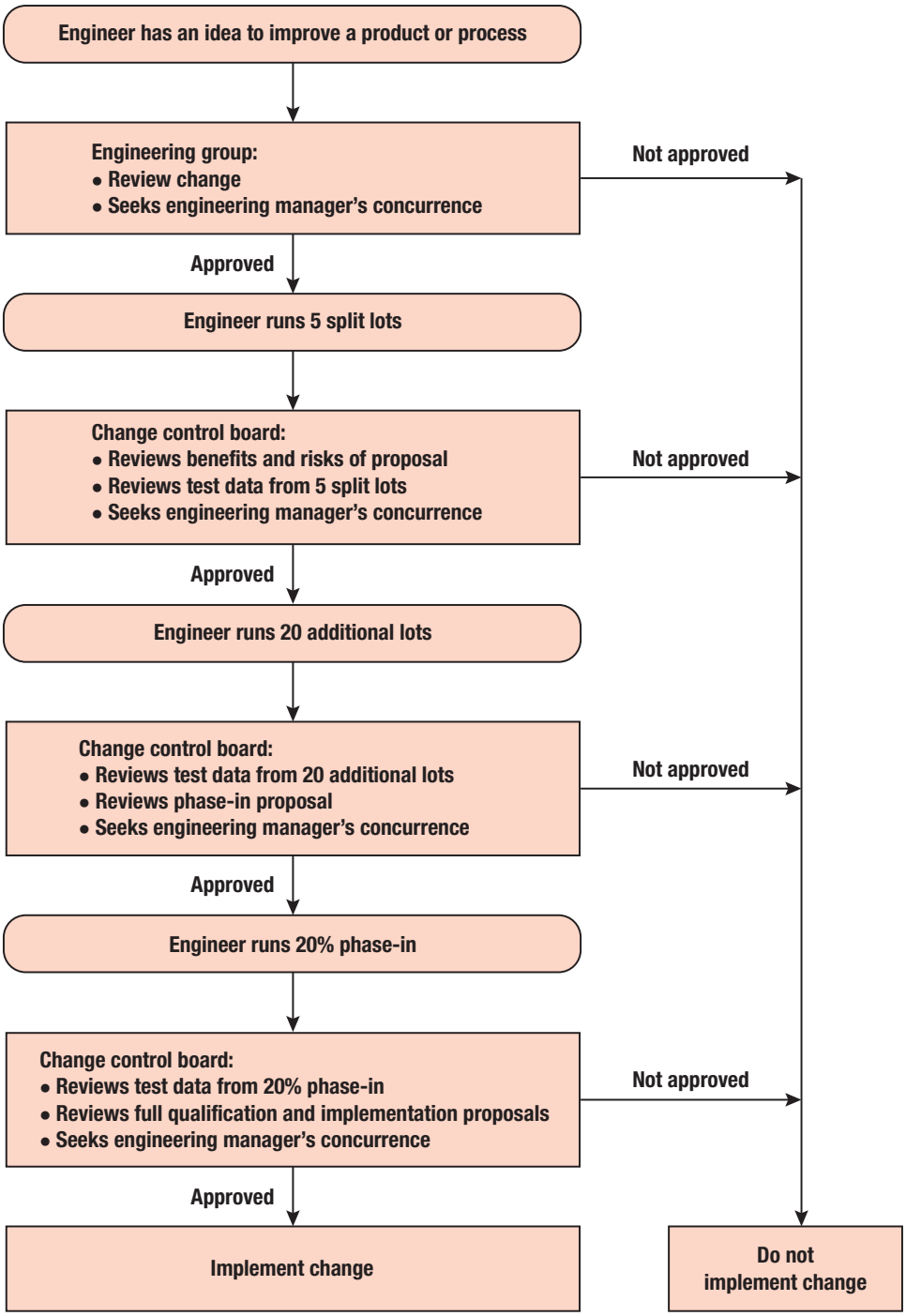

Figure 9.6 Change control process at IBM Microelectronics.

regimen of monitoring the manufacturer of the part, and the part's fabrication and field performance.

- *Unmanaged Risks.* Risks that the product development team chooses not to proactively manage.

If risk management is considered necessary, a plan should be prepared. The plan should contain guidance on how the part is monitored (data collection), and how the results of the monitoring feed back into various manufacturers and parts selection and management processes. The feasibility, effort, and cost involved in management processes should be considered prior to the final decision to select the part. In addition, feedback regarding the part's assembly performance, field performance, and sales history is also essential to ascertain the reliability risks.

9.4 Summary

For many products, there is a complex supply chain involved in producing parts for the final product. To produce a reliable product, it is necessary to select quality parts capable of reliable performance under the life-cycle conditions. The parts selection and management process is usually carried out by a product development team that develops part assessment criteria to guide part selection. Based on these criteria, a part is selected if it conforms to the targeted requirements, is cost-effective, and is available to meet the schedule requirements.

Key elements of part assessment include performance quality, reliability, and ease of assembly. Performance is evaluated by functional assessment against the datasheet specifications. Quality is evaluated by process capability and outgoing quality metrics. Reliability is evaluated through part qualification and reliability test results. A part is acceptable from an assembly viewpoint if it is compatible with the downstream assembly equipment and processes.

In supply chain management, one of the key risks is associated with change. Changes of concern to product reliability include a change in the companies that comprise the supply chain, a change in any of the materials and processes used to make the part and control quality, a change in any of the processes in which the part is assembled into the product, and a change in any other assembly process that could affect the reliability of the part.

The risks associated with incorporating a part into a product fall into two categories: managed risks, which are risks that the product development team chooses to proactively manage, including monitoring the manufacturer of the part; and unmanaged risks, which are risks that the product development team chooses not to proactively manage. A risk management plan should also be prepared. The plan should contain guidance on how a particular part is to be monitored, and how the results of the monitoring will feed back into various parts selection and management processes.

Ensuring the quality of the supply chain is essential for ensuring the quality of a manufactured product. Companies must be proactive in part assessment, managing changes, and risk assessment in order to ensure that their final products are reliable in the field.

Problems

9.1 Discuss the different test data that can be used to assess reliability of parts. Which of these data are most appropriate in making reliability assessments?

9.2 Consider the supply-chain assessment in parts selection and management.

(a) How does the supply-chain assessment help in developing reliable products?
(b) Why is the identification of each company in the supply-chain of value in the design of reliable products?
(c) If you have already assessed a manufacturer, and then the company changes its name, is it necessary to reassess the manufacturer? Explain the various possible circumstances.

9.3 Identify the following as a quality issue or a reliability issue, or both. Explain why.

(a) Two out of every 10 products made have a critical part put in backward that causes malfunction in test.
(b) Devices show failure after a 1000-hour long, 125°C high temperature operating life test during qualification testing.
(c) One out of every five shafts produced is out of tolerance.
(d) One out of every five devices has a joint that weakens in operation after 3–5 years in a 10-year application, causing electrical signal noise to increase over the allowed performance limit.

9.4 Find C_{pk} for $\mu = 3$, $\sigma = 0.45$, $USL = 4.3$, and $LSL = 1.9$. Comment on the result.