

I

Introduction

Preface

Product quality is an important matter in industry. It becomes more and more important given the recent trend that customers evaluate goods critically and make complaints about any issues that arise. Managers of companies, though they did not recognize it before, will now need to appreciate the following situation. In order for companies to be successful in modern society it is of fundamental importance for them to maintain the quality of products at the highest level possible, subject to operating profitably and producing products of uniform quality with reliable methods.

To realize this it is necessary to explain concretely to the managers of companies what management needs to do. The most important management principle for maintaining a high-quality product is to establish company-wide determination to serve their customers. After this is established and a firm decision is made to endeavor to maintain a reputation for high-quality products, management should inform all the employees of this strict requirement for product quality. Managers should take the initiative in related activities. They should show with their behavior that quality is their company motto, and they also should try to ensure that the workplace environment is conducive to maintaining the highest possible product quality.

The policies for the control and management of a company should be practical and informed by progressive ideas, and they should be adhered to. Analyze the market to obtain the information on customer needs, then design and produce the products based on the result of analysis so that production is profitable. Calculate and control the costs required for planning, production, and control, and avoid waste. Whether or not it is possible to maintain high quality really depends on the design and the administrative efficiency of the company. From the above standpoint, treatment and training of the employees is very important.

It will be difficult to maintain the required level of product quality without management and employees being in perfect agreement about the meaning of quality. Employees, including those working in factories and those working in offices, should be trained so that they are willing to cooperate with management. They should be trained to contribute to producing products of high quality and to understand that their efforts will result in profit not only to the company but also to themselves.

Since such a way of thinking does not occur naturally, management should take the initiative in training activities. If good plans are incorporated into the training programs for mental activities as well as for physical labor, the effects would spread into every area of the company. The basic thinking needed to improve the quality of output is common in the divisions related to physical labor and mental activity.

So far, we have discussed the problem of quality from the standpoint of management. Now we discuss it from the standpoint of operation. A reliable consistent production process and products with uniform quality can be achieved only when the production process is planned and controlled using scientific methods for the purpose of producing products of high quality.

Design, production method, and standards for materials and process specification should be appropriate, accurate and efficient, and they should be obeyed strictly. Workers should be trained and supervised so that they can understand and carry out their jobs well. Machines, equipment, instruments, tools, and skills of workers should be suited to carrying out the required tasks within the assigned time using appropriate methods.

Even if all the above conditions are satisfied, however, it is not generally easy to maintain product quality. This is because there is a shortcoming in the control system in general management. Recently, a lot of research has been done to address this shortcoming, and as a result some tools have been developed. They are statistical methods developed for the purpose of maintaining the quality of the production process. Using these methods, we can determine product quality with pre-assigned accuracy, and in addition we can improve the efficiency of production and also reduce costs. Scientifically speaking, the main aim of these methods is to control the factors that affect the quality of the final products going out to the market.

Establishment of a system of statistical quality control provides various advantages to the company as follows.

- a. Variation of quality of the continuous production process is minimized.
- b. Data based on samples taken from the production process provide reliable information to judge the state of the quality of the process.
- c. Inspection cost (indirectly production cost) is minimized.
- d. It is possible to obtain reliable basic information to test whether the current design and control limits for quality are appropriate or not.

- e. It is possible to obtain practical basic information to assess the current production capability.
- f. The results of sampling inspection usually provide proof of the actual quality of the products.

There can be no doubt that quality is the most essential foundation for a company to be successful. This has been demonstrated by many substantial companies. Quality is recognized as the most important matter. Therefore, it is necessary to position quality as the sound logical foundation for management and to adopt quality control as one of the valuable control methods among the industrial factors that are vital to the prosperity of the company.

There are two fundamental tasks necessary for successful practice of quality control. They are (1) to set up a system of control, and (2) to execute the actions resulting from the system of control.

The latter requires the support of management to ensure that the newly established system of control has a chance to work successfully; while the former provides the technical means, within which statistical quality control plays the principal role. We shall discuss these matters in detail below. There are some preliminary steps required to set up the initial control system. You should perform these logical steps one by one. However, as it is not essential to complete one step before proceeding to the next, it is sometimes convenient to perform some steps in parallel.

Step 1. Establishing the Quality Standard

Product quality captures the special characteristics useful for discriminating one's products from those of rival companies, special characteristics for discriminating among the same kind of products, or special characteristics for grading the products of the same production process. There are two purposes for quality. One is to demonstrate that two or more products are in the same category, as occurs when comparing the products manufactured by rival companies. The other is as a measure of fitness for purpose.

In either case quality is not measured on an absolute scale but merely on a relative scale. One can say that something is good from a certain point of view only when it is compared with some standard on a one-dimensional scale. In such cases quality becomes a variable and the result of a comparison can be expressed as quality being higher or lower (better or worse) than the standard.

When defining the quality of a product, possible characteristics related to the goodness of quality include size, materials, shape, chemical components, function, fitness for purpose, appearance, and practicability. These characteristics depend on (a) quality of design or (b) quality compared with the standard. The former relates to technical specification for manufacturing, and the latter

relates to the method for comparing with the standard and the extent of difference from the standard.

Quality of design includes the problem of the trade-off between cost and outcome. It is a commercial issue to be considered carefully by both engineers and administrators. Consider an ideal case where engineers design a product with the best quality. If nobody buys the product in the market because of high cost, the idealistic engineers are to blame. If the engineers pursue high product quality simply for the sake of quality itself without any consideration for the practical use of the product, they are not fulfilling their duties. The engineers are responsible for the commercial aspect of the product as well.

If the accuracy of size, chemical purity, or any other quality attribute improves, the value of the product increases, but so does the cost. Eventually, comparing the additional value of the product that is due to an improvement of quality and the increase in cost required for the improvement, the point at which the latter exceeds the former will be the limit for quality improvement. Therefore, it is necessary for the engineers involved in production engineering and those involved in the production process to set the quality standard so that the standard is consistent with the reason for producing the product while the cost remains commercially viable.

The problem of quality versus cost discussed above also occurs in connection with quality compared with the technical standard. For example, suppose there is a production process in which 0.1% defective items are constantly produced. That is, on average there is one unit whose quality is below the required level among 1000 units produced in a day. It is necessary to inspect 1000 units per day in order to detect one defective unit. Ordinarily the inspection cost for 1000 units is much higher than the cost of the loss or inconvenience of a customer who buys the defective unit. In such cases it seems it is more economical not to carry out 100% inspection. It reduces the cost if we perform sampling inspection instead of 100% inspection, to gain assurance that the percent defective is less than 0.1%. Customers will be satisfied if an agreement is made in advance such that, when a customer happens to buy a defective unit, it will be replaced by a non-defective one or the possible loss will be compensated. The reason is that the cost required for 100% inspection causes an increase in the price of the product, which is not good for customers.

As the cost of quality is a vital factor in establishing the quality standard for the design or the technical standards, management should cooperate with the engineers to try to strike an appropriate balance between the cost of maintaining quality and the market price of the products. Among many factors that affect this issue, the main ones are as follows.

1. Desire of the manufacturer to maintain their reputation with their customers.
2. Quality of product design.

3. Skills of workers and quality of machines or tools needed to meet the prescribed quality requirements.
4. Research into target market, market needs for functionality, and requests from the market for practicability and price.
5. Rapid management capability to get access to raw materials.
6. Other economic factors related to achieving the required quality with reasonable production cost.

Step 2. Establishing a Section to Evaluate Quality

Having chosen the appropriate quality standard, it is necessary to establish a section to assess whether or not the produced products conform to the quality policy of the company. The assessment is made by inspectors in the company. Inspectors have duties to test the products against the quality standard set by engineers in the company. The relation between inspectors and the company is just like the relation between public prosecutors and a democratically elected government. In the case of government it consists of three independent divisions, *viz.* divisions of administration, legislature, and prosecution, for mutual inspection and maintaining balance. The administration practices the law which is made by the legislature, and the prosecutors check on whether the law is violated.

In a company, the administration division is represented by the chief officer and the general manager. For manufacturing, the duty of the legislature is practiced by the department of design. The duty of inspection is similar to that of prosecution: the inspectors judge whether the products satisfy the quality requirements by comparing them with the specification and standard decided by the department of design.

Of course, quality must be built into a product. It is not possible to change defective items to non-defective ones by inspection. The quality of products is not determined by inspection. An inspector's responsibility is simply to judge whether or not quality is of the required level.

Generally, responsibility is divided as described above, that is, the inspection department operates independently of the division of manufacturing. This is because in most companies it is desirable and necessary to do so.

Thus the three divisions, that is, the planning division for deciding on designs and standards, the manufacturing division for producing products based on the designs, and the inspection division for evaluating the quality level, are of the same rank and have their own independent functions.

If product quality is below the quality standard, it will be due to one or both of the following reasons: (1) design and specification made by the planning division are not good; or (2) the manufacturing division cannot produce products according to the design and specification, either because of a lack of capability

or because of failures in the manufacturing process. It is important to keep the inspection division independent of the planning and manufacturing divisions in order to maintain the reputation of the quality of the products. When product quality is lower than the required level, the inspectors should point this out objectively, and clarify where the responsibility lies, with the cooperation of other appropriate sections. In fact, the inspectors should, to a certain extent, be independent of both of the design and manufacturing divisions in relation to stabilizing the company's product quality. In extreme cases, such as when defective items are being produced continually, the inspection division should have the authority to restrict the activity of the manufacturing division until the cause is found and removed. If there are any mistakes in the design of the product (or a component of the product) or in the system of manufacturing, the inspection division should be able to ask the design division to modify the design in order to remove the causes.

The main aims of inspection are not only to detect defects and remove them in the production process but also, more importantly, to prevent the production of defective items. Inspectors should have skills of a high level, and therefore the selection and training of inspectors is very important for the company. The reputation of the quality of the products – and therefore the reputation of the company – depend heavily on the skills, judgment, and honesty of the inspectors.

However, the rejection rate might become high owing to careless inspection or inaccuracy of measurement, even though both the design and production methods are not poor. It is not acceptable for inspectors who judge the quality of work done by other people to make mistakes in their own jobs. Inspectors should not make any mistakes because of a lack of attention to details, an irresponsible attitude in their daily jobs, or inappropriate or maladjusted machines or equipment.

Inspectors need to understand the importance of their role. They should be provided with the equipment necessary to carry out inspection, they should be aware of the necessity to interact objectively and cooperatively with people in other sections, and they should be trained well for their jobs. Of course, the manager also needs to have a very good understanding of the duties of the inspectors and to supervise them sensibly, so that if one of them happens to make a mistake in performing his job, the manager does not take him to task inappropriately.

Step 3. Establishing Inspection Standards

For production control it is necessary to start by establishing a series of inspection standards. The standards include identifying which objects are to be inspected; methods, instruments, and equipment to be used; conditions

of inspection; the standard procedure for each inspection; the classification scheme for characteristics to be inspected; and the relative importance of inspected items.

Inspection standards consist of standards for (a) raw materials, (b) processing, (c) final products, and (d) their functions. The quality of purchased raw materials or parts or outsourced processed goods is checked for conformance to the inspection standards for raw materials. Inspection standards for processing are used to check characteristics such as shape, size, look, and finish of the intermediate products. Inspection standards for final products are used to check whether the final product matches the quality of design. When many parts are assembled into a large system the standards are used to check the functioning of the entire system.

These standards are written by the leaders of the design and engineering division or the production division, in accordance with company policy. The appropriate people to write standards describing the technical requirements will be chosen from those responsible for inspection. Inspection standards written in this way will be distributed to all inspectors, and they will be used just like the Bible.

Step 4. Selection of Inspection Methods

There are various kinds of inspection applied in industry. They include inspection of tools, inspection of the first product, patrol inspection, inspection of the process, concentrated inspection, and final inspection. Which of these varieties of inspection are applied depends on the purpose. Inspection of tools is used in the cases of frequently repeated operations to produce the same parts with the same equipment: for example an automatic stamping press machine. In such cases, the tools and forms are inspected for deterioration and damage rather than inspecting the components being produced.

Inspection of the initial product is also used in the cases of repetitious operations. The operation is checked completely for conformance to the requirements. If the first product conforms, it is assumed that subsequent operations should be all right. However, this approach will not be adequate in cases where most operations are manual and the operators are neither trained well nor supervised closely.

Patrol inspection is a method described by its name. Patrolling inspectors take small samples from the production process and check the quality of intermediate products.

Process inspection is what is most commonly applied. It takes place when proceeding from one process to the next process.

In contrast to the above inspections, which are made at the place of production, concentrated inspection is done elsewhere. For this method, since all

inspectors work at the same place and therefore their work can be checked easily, less-experienced inspectors may participate and inspectors can share their work.

The final inspection is executed at the end of production, before sending products to customers or to the company warehouse, after all manufacturing processes and necessary treatments are over.

Inspection of tools and of the initial product can be regarded as types of sampling inspection, whereas for the other inspections either 100% inspection or sampling inspection is used. 100% inspection is used to remove defective items that might be produced during the production process, that is, to prevent defective items being sent out to customers. However, as is explained later, there are some factors that interfere with achieving this goal.

Sampling inspection is performed to obtain information about the production process, and its results are used for deciding on an action: accept, reject, or re-inspect the lot. It is a method to select and inspect part of a lot of products, analyze it, and judge the condition of the whole lot based on the result of the analysis. It is applicable in industry because it generally provides accurate results and is very economical to carry out.

Sampling inspection is based on a rule that a sample randomly taken from a group of products of the same kind represents the whole group within certain limits of probability. It is a reasonable assumption that, under the same conditions, the same outcome will occur. Given this assumption, a product produced by a certain method of production should be exactly the same as the succeeding product produced by exactly the same method of production. Similarly, the third and fourth products should be the same. Therefore, any product taken randomly from the group of products using the same method of production represents the whole group of products.

However, it is dangerous to assume the current production process in the factory is the same as that of the previous products produced. In general it is impossible to keep producing the products under exactly the same conditions. The attentiveness of workers changes as they tire. Machines and raw materials are not always of exactly the same quality. Therefore, even in the same manufacturing organization a series of products cannot be exactly the same.

The most that can be said is that they are the same, or homogeneous, within certain limits. The factors that affect the similarity of products such as the attentiveness of the workers and inhomogeneity of the raw materials are not the same or of the same level every day or every hour.

In other words, the quality of an item or a group of items produced at an arbitrary time point is a consequence of a combination of the conditions of all factors that affect quality. To assume that a single item represents all possible other items is to assume that no other combination of the conditions occurs in the other items. Since it is impossible to assume that a single item has all the information related to the random variation of all factors, it is necessary to

make a selection of items to get a proper representation of a large lot. Each item should be selected using the same probability law with respect to the combination of the factors that affect the quality. Therefore, you have to study how to use random selection to be successful in the industrial use of sampling.

The next section provides a detailed explanation of how to use random selection. Here we simply add the comment that, whichever of these methods of inspection is selected, it has to be applied to appropriate points in the production process.

Step 5. Investigation of the Current State of Quality

To establish a system of quality control in a company requires a complete understanding of the current state of quality. For this purpose it is most effective to reinvestigate past production conditions, the design conditions in the engineering department, specifications for production, standards for inspection, and any other matters affecting the quality of work done by the production department. The reinvestigation should be done systematically to establish guidelines for production based on a scientific foundation, not just to obtain the information. A statistical investigation is one of the most useful methods for the above reinvestigation, in particular for use in detecting hidden causes of defects in production and variation in quality. The statistical investigation consists of collecting a series of facts related to errors of operation, delays in production in the factory, errors in design, standard costs, additional costs for control, and other factors affecting the efficiency of production. Such research studies have been carried out in many manufacturing companies, and as a result of analysis it is known that the main causes of defects in production can be classified as (1) bad raw material, (2) operator error, (3) low mechanical efficiency, (4) inappropriate design and (5) inappropriate methods of manufacture.

Inappropriate methods of manufacture generally derive from poor planning of operations, such as insufficient or no analysis of operations in the production line. They often occur because management does not standardize the training of workers, that is, it does not train them to work using the most efficient methods of operation as determined by the production engineers.

The problem of inappropriate design can be solved by ensuring that the design engineers have a deep understanding of economical methods of working and of economic issues. It is expected that the design engineers will themselves acquire the necessary theoretical knowledge and understand the actual capabilities and limitations of the workforce, and so be able to create a design that provides a sensible balance between scientific ideals and the reality achievable with the current equipment and skills of workers.

Low machine efficiency is a consequence of failing to maintain equipment in good condition. Machines should be cleaned, adjusted, and used carefully.

They should be checked regularly, and major problems should be prevented in advance by repairing small problems. Low machine efficiency is also a consequence of the failure of production engineers to analyze the production process carefully.

Operator errors occur because workers are not supervised properly, that is, they are not directed to investigate their operational errors. This happens when supervisors do not have a clear understanding of the need to supervise workers to ensure that they use proper methods, proper procedures, and proper tools, and when problems relating to the handling of raw materials, the order of the production process, and the assignment of workers with necessary skills to machines are not managed systematically.

Probably the most important factor resulting in defective products is the poor quality of raw materials. Poor raw materials and parts result in additional cost in the subsequent process and it is difficult to produce good final products. If the raw materials are bad, it is inevitable that the quality of the final products is low, and this results in higher production cost compared with the results from using good raw materials. Therefore, it is vital to make a careful check of raw materials in acceptance inspection based on the raw material specification. Materials should be inspected rigorously following the inspection standards at the acceptance stage and also during the production process. Bad materials must not be allowed to enter the production line.

There are at least two reasons, namely to produce products economically and to provide customers with high-quality products, why management has to ensure that arrangements are in place to obtain raw materials of high quality. An approach based on sampling inspection as described earlier can be used for this purpose. Its application is relatively simple and its effect is very substantial. The following shows some of its advantages.

1. It is possible to decide whether the whole lot of raw materials is to be accepted, rejected, or re-inspected by the inspection and analysis of a small sample taken from the lot. This method reduces the cost of inspection as well as the production cost.
2. It is possible for the company to make the supplier of raw materials aware of their quality by providing ongoing results of inspection of the raw materials. The company can obtain raw materials of high quality by requiring the supplier to maintain a high standard of quality.
3. It is desirable to record the result of analysis and the number of defective items in the sample for each lot of acceptance inspection. This allows their relationship to be investigated should any problems occur when using the lot of materials in the production process. It is useful in educating workers about the relationship between the quality of products and that of raw materials. The analysis of samples from acceptance inspection is useful in preventing quality problems and for predicting a possible increase in cost that

is due to quality problems. Since the supervisor of the production process knows the properties of the materials from the results of acceptance inspection, methods can be planned in advance to prevent possible quality problems.

4. The following storage policy is recommended. Store the lots of materials judged by sampling inspection to be of high quality in storehouses, and use those judged to be of relatively lower quality immediately in the production line. Then the production line works every day regardless of the result of the current inspection result, and materials of higher quality are accumulated gradually in the storehouses. As a result the requirement for quality improves gradually, and you do not need to be concerned about the possibility that the amount of production is affected because of the quality of materials, even if you send back the lots of materials rejected using the new standard to the supplier for exchange or adjustment.
5. Based on the results of analysis of sampling inspection, you can make a list of reliable suppliers of materials.

To remove the five causes of defect explained at the beginning of this section it is very important to detect the occurrence of a defect in the production process as soon as possible. A method developed in statistical quality control plays an important role in detecting the defect immediately. Quality control engineers are not themselves responsible for removing the detected causes. This is generally the role of production engineers. However, quality control engineers often have to make an initial assessment of the possible causes and point them out. Identification of the cause and developing an understanding of its relationship to special operating conditions can lead to significant improvement of the production process.

Statistical quality control aims to detect the causes of variation in quality logically and systematically using scientific methods. The methodology consists of relatively simple methods for detecting actual causes of defects, and by using it you can decrease the number of possible causes that may have a bad influence on production. How to use the methods in practice will be explained in succeeding chapters. However, before proceeding to the next chapter it will be appropriate to explain technical terms used in quality control and to introduce some fundamental concepts of theoretical statistics.

Technical Terms Used in Quality Control

1. Above normal
A term meaning that the quality exceeds the standard.
2. Apparatus standard
List of conventions including abbreviations and signs used in figures. It is used to describe the result of inspection.

3. Allowable defect number
Allowable number of defective items per sample in sampling inspection.
4. Average quality
Predetermined quality level with which observed quality is compared.
5. Band type chart
Control chart to express the quality of products. It consists of three bands of “above normal”, “normal”, and “below normal”.
6. Below normal
A term meaning that the quality is lower than the standard.
7. Check inspection
Sampling inspection of completed products carried out by the section responsible for final inspection.
8. Consumer’s risk
Probability that the lot with percent defective higher than the allowable percent is accepted.
9. Control chart
Chart consisting of three lines, i.e. standard line and upper and lower control limits.
10. Control limits
Upper and lower limits. The production process is said to be in control when the quality of the products plots within these limits.
11. Consumer’s complaint
Complaints from customers regardless of the type of consumer.
12. Defect
Fault of a unit with a quality characteristic that does not satisfy the necessary condition.
13. Defective
Unit with one or more quality defects.
14. Detailed inspection
100% inspection of the units of the lot on characteristics or conditions related to quality.
15. End requirements
Explicit or implicit requirements prescribed for the completed product.
16. Electrical inspection
Inspection using an electrical test to check whether the item conforms to the requirement.
17. Engineering changes
Changes that affect the function, appearance, maintenance, or interchangeability of the product.
18. Engineering change notice
Notice of changes approved by the engineering department.

19. Engineering information
Changes of technical specifications, charts, and their requirements approved by the engineering department.
20. Expected quality level
Prescribed quality level or predicted quality level at the time of delivery to customers.
21. Final inspection
Inspection of products to confirm that they satisfy the global requirements before delivering to customers.
22. Fraction defective
Proportion of the units among the total units that are below the standard.
23. Inspection item
Characteristics, performance, properties, and other things to be inspected.
24. Isolated defect
Very rare defect, the possibility of improving which can be neglected.
25. Limit line
Line indicating upper or lower limit of the control chart. The pair of allowable limits of variation.
26. Lot
A certain amount of the same kind of raw materials or same kind of products taken from the same source. For example, in the case of producing products on a conveyer or on a production line a lot is defined by the amount of product produced per day.
27. Manufacturing information
Documents concerning the method of manufacturing, such as design, specification, instructions, notice of changes, layouts, and other relevant information.
28. Manufacturing standards
A set of approved directions, descriptions, and practicing methods to measure the gauges and sizes of the standardized components and to decide the tolerances and other procedures.
29. Mechanical inspection
A form of inspection using mechanical tools or gauges.
30. Nonconformance
A product or unit that does not conform to specification.
31. Normal distribution
It is known that Gaussian probability distribution, also called the Normal distribution, generally approximates the observed frequency distributions of measurements. For the Normal distribution the interval between three times the standard deviation above the average and three times the standard deviation below the average contains 99.7% of the distribution.

32. Observational standard

An object made as a visible standard for assessing quality characteristics, such as shape, color, composition, and appearance. Each item should conform to this standard. It is used in situations where it is difficult to describe the standard with pictures, numbers, or measurements and language.

33. Observed number of defects

Number of defects detected in the sample.

34. Output

Amount of product produced during a certain period.

35. Percent defective

Percent of defective units among all units inspected.

36. Piece parts

Parts constituting the components of the assembled product.

37. Process

Operations conducted in the assembly of the products.

38. Process inspection

Inspection of parts, partial assembly, and process.

39. Producer's risk

Probability of having to re-inspect a lot conforming to specification because a sample is rejected as a result of sampling inspection. Here, "producer" means the company itself or a division of the company that supplies materials or parts to other divisions.

40. Quality level

Average quality.

41. Quality report

Periodic report to the management on the current state of quality.

42. Quality surveys

Surveys to assess whether the production process conforms to the design and to evaluate globally everything that affects product quality, including the production method, the procedure and the results of inspection, and the level of experience of the workers.

43. Raw material inspection

Inspection of raw materials and outsourced components.

44. Sample (lot)

A certain number of units selected from the lot for sampling inspection.

45. Sampling inspection

Inspection of the sample selected from the lot to decide whether to accept, reject, or re-inspect the lot.

46. Spotty condition (lot)

Insufficient condition of quality concentrated in a small part of the whole group of products or of the lot.

- 47. State of control
Production condition shown by the control chart when a sequence of 25 or more points plots within the control limits.
- 48. Subsequent lot
Term used in a situation where successive lots produced in a certain production process are rejected by inspection.
- 49. Temporary information memorandum
Memorandum issued for a certain period or a certain amount of production or to advise that it is permissible, on a temporary basis, not to conform to the standard instruction for production.
- 50. Lot tolerance percent defective
Critical value of percent defective for the lot to be accepted, i.e. a lot with percent defective larger than this critical value should be rejected.
- 51. Tool made sample
Sample of a new product which is made in the production process to be used in actual production before producing the products formally. It is used as an example of the new product.
- 52. Visual inspection
Inspection to investigate appearance.
- 53. Workmanship
Quality of product determined by tool, accuracy, and skill of worker.

