# SECTION 41
# QUALITY IN JAPAN

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## *DEVELOPMENT OF MODERN QUALITY CONTROL IN JAPAN*

**Introduction of Quality Control from the United States.** Prior to World War II, Japanese research on and application of modern quality control were limited. Japanese product quality was poor relative to international levels. These poor products were sold only at ridiculously low prices, and it was difficult to secure repeat sales. Among the exceptions were the high-technology products of some Japanese companies, primarily for military use, which were manufactured without successful application of mass production techniques.

The concepts and techniques of modern quality control were introduced from the United States immediately after World War II. The General Headquarters (GHQ) of the Allied Occupation Forces in Japan was experiencing difficulties with the poor state of the country's communication systems and the defective quality and late delivery of communication equipment and components ordered from Japanese manufacturers. GHQ's Civil Communication Section (CCS) was instructed to provide communication equipment manufacturers with business management guidance, including advice on quality control. Many Japanese manufacturing companies received help from the members of the Section such as Frank Polkinghorn, Charles Protzman, W. G. Magil, and Homer Sarasohn.

**CCS Course.** To bring all these efforts together, Protzman and Sarasohn ran a seminar in the autumn of 1949 called the CCS Course, mainly for the top executives of communication equipment manufacturers. This course was designed to elevate the quality of management, and quality control was a part of it (Ikezawa et al. 1990, Hopper 1985).

It was thought then that the statistical methods used in the quality control activities were very helpful, indeed, indispensable, for the reconstruction and development of Japanese industries. It should be noted that during the War, Japanese industries were almost completely destroyed. Since Japan lacks abundant natural resources and has virtually the highest population density in the world, it became an overriding national priority to design and manufacture industrial products of superior quality and export them to foreign countries. Modern quality control is the most important and indispensable tool for improving and maintaining the quality of manufactured products.

**Establishment of the Japanese Union of Scientists and Engineers.** The Japanese Union of Scientists and Engineers (JUSE) was established in April 1946 and has been at the core of quality control activities in Japan (Kondo 1978). This nonprofit organization is not financially supported by, or controlled by, the government. It was established with the aim of "contributing to the development of culture and industry through the comprehensive promotion of various projects and activities needed for the advancement of science and technology." To achieve this aim, close cooperation between scientists and engineers has been emphasized, as is evident in the name of the organization.

Among JUSE's early activities was the formation of the Quality Control Research Group in 1949, which was composed of people from industry, academic institutions, and government. The same year, the Basic Quality Control Course (the first one lasting 12 months, and subsequent ones lasting 6 months) was inaugurated with the aim of reporting the Quality Control Research Group's findings to industry. The course has since been held 89 times through April 1996 and has been attended by 29,741 engineers, who went on to provide the nucleus of quality control activities in their respective companies.

A famous American, W. Edwards Deming, accepted the invitation of JUSE to visit Japan in 1950. He lectured at JUSE's 8-day quality control courses for engineers and quality control seminars for top management held in several large cities in Japan. His lectures at these seminars helped the Japanese participants to understand the importance of statistical quality control (SQC) in manufacturing industries (Deming 1986).

**Deming Prizes.** In recognition of Deming's friendship and contributions to Japan, at JUSE's suggestion the Deming Prize was established in 1951 to encourage the development of quality control in Japan. JUSE serves as secretariat to the Deming Prize Committee. The Deming prizes include the Deming Prize itself and the Deming Application Prize. The former is awarded every year to a person whose contribution is judged outstanding in theoretical research work and in the practical application of statistical methods. Those who promote increased use of statistical methods in the industries are also eligible.

The Deming Application Prize is awarded every year to the companies (including public institutions) or divisions that have achieved the most distinctive improvement of performance through the implementation of company-wide quality control based on SQC. The Deming Application Prize provides a powerful incentive for Japanese companies to promote and achieve their quality control activities.

Since their inception, the prizes have been awarded to 140 companies and 5 divisions. JUSE's managing director is responsible for the procedures of awarding the Deming prizes.

**Development of the Quality Control Concept into Company-Wide Quality Control.** Statistical methods were found by Japanese engineers to be very effective for assigning causes of variation in manufacturing processes, clarifying the correlation between manufacturing conditions and product quality, and reducing the work force needed for inspection by introducing sampling inspection techniques, among other benefits. However, during the first decade after their introduction from the United States in the late 1940s, the application of these methods was limited only to the fields of manufacturing and inspection.

Although the application to these processes yielded remarkable results, it became clear that it was not a sufficient condition for achieving the main objective of quality control, that is, customer satisfaction. To achieve this objective, it is of course necessary not only to place more emphasis on the processes that take place before manufacturing (e.g., market surveys, research, planning, development, design, and purchasing), but also to apply the quality control approach to those that take place after inspection (e.g., packaging, storage, transportation, distribution, sales, and after-sales service).

For example, it is well known that design flaws often occupy the top position in Pareto diagrams of complaints relating to household electrical appliances. Eliminating such shortcomings, elucidating their causes and taking steps to prevent them from recurring in the design of new products are important actions not only for eliminating customer dissatisfaction, but also for improving the health and character of the company itself. More and more people began to recognize the significance of this in the mid-1950s, as trade liberalization became imminent. The importance of company-wide quality control (CWQC) was emphasized and began to be understood by manufacturers. For Japan, with its scarcity of natural resources and need to pay for them by trading in highly competitive international markets, improving product quality to levels acceptable for export was indispensable.

In 1954, Joseph M. Juran visited Japan at JUSE's invitation to hold quality control courses for top and middle managers. These courses had an immeasurably large impact on Japanese quality control in the sense that they extended the quality control philosophy to almost every area of corporate activity and clearly positioned quality control as a management tool. Taking its lead from these courses, JUSE initiated the Middle-Management Quality Control Course in 1955 and the Special Quality Control Course for Executives in 1957. These courses are improved and still held today (Ishikawa and Kondo 1969, Mizuno and Kume 1978).

Teijin Co. (a synthetic fiber manufacturer) and Sumitomo Electric Industries Co. won the Deming Application Prize in 1961 and 1962, respectively. In these companies, the quality control activities were defined broadly to include marketing, design, manufacturing, inspection, sales, and administration departments and subsidiaries, and the companies achieved outstanding—even epochal—results, for which the prizes were awarded. Their success stimulated other Japanese companies, providing them with a very powerful incentive to broaden their quality control activities.

The internal quality control audit by top management, started in many companies in the latter part of the 1950s, was also found to be very effective for promoting and improving CWQC activities. The type of CWQC practiced in Japan has two principal features. The first is the wide span of coverage of the quality control activities practiced, and the second principal feature of CWQC is total employee participation in quality control activities and ancillary activities. They are explained in more detail later.

**PDCA Cycle.** A usual definition of control is checking and directing action. This means comparing the actual results of an action with a standard or target, monitoring the disparity between the two, and adopting corrective measures if that disparity becomes abnormally large. This process is the familiar plan-do-check-act (PDCA) cycle shown in Figure 41.1*a*.

Following this PDCA cycle is more effective than adopting the perfectionist approach of concentrating exclusively on developing flawless plans. In addition to the factors which can be controlled accurately, usually there are many other extraneous factors likely to influence the results, and it is almost impossible to establish standards over all such factors. For this reason, even though the plan may be nearly perfect, we still need to keep on checking and taking corrective actions in this way.

The Crosby-style exhortation to "do things right the first time" is criticized (Tsuda 1990), for if this were all that was necessary to obtain good quality, we would all have an easy time of it. But it seldom is possible to judge immediately whether things have, in fact, been done right. The PDCA

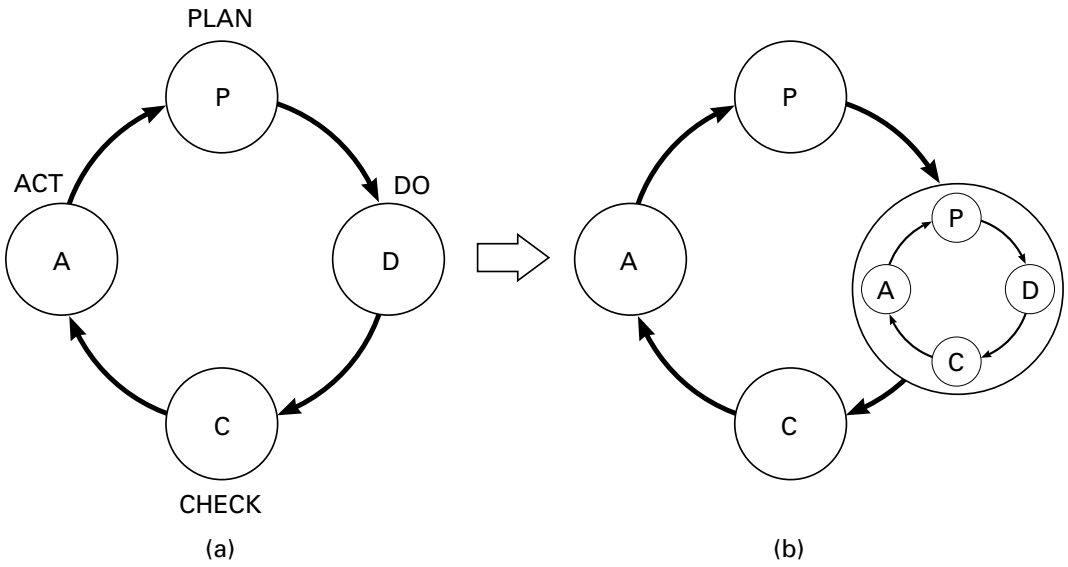



**FIGURE 41.1** PDCA cycle. (*Source: Kondo 1977.*)

cycle means continually looking for a better method of doing things. By following this PDCA cycle, it is expected that the results will be obtained, and also that the process itself will be improved in an upward spiral. This leads to improvement and strengthening of the company structure.

In some forms of manufacturing planning, the quality standard and operations manual are established by the engineering staff and management, and the workers are requested only to perform their jobs in accordance with the established manual. Thus the planning and execution are separated.

In such cases, if manufactured products are found to be defective, the supervisor may seek the causes and reproach the worker. The worker may then reply, "I am not responsible for the defect. I honestly followed the operation manual that you gave me. You are responsible for the result." It is clear that when workers are responsible only for following the established manual, their responsibility for quality becomes obscure. Such vague responsibility is detrimental to high quality of conformance, which is achieved only if the workers are conscious of quality and have a keen sense of responsibility.

It is true that the workers are assigned to perform the manufacturing job. However, this job performance is also composed of a plan-do-check-act cycle, as shown in Figure 41.1*b.* The extent to which the PDCA cycle is followed in this portion of the overall job is considered to reflect the self-control of workers. Everyone is in a state of self-control to a greater or lesser extent. Thanks to this ability of self-control, we humans can enjoy our lives, including sports and leisure. Of course, education and training are to a certain extent necessary to cultivate the self-control capacity of the workers.

Regarding checking, we tend to stress identifying the deficiencies in a process. We advocate quantifying deficiencies relating to quality, quantity, and cost, and expressing them in the form of hard data, since this is the first step in improving the process. This is correct and should be strongly emphasized. However, it should be underlined that as long as processes have deficiencies they are also bound to have their opposite, that is, strengths. While it is important to identify deficiencies and prevent them from recurring by eliminating their causes, it is equally important to identify strengths and ensure their recurrence by standardizing their causes.

There are two types of corrective action—temporary and permanent. The former is aimed at results, while the latter is targeted at processes. Because temporary corrective action consists of adjusting or reworking the results of a process, it can be implemented without knowing why the abnormality occurred in the first place. Permanent corrective action, on the other hand, consists of investigating the abnormality, identifying the reasons for its occurrence, and either preventing or institutionalizing its recurrence by eliminating or standardizing its causes. This makes it essential to understand the causes. Permanent corrective action thus focuses on the process rather than on the results. The reason companies introduce and promote quality control is said to be the desire to improve company health. In order for this to happen, it is not good enough for the company simply to produce acceptable outputs; the internal processes giving rise to those outputs must also pass

muster. The permanent corrective actions we undertake every day in our workplaces may be individually insignificant, but together these small improvements can result in major improvements to the health of an entire company. In light of this, permanent corrective action is obviously far more important than temporary corrective action.

**Education and Training of the First-Line Workers and the Birth of the Quality Control Circle.** The importance of the role of first-line workers has been recognized along with the progress of company-wide quality control. Without the daily efforts of those workers, the quality of conformance of manufactured products cannot be achieved. To offer training to the workers, a 13-week shortwave radio series, "Quality Control for the First-Line Supervisors," was planned and broadcast from October to December 1956, and it was continued by NHK (the Japan Broadcasting Corp.) until 1962. During the first year about 100,000 transcripts of the radio broadcast text were sold. In 1959 a weekly television series on quality control was initiated. *Quality Control Text for Foremen,* edited by K. Ishikawa, was published by JUSE in 1960, and 200,000 copies were sold before the end of 1967. Thus the education and training of supervisors and first-line workers were carried out very enthusiastically. This provided the most important basis for the birth of the quality control circle movement.

In 1962, JUSE began publishing the monthly magazine *Gemba-to-QC* (*Quality Control for Foremen*) as a sister magazine of *Hinshitsu Kanri* (*Statistical Quality Control*), which began publication in 1950. This new publication aimed at

1. Education and training of supervisors and workers and dissemination of statistical methods among them
2. Formation of quality control circles
3. Application of the workers' knowledge to their own daily jobs, attainment of the set target, and elevation of their own capability

A quality control circle consists of a group of workers and a foreman who voluntarily meet to solve job-oriented quality problems. These activities are intended to be tightly linked with company-wide quality control activities. The quality control circle activities are the quality control activities of the first-line workers on the shop floor, who are responsible for attainment of the design quality of manufactured products. Quality control circle members study activities on the shop floor, using the *Hinshitsu Kanri* magazine as a textbook, and they thus become the core of the activities.

In May 1962, the first quality control circle was registered at the Quality Control Circle Headquarters of JUSE in Tokyo, and thereafter the number of quality control circles and the number of members have been increasing year after year. The number of registered quality control circles at the end of May 1996 was 397,216; registered members numbered 3,038,038.

Recognition of the daily efforts of quality control circle members is important, and JUSE undertook to organize quality control circle conferences for presentation of the members' case studies. The first Foremen's Quality Control Conference was held in Tokyo in November 1962, which was the third nationwide Quality Month; 12 papers were presented and 235 foremen attended. In parallel with this annual conference, the first nationwide Quality Control Circle Conference was held in May 1963, where 19 papers were read and 193 people attended. These conferences and local quality control circle meetings have continued with great success. Mutual visits and discussions among quality control circle members from different companies were also revealed to be very effective in motivating the workers and broadening their viewpoints. These visits were started in March 1963, and JUSE assists in arranging them when its services are requested.

According to the Quality Control Circle *Koryo* (*General Principles of the Quality Control Circles*), published by JUSE in 1980 and revised in 1990 and 1995, the major purposes of the quality control circle movement are

1. To improve the leadership and management abilities of the foremen and first-line supervisors in the workshop and to encourage improvement by self-development
2. To increase employee morale and simultaneously create an environment in which everyone is more conscious of quality problems and the need for improvement
3. To function as a nucleus for company-wide quality control (CWQC) at the workshop level

The basic goals behind these immediate purposes are

1. To display human capabilities fully and eventually to draw out unlimited possibilities
2. To develop respect for humanity and build a happy, bright workshop, which is meaningful to work in
3. To contribute to the improvement and development for the enterprise

As recommended by Juran, JUSE has been sending foremen's quality control teams composed of quality control circle leaders and members abroad since 1968. They visit various plants in foreign countries and present papers on their own case studies in the workshop at various conferences and meetings. The Quality Control Circle Cruising Seminar was also started in 1971; the members spend two weeks on a boat trip and attend seminars and discussion meetings held on the boat. They visit various countries in Southeast Asia during the trip.

Regarding the major effects of quality control circle activities, it can be said in the first place that the willingness, creativity, and viewpoints of first-line workers are enhanced or broadened, which results in the formation of centers of quality control activities in the manufacturing process. The elevation of morale and the improvement of human relations among workers are clear. The reduction of manufacturing defects is always evident, and this brings out the elevated level of quality assurance. Thus the engineers and staff personnel can, without any worry, entrust to the foremen and workers the greatest part of their daily duties as troubleshooters in the manufacturing line, and they can concentrate their efforts on their own proper duties (development of new products and techniques, etc.)

The recent quality control circle activities are further marked by the following features (Kondo 1976):

1. *Division of a quality control circle into subcircles and minicircles:* As study among workers progresses and their capabilities are enhanced, the quality control circles are often divided into smaller circles. Some workers become the leaders of these smaller circles, to which the foremen, who were the former leaders of the larger quality control circles, serve as advisors and promoters.
2. *Formation of joint quality control circles:* Joint quality control circles are also often organized by combining quality control circles along manufacturing lines or quality control circles of manufacturing and inspection, etc. These joint quality control circles are effective in finding and solving new quality problems.
3. *Service of workers as quality control circle leaders:* Formerly, it was the custom for the foremen to be elected as the quality control circle leader. However, as the quality control circle members progressed in their studies, many of them assumed prominent leadership roles in quality control circles. In many Japanese companies it became customary to rotate the leadership among the quality control circle members.
4. *Establishment of autonomous administrative systems in quality control circle activities:* Conferences and meetings of quality control circles are always conducted by the attending members who were assigned as the session moderators. The company staff members and university professors serve only as the advisors.
5. *Expansion of quality control circle themes:* The themes being chosen include not only the reduction of defects, elevation of productivity, and reduction of manufacturing and inspection costs, but also improvements in preventive maintenance jobs, the manufacturing schedule, and other aspects of production.
6. *Improvement of techniques employed:* In quality control circle activities the elementary statistical tools are called the "seven tools." These are: stratification of data, Pareto diagram, checksheet, histogram, cause-and-effect diagram, graphs such as control charts, and scatter diagram. In addition, techniques such as regression analysis, process capability studies, analysis of variance, and value analysis are being used.
7. *Quality control circle activities in supporting operations:* Quality control circles are being formed, and their activities are becoming broader, not only in manufacturing and inspection workshops but also in supporting services such as warehousing, transportation, purchasing,

administration, reception, and telephone operation. The above-mentioned statistical methods are helpful and effective in quality control circles in these areas.

8. *Quality control circle activities in subsidiary companies:* Quality control circle activities in subsidiaries that make parts and components or carry out an intermediate manufacturing process are recognized to be very important, in fact indispensable, for ensuring product quality, and parent companies are encouraging the formation of quality control circles in their subsidiaries. Mutual visits and discussion among quality control circle members from the parent company and from its subsidiaries are always effective in identifying and solving quality problems.

Along with the expansion of company-wide quality control activities in the service industries in Japan, quality control circles are becoming active and effective in hospitals and in companies that operate hotels, restaurants, banks, department stores, supermarkets, retail stores, etc.

**Quality Revolution in Japanese Industry—Breakthrough.** At the end of World War II, the former Japanese military and political leaders were no longer in power, having been replaced in large part by relatively young industrialists who wanted Japan to advance as an industrialized country and not to fall back into the old agricultural economy of the type prevalent in some parts of developing countries. After this decision was made, however, they faced a difficult road. Poor product quality was a principal obstacle; no one wanted to repeatedly buy such low-quality goods. For a country so lacking in raw materials, the inability to sell finished goods for export also meant an inability to earn foreign currency and hence an inability to buy the materials needed to create an upward spiral of industrial development. Thus a revolution in product quality became essential (Juran 1981). This quality revolution has been taking place in Japan since the early 1950s as the result of efforts to apply the concepts and techniques of statistical quality control on a company-wide scale. Three of the principal reasons often cited as to why this has been relatively easy to accomplish in Japan are as follows.

1. Japan is a uniform society composed of people of the same race who speak the same language.
2. Japan has a comprehensive system of compulsory education, and the general education level is high.
3. Japanese companies practice the custom of lifetime employment and the turnover rate of employees is therefore low.

Of these three, the second is likely to continue in the future and education levels may well improve even further. However, labor shortages are becoming more and more severe and it is impossible to say whether the first will continue to hold, although this will depend on how the labor shortages are dealt with. Even the third may not apply so strongly in the future as more young people become reluctant to take up employment in industry and those who do so tend to change jobs more frequently. It is important to keep a watchful eye on these trends. Various other reasons are given in addition to the above three.

In Japan, apart from a limited number of occupations such as medicine and the law, professionalism is not so strongly entrenched as it is in the Western countries. Each of the unique features of these countries has its own particular advantages and disadvantages, but their existence gives rise to some noteworthy differences.

For example, in the United States, people improve their status by moving from company to company without changing their specialty to any great extent. In contrast, in Japan, although there may be exceptions, people typically get promoted by changing jobs within the same company. This process of promotion makes it necessary for them to learn a series of different jobs, so in one way it may be rather hard on them. However, the richer experience within the company and the deeper understanding they gain of the relationships among different departments are great advantages. The fact that the custom of lifetime employment continues in Japan even today, whether or not it will in the future, may be because this in-company promotion process gives people the opportunity to experience a wide range of different jobs and helps them remain interested in their work over a long period of time.

The quality revolution was indispensable for the survival of Japanese industries. However, the following “trade-off argument” is often commonplace:

Improving quality is a good thing, but it raises costs, so it needs to be done judiciously.

There is an optimum to quality of conformance with regard to the manufacturing cost. As shown by the solid line in Figure 41.2, increased conformance reduces the losses incurred by defects, but the cost of quality improvement needed for greater conformance rises sharply as quality approaches the perfect state. Thus the optimum should always fall short of perfection because the total cost soars as the percent defective approaches zero.

However, the above optimum is doubtful. Both basic manufacturing cost and losses incurred by defects are easily defined, but the cost of quality improvement is usually indefinable. When creative ideas by which we can increase the conformance with less additional cost are introduced, the curve of quality improvement cost is shifted down as shown with broken lines in the figure. Then the total cost can be reduced, and the optimum moves toward zero defect. Thus the optimum is indefinable and movable. We must really search for the ways and means by which we can reduce the defects with minimum cost, instead of trying to find the indefinable optimum. It may be said that this approach is a "breakthrough," which is quite different from the superficial optimization. It is clear that the successful breakthrough is always accompanied by the creative idea and strong will of the people concerned (Kondo 1977).

Dividing quality into two categories of must-be quality and attractive quality is an important step to attain customer satisfaction (Kano et al. 1984). As described later, the former quality can be related to the reduction of cost and the latter concerns the enlargement of market size and share and the increase of profit. Thorough investigation of both qualities is indispensable for the quality revolution.

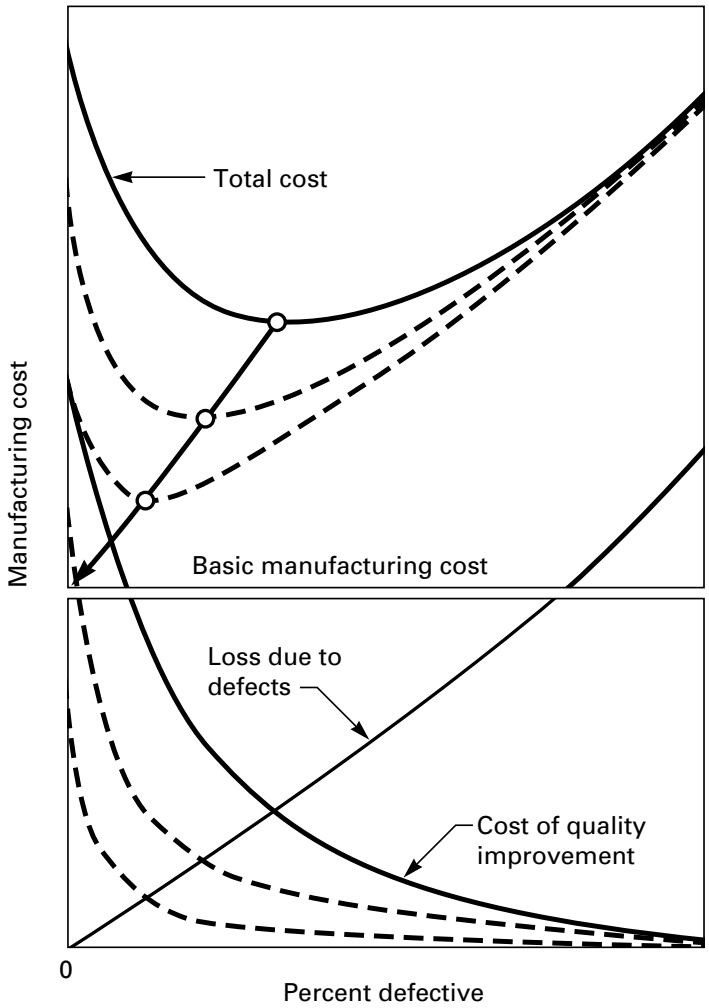



**FIGURE 41.2** Plausible optimum of manufacturing cost. (*Source: Kondo 1977.*)

Juran (1981) summarized three features of quality control activities in Japanese industries that created the revolution in quality:

1. A massive quality-related training program
2. Annual programs of quality improvement
3. Upper management leadership of the quality function

**Company-Wide Quality Control after the Energy Crises.** Although there were variations among countries and industries, the world economy in general showed significant growth from the latter half of the 1960s to the early 1970s. This rapid growth was checked by the first and second energy crises, in 1973 and 1979, respectively. Japan is particularly vulnerable economically, since it depends on other countries for its supplies of crude oil and other natural resources. During the energy crises, there were even attempts in some quarters to corner the market in goods such as detergents and toilet paper, but the Japanese government and individual companies took various steps to deal with the situation.

The energy-saving measures introduced during that time can be broadly divided into energy saving in manufacturing processes and the like, and the creation of energy-saving products. In addition, companies had to institute a wide range of countermeasures on an organizationwide scale. These measures included providing education and training for the surplus personnel they now had in their production and engineering departments (as a result of the drop in manufacturing volumes) and assigning them to sales departments to provide extra support. Various benefits accrued from giving a higher priority to these kinds of countermeasures. For example, engineering staffs dispatched to sales departments were able to obtain a better understanding of the market, and the education and training programs carried out by companies enabled them to speed up production extremely rapidly when the economic good times returned.

The Japanese economy was subsequently rocked by the rapid appreciation in the value of the yen. However, many Japanese companies were able to emerge stronger each time they came through one of these difficult experiences. In this sense, the energy crises in the 1970s could be regarded as heralding the new dawn of the 1980s and 1990s.

According to Juran (1981), by the mid-1970s the Japanese had caught up with their Western counterparts in terms of creating quality products. The successful efforts made by Japanese industry to cope with the energy crises and to create quality products could probably be considered early indicators of the industrial restructuring that was to take place in Japan beginning in the early 1980s. In addition, these efforts and the restructurings are evidence of the realization by the Japanese that they were in the process of surpassing other countries and becoming a world leader in terms of product quality, and point to Japan's new sense of mission and responsibility.

Since the early 1980s, diversification of business has been a common feature of Japanese companies. However, expansion into a new area of business is accomplished in a distinctly Japanese way. While a company may be extremely enthusiastic about the move into a new line of business, and while this move may mean reducing involvement in an old, mature business, it is only in exceptional circumstances that the company abandons the old business completely. This is because Japanese companies tend to feel that they ought to continue with a business as long as some customers still require them to, even if the business has matured and demand has shrunk. Many companies even continue to actively develop new products in these mature fields with considerable success.

A notable difference between Japan and Western attitudes toward companies is that in Japan, even privately owned firms are regarded more as public institutions than as their owners' possessions. Japanese executives appear to feel more strongly that they are stewarding their companies for the benefit of society.

An interesting feature of new product development in Japanese companies is the active development of applications, particularly nonmilitary ones, for new products. Compared with new products for military use, products for the civilian sector are not subject to as rigorous usage conditions and generally have lower quality and reliability requirements. However, the demand for products in the civilian sector is far greater than that for the military, making it easier for industries to become

established in this sector. There are also more opportunities for producing improved versions of products, and it is easy to obtain quality information under a variety of usage conditions. The development of carbon fibers for use in fishing rods and tennis rackets is a good example.

Because of intense competition in global and domestic markets, a company's ability to develop new products and technology became an important and indispensable factor determining its competitive advantage. It became extremely difficult for a company without this kind of ability to ensure its continued growth through diversification and entry into new business fields. In the hope of making some important gains, more and more Japanese companies are establishing research and development facilities in Japan and overseas.

Japan's direct overseas investment began to increase in the latter half of the 1960s, and the rate of increase has been particularly high since the late 1980s. This overseas activity builds on a long and successful experience of joint ventures between Japanese and foreign corporations going back to the 1970s. It is interesting to see that there are many examples in which the excellent quality management activities of a Japanese subsidiary have had beneficial effects on their overseas parent companies and have contributed greatly to the promotion of quality management in those companies. In fact, the joint ventures of Aisin Warner, Fuji Xerox, Yokogawa-Hewlett-Packard, and the Bipolar Department of Texas Instruments, Japan, have won the Deming Application Prize, and they have accelerated the progress of quality management in their parent companies.

After being invited in 1961 by the government of Thailand to manufacture dry cells there, Matsushita Electric Industries faced up to and overcame many difficulties in making the business a success (Tsutsumi 1988, 1991). The company used this valuable experience to formulate the following basic policy regarding its overseas operations:

1. We will conduct the sort of business operations that will be welcomed by our host country.
2. We will execute our business activities in accordance with the policies of the host nation's government. At the same time, we will make constant daily efforts to ensure that the host country's government fully understands Matsushita's philosophy.
3. We will promote thorough localization of people, materials, finance, and know-how in the local community in the spirit of responsible self-management.

For this purpose, Matsushita intends to foster a positive participative outlook in a desire for improvement on the part of local employees. It ensures that all employees enjoy their daily work and find it worthwhile and engenders a sense of responsibility toward their manufacturing activities. Matsushita encourages them to see that they are contributing to their own country's development through those activities. These basic policies are backed up by specific strategies actively promoted in each of Matsushita's overseas companies.

In this way, more and more Japanese companies are setting up manufacturing operations abroad, and more and more of the components and materials used in Japan are being purchased overseas. How to use the CWQC expertise effectively in this kind of global industry, particularly in Japanese overseas manufacturing operations, is an important subject that will probably require continued investigation.

**Deming Application Prize for Overseas Companies.** Originally the Deming Application Prize was for Japanese companies only. However, companies from countries outside Japan expressed a strong interest in it. In response, the Deming Prize Committee drafted new regulations for the operation of the Deming Application Prize in 1984, making it possible for companies from countries outside Japan to apply. This opened the door for overseas companies passing the examination to receive the Deming Application Prize for Overseas Companies. The first company to win this prize was the American electricity utility Florida Power and Light Company, in 1989. The next was Philips Taiwan, in 1991, and the third was AT&T Power Systems in the United States, in 1994. These successes, which indicated Japanese management systems can be applied to any kind of industry anywhere in the world, attracted worldwide interest.

## *COMPANY-WIDE QUALITY CONTROL IN JAPAN*

**Two Basic Features of Japanese Company-Wide Quality Control.** Japanese quality control activities have been gradually broadened from the narrow fields of manufacturing and inspection to almost all company branches. As mentioned earlier, it became widely known that achievement of "fitness for use and environment" is important to ensure product quality and to secure customer satisfaction and that it is realized by improving not only the quality of conformance but also the quality of design.

The Deming Prize Committee for example, defined the company-wide quality control as follows:

> It is the activity of economically designing, producing, and supplying products and services of the quality demanded by customers, based on customer-focused principles and with full consideration of the public welfare. It achieves corporate objectives through the efficient repetition of the PDCA cycle of planning, implementation, evaluation, and corrective action, doing so by means of the understanding and application of the statistical approach and statistical methods by all employees to all activities for assuring quality, where such activities include the chain of activities comprising survey, research, development, design, purchasing, production, inspection, and marketing, together with all other related activities both inside and outside the company.

Quality control activities in Japanese industries were expanded in the 1960s (Ishikawa 1965) to:

1. Establishing the top management policy on quality and the long-term quality control plan of the entire company to realize the policy
2. Introducing the quality control concept and techniques into new-product development
3. Establishing the quality assurance system, which covers the whole company
4. Conducting quality control audits
5. Expanding quality control activities to include the sales and marketing activities of the agents, the trading firms, the stores and shops, etc.

A second feature of Japanese quality control is the willingness of employees to participate in the quality control activities of the company. For example, the quality control circle movement, discussed before, came from this idea. In Japanese companies quality control activities are not restricted to quality control staff but include all personnel of the company, from the president to the factory workers and the sales persons. Among them, the leadership of top management is indispensable for launching and continuing the activities. Thus the quality control activities in Japanese companies, which we call "company-wide quality control," is a movement that involves the entire company.

**Company-Wide Quality Control Education and Training.** Study of and education in modern quality control were started in Japan in 1949. It was a prevailing thought then among the members of the Quality Control Research Group in JUSE that a Japanese model of quality control should be established because of differences in background and cultural pattern between Japan and Western countries (Ishikawa 1972). For example, company-wide quality control, in which all company employees participate, is a specifically Japanese approach. The concept of professionalism, which is rather widespread in Western countries, had not yet been established in Japan as of 1949.

Introduction and promotion of company-wide quality control led to a revolution in management philosophy, which required lengthy, persevering efforts in education and training. Thus, since the early 1950s education and training in quality control have been continued for everyone from top management to first-line workers in each and every department, including research and development, designing, manufacturing, inspection, purchasing, marketing, sales, and administration. As an example, training courses that have been held by JUSE are summarized in Table 41.1. Currently there are more than 60 quality control training courses of different kinds, which are held regularly by

**TABLE 41.1** Education and Training Courses of JUSE

| Title | Frequency per year | Year established |
|---|---|---|
| Quality control [QC] | | |
| QC Top Management Course (5 days) | 3 | 1957 |
| QC Executive Course (5 days) | 5 | 1962 |
| QC Introductory Course for Executives and Management (3 days) | 5 | 1981 |
| QC Middle Management Course (12 days) | 7 | 1955 |
| QC Basic Course for Assistant to Section Chief (6 days) | 4 | 1992 |
| QC Basic Course (30 days) | 5 | 1949 |
| QC Introductory Course (8 days) | 8 | 1957 |
| QC Introductory Course for Quality Function Deployment (4 days) | 5 | 1989 |
| QC Basic Course for Foremen (6 days) | 16 | 1967 |
| QC Basic Course for Group Leaders (4 days) | 12 | 1974 |
| TQC Instructor Course (6 days) | 3 | 1976 |
| QC Course for Purchasing Department (10 days) | 1 | 1971 |
| QC Introductory Course for Purchasing Department (4 days) | 1 | 1983 |
| QC Course for Sales Department (10 days) | 1 | 1968 |
| QC Introductory Course for Sales Department (4 days) | 2 | 1983 |
| QC Middle Management Course for Seven Management Tools (4 days) | 2 | 1993 |
| Introductory Course for Seven Management Tools for QC (3 days) | 15 | 1984 |
| Introductory Course for Seven Management Tools for QC in Sales Department (4 days) | 2 | 1989 |
| Policy Management Seminar for TQC (3 days) | 4 | 1989 |
| Product Planning Seven Tools Seminar (4 days) | 1 | 1995 |
| QC Course for GNP (Pharmaceutical) (3 days) | 1 | 1977 |
| QC Introductory Course for GNP (Pharmaceutical) (2 days) | 1 | 1977 |
| QC circle [QCC] | | |
| QC Circle Executive Course (1 day) | 1 | 1994 |
| QC Circle Middle Management Course (2 days) | 11 | 1980 |
| QC Circle Instructor Course (6 days) | 11 | 1972 |
| QC Circle Leader Course (3 days) | 42 | 1977 |
| QC Circle Leader Course for Service-Sales Industries (3 days) | 2 | 1990 |
| QC Circle Cruising Seminar (13 days) | 1 | 1971 |
| Reliability [RE] | | |
| RE Management Course (3 days) | 1 | 1966 |
| RE Course (15 days) | 1 | 1960 |
| Basic Course (4 days) | 5 | 1960 |
| RE Six-Day Course (6 days) | 1 | 1980 |
| RE Seminar on Electronics and Machinery Systems (3 days) | 1 | 1995 |
| RE Course on FMEA-FTA (2 days) | 13 | 1976 |
| RE Course on Design Review (2 or 3 days) | 12 | 1977 |
| RE Course on Checklists (3 days) | 1 | 1989 |
| RE Course on Test (3 days) | 2 | 1983 |
| RE Course on Failure Analysis (3 days) | 2 | 1985 |
| RE Course on Computer Aided Reliability Engineering (3 days) | 1 | 1991 |
| Design of experiment [DE] | | |
| DE Tokyo Course (12 days) | 1 | 1955 |
| DE Osaka Course (20 days) | 1 | 1962 |
| DE Introductory Course (8 days) | 6 | 1963 |

**TABLE 41.1** Education and Training Courses of JUSE (*Continued*)

| Title | Frequency per year | Year established |
|---|---|---|
| Multivariate analysis [MA] | | |
| MA Seminar (7 days) | 1 | 1984 |
| MA Advanced Course (4 days) | | 1970 |
| MA Basic Course (4 days) | | 1984 |
| Operations research [OR] | | |
| Corporate Strategy Managers Course (6 days) | | 1962 |
| OR Introductory Course (5 days) | | 1987 |
| Industrial engineering [IE] | | |
| IE Seminar (16 days) | | 1963 |
| IE Basic Course for Foreman (6 days) | | 1971 |
| Marketing research [MR] | | |
| MR Seminar (16 days) | | 1963 |
| Software production control [SPC] | | |
| SPC Course for Managers (6 days) | 1 | 1988 |
| SPC Course for Engineers (8 days) | 2 | 1980 |
| SPC Course on Design Review (3 days) | 1 | 1994 |
| Sensory inspection [SI] | | |
| Sensory Inspection Seminar (11 days) | 1 | 1957 |
| Introductory Courses for Sensory Inspection Seminar (3 days) | 1 | 1995 |
| Product liability [PL] | | |
| PL Prevention Introductory Course (3 days) | 5 | 1973 |
| Product Safety Advanced Course for Engineers (2 days) | 2 | 1994 |
| Product Safety Advanced Course for Promoters (3 days) | 2 | 1994 |
| Other management techniques | | |
| Statistical Application Seminar for Clinical Test (7 days) | 1 | 1972 |
| New Finite Element Method Introductory Seminar (3 days) | 1 | 1987 |
| Finite Element Method Seminar for Fluid Mechanics (3 days) | 1 | 1977 |
| Cost Reduction Seminar (6 days) | 2 | 1981 |
| VE Basic Course for Foremen (5 days) | 1 | 1984 |
| Analytic Hierarchy Process Seminar (2 days) | 1 | 1992 |
| Logistics System Design Seminar (3 days) | 1 | 1993 |
| Other management techniques | | |
| Data Envelopment Analysis Seminar (2 days) | 1 | 1994 |
| Biostatistical Application Seminar for Pharmaceutical Data (24 days) | 1 | 1989 |
| ISO 9000 (JIS Z 9900) | | |
| JAB Accredited ISO 9000 Assessor Training Course (5 days) | 5 | 1995 |
| ISO 9000s Internal Auditor Training Course (4 days) | 10 | 1994 |
| ISO 9000s Promoter Course (2 days) | 4 | 1994 |
| ISO 9000s Introductory Course (1 day) | 3 | 1994 |

***Source:*** Ishikawa 1969.

nonprofit organizations such as JUSE, Japanese Standards Association (JSA), and the Association for Overseas Technical Scholarship (AOTS).

Furthermore, many Japanese companies are enthusiastic about quality control education for the employees of both the parent company and the subsidiaries. Many companies have their own education and training programs. Education and training in company-wide quality control usually start with top management and are then extended to middle management, supervisors, and first-line workers. It is often emphasized that the progress of company-wide quality control exactly reflects the leadership of the company's top management.

On-the-job training is also emphasized. One example is the training that results from internal quality control audits by top management, which are effective in obtaining the facts within the company and lead to appropriate corrective actions. Another example is the on-the-job training of engineers. Concerning the training of engineers who design color television sets, Juran (1978) commented as follows:

> A second aspect of training of designers is "practical experience." One major area for such experience is in the production shop, to give the designers an awareness of some of the realities faced by the production personnel and thereby to give them a better understanding of how to design for "producibility." A second major area for designer experience acquisition is in field service work. Through such experience, the designers learn much about the conditions of use, the problems of diagnosing field failures, the difficulties of making repairs, etc. As a result, they understand better how to design for reliability and maintainability.
>
> With respect to such "training by practical experience," there are wide differences between Japan and the West. It is common, though not invariable, for Japanese companies to require that designers acquire such shop and field experiences before being assigned to key responsibilities in product design. In the West the requirement for such experience is unusual.

For the above-mentioned purposes of broadening the viewpoint of designers and engineers, job rotation of employees is also emphasized in Japanese companies. The lack of established professionalism in Japanese society is thought favorable for this rotation.

**Policy Management ("Hoisin Kanri") in Japanese Companies.** Quality control activity in Japanese industries is company-wide, and top management personnel are in the position of leading and promoting the quality control activities of their companies. They are responsible for deciding top policy on quality of manufactured products and service and for establishing the long-term plan of company-wide quality control in order to realize that policy. In addition, they evaluate whether the policy and the plan are being realized on schedule and whether any corrective actions need to be taken by top management. These activities are a form of company-wide PDCA cycle and are called "policy management" ("hoisin kanri") in Japanese industries. This concept of policy management is followed in many but not all Japanese companies. Internal quality control audits by top management, which will be described later, are an effective way to evaluate the results as a basis for appropriate corrective actions.

Recently, many Japanese companies have undertaken to investigate and decide at the start of every fiscal year what their long-term plans and targets will be for the coming 3 to 5 years, the plan and target for the first year being set to coincide with the present fiscal year. In this way, long-term plans are taken into consideration in establishing each annual or semiannual plan and target.

A company's basic business philosophy is of fundamental importance, since it underpins the enterprise's annual and long-term policies and provides its employees with a standard by which to measure their behavior. In the future, it will probably become of even greater importance for every company to work out a philosophy that can be accepted and bought into by all its employees, is regarded as an attractive feature by its customers, and forms the basis of goals shared by its entire work force.

The company's basic philosophy has a close bearing on the quality created by the company. Quality has had a far longer history in the life of humankind than either cost of productivity, and is the only one of the three that is a common concern of both company and customers (Kondo 1988). It is for reasons such as these that quality is regarded as a more human concept than cost or productivity. From now on, while quality may not be everything, it will almost certainly be an essential

attribute that can attract customers and act as the focus of a shared commitment on the part of all employees. As described before, quality improvements effected by creative methods result in lower cost and higher productivity and the development of new products with attractive qualities that meet customers' true needs, expand markets, and increase corporate profitability.

It is extremely important for the upper managers to tell everyone in the company their basic philosophy regarding the quality of the products and services their company offers, and the quality management activities the company is undertaking to ensure that quality. This quality policy forms the guidelines for establishing specific quality targets for new products and quality improvement plans for existing products in the course of policy management.

It is widely understood that planning should be results-oriented rather than procedure-oriented. For example, a plan to extend standardization might at the end of the year have produced 100 new procedure manuals. If all this effort failed to improve operating results, this would be evidence that the plan had been procedure-oriented. At the investigation and discussion stage of the draft annual plan, the persons concerned are encouraged to offer many alternative proposals. It is of great importance at this stage to discuss thoroughly the true aim of the proposals and to clarify the "resultant present problem." The above-mentioned extension of standardization is merely a procedure. The high percentage of defects and rework, low productivity and yield, etc., are the resultant present problems. After the resultant problems become clear, data are collected and analyzed. The "vital few" problems can be further determined with a Pareto diagram. Two-stage Pareto analysis always makes the problems and the corrective actions clearer. Once a procedure-oriented policy such as that described above has been converted to a results-oriented policy, the resultant policy consists of the following three items:

1. *Aims:* The reasons why the policy should be implemented
2. *Goals:* The direction to move in, how far to go, and the deadline
3. *Priority procedure:* The methods to be used

Goals should be inspiring; if not, people do not give them serious attention, and they are not achieved. Two Japanese examples are given here.

At the Car Radio Division of Matsushita Electric Industries Co., engineers and staff personnel up to the division manager were discussing an unattained goal of 10 percent price reduction for a car radio as requested by an automobile company. When former President Konosuke Matsushita visited the division, he was told of the situation. He said, "You should consider 15 percent cost reduction when you are requested by a customer to reduce the price by 10 percent." Because he was the founder of the company and was esteemed as a "godfather" by all employees, they started to investigate cost reduction possibilities more thoroughly and finally achieved a 13 percent reduction. After hearing of this success, Matsushita visited the automobile company and expressed his appreciation by saying, "Thanks to your request for a 10 percent price reduction, we have succeeded in achieving a 13 percent cost reduction. Thank you very much for that."

At the Nankai Plant of Bando Chemical Co. near Osaka, where V-shaped belts are manufactured, it was previously the custom for the plant manager to announce the monthly production target and to urge the work force to achieve this target. However, the target was never achieved even though the employees exerted all possible efforts, especially toward the end of every month. On the advice of an outside consultant, the plant management changed the procedure for determining the monthly target by having the plant manager prepare a draft target and ask the work force in every workshop to thoroughly investigate the possibility and the ways and means of attaining the target. In the early stage of this revised procedure, the sum of the individual targets proposed by the work force was more demanding than the draft target indicated by the manager. The plant manager, however, established the proposals of the work force as the targets of the month because they were the result of their thorough investigations. Interestingly, the work force always achieved their targets. Moreover, a few months later the overall target proposed by the work force started to rise month after month, and in half a year or so it even exceeded the previously unmet target of the manager.

There are two ways of determining the target, from the top down and from the bottom up. The example of Matsushita is top-down, and the case of Bando is bottom-up. Both of these were very

successful. Top management is always concerned about the future of the company, and the top-down target is usually determined from the company's needs. On the other hand, the employees usually investigate the draft target indicated by the top management from the viewpoint of feasibility. If the draft target is not investigated thoroughly by the employees, they easily find their own good excuses when it is not achieved.

Many Japanese companies, during annual or semiannual planning, adopt a combination of top-down and bottom-up approaches. Top management prepares a draft plan, which then is discussed, for example, among the top managers and the division managers. From this discussion the draft plans of each division are made. The draft plan of each division is then further discussed among the divisional and lower managers and finally among the supervisors and quality control circle leaders. After these investigations and discussions, the detailed draft plans are formulated. They are brought to the top management, which decides on the final annual plan of the company. This procedure of deploying the annual or semiannual planning throughout the company is called "playing catch" in Japanese companies. The procedure is believed to be effective in establishing the annual plan, although it is somewhat time-consuming. Through this procedure, what was a norm enforced by top management is revised to become the voluntary target of each employee. This revision is extremely important for motivation.

The establishment of results-oriented plans makes evaluation easier, and the characteristics used in the targets become the basis for review by the respective managers. Corrective actions are cooperative. When it becomes clear that a target will not be achieved, for example, companies often assign additional budget, work force, etc., in order to attain the target within the time limit. Although this may be called a type of corrective action, it is actually a superficial countermeasure, or adjustment. A matter of greater importance is to detect the assignable causes by which failures, defects, rework, delays, etc., are created and to remove them from the process. This is the action of "cause removal," which is essential for improving the basic process.

An example of the breakdown of a broad goal into subgoals is that of Komatsu Ltd., a manufacturer of construction machinery. This company originated the "flag diagram" by skillfully combining the Pareto and Ishikawa diagrams (see Kondo 1977). An example is shown in Figure 41.3.

This diagram shows machining time classified into several major items according to the Pareto principle. Each item is further broken down into the respective secondary items. The target line is drawn in the diagram of each item. The subsequent performance is also plotted in the same diagram and compared with the respective target. Each diagram becomes an item for review by the responsible manager and for appropriate corrective action in the event of significant deviations in performance. Such diagrams make it easier for all employees involved to understand their own situations, the roles of their colleagues, and the interrelationship among them. Such understanding contributes to the common interest. New and worthwhile ideas are easily born from discussions among employees who have common interests and yet can see the problems from different viewpoints.

**Internal Quality Control Audit by Top Management.** Internal quality control audit by top management is one of the outstanding features of Japanese company-wide quality control (Kondo 1969). It is carried out in ways similar to the activities of checking and taking corrective actions in the policy management discussed above. The aim of this internal quality control audit differs from that of the external audit—its purpose is not merely for the employees "to pass the examination" but to stimulate mutual discussion between the auditors and the people involved in order to find ways and means to improve the present situation. Corrective actions on both sides are required. Thus the internal audit is educational in character, involving on-the-job training as well as the survey itself. It may be defined as follows: The internal quality control audit is a study of the present situation regarding the system of company-wide quality control and the quality functions of whole processes in order to find and take the necessary corrective actions. This is the reason why many Japanese companies prefer to call the internal quality control audit the "quality control diagnosis" or the "discussion meeting of [those performing] quality control activities with top management."

The procedure of carrying out the internal audit is not fixed but is flexible according to the situation of the division, the department, the plant, or the branch office audited. It is also flexible according to the kind of internal audit being undertaken in the company; usually a company has a few kinds of audit at different levels, as will be mentioned below.

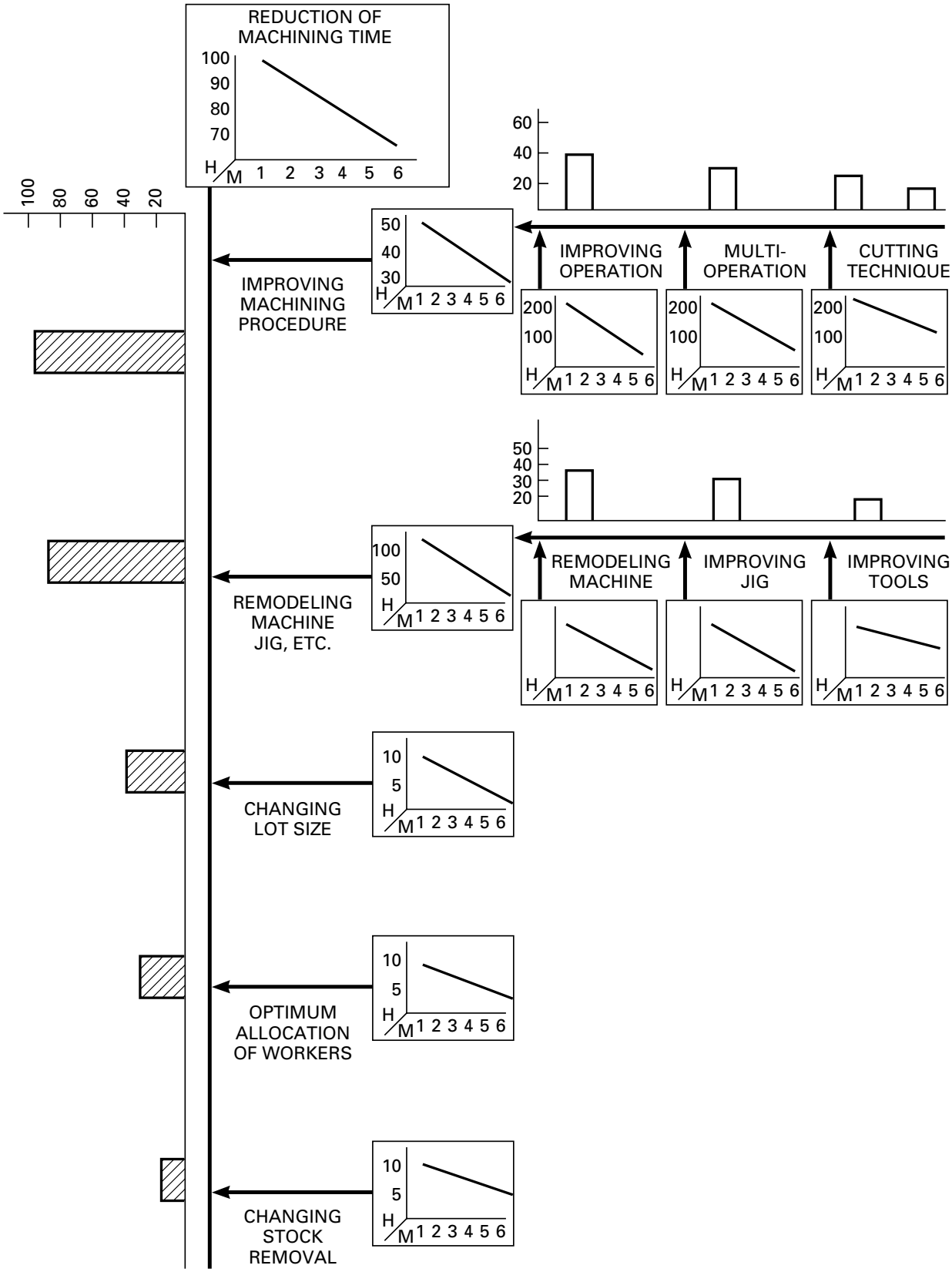



**FIGURE 41.3** An example of "flag diagram." (*Source: Kondo 1977.*)

The top managers of a Japanese company are in the position of leading and promoting the company's quality control activities. They are responsible for determining the top policy on the quality of products and services and for establishing the long-term quality control plan in order to realize that policy. The aim of the internal audit is to determine whether the policy and the plan are being realized and attained on schedule and whether any corrective actions by top management are needed.

Mizuno (1967) explained the aim of the audit as follows:

> It is essentially desirable in the quality control function that effective daily checks be made and that the important quality problems in the company be pinpointed in order to take corrective actions. However, it is embarrassing for a company to remain unaware of the problems involved. The aim of the internal audit is to investigate and analyze systematically the hidden causes of those quality problems that cannot be detected by daily checking. Because the audit in any form is an energy-consuming job, it is a must for the auditors and the coordinators to pursue resultant benefits that are worthy of the input energy.

The educational character of the audit is considerable. The audit offers the best chance for top management to grasp systematically those facts that may reflect on themselves. The employees audited are also given opportunities to examine and to rearrange their daily work. Moreover, the internal audit contributes to the improvement of mutual understanding and human relations among the employees. Such an opportunity can hardly be obtained through the daily meetings and reports. For these reasons, it is often effective to announce beforehand the audit theme and the checklist being used in the audit.

The audit is usually carried out in either of the following ways: In some companies the audit is done by the president and by the members of the board of directors separately; in other companies it is done by a top management team that includes the president. In the audit by the directors, the emphasis is usually on the general management of the company. In the audit by the management team, there is usually more emphasis on specifics than in the audit by the directors. The two audits are planned to be correlated with each other. Usually, the auditors are accompanied by quality control staff members and sometimes by a university professor as a third party. The audit is done either with or without a predetermined theme. When the theme of the audit is not determined beforehand, it usually covers a wide range of items.

At Toshiba Corp., for example, it was reported (Sugimoto 1968) that the following items were checked by the president during the plant tour:

1. Putting the shop in order—its cleanliness and working environment
2. Layout of the shop and the machines
3. Flow of materials and the line balance
4. Material handling
5. Operation standards
6. Efficient use of jigs and tools, mechanization, and automation
7. Maintenance of machines and measuring instruments
8. Inventories of on-line stocks, materials, and parts
9. Attitude and motivation of workers
10. Administration of storehouse
11. Reducing the number of slips and chits
12. Content and worker-hours of indirect work
13. Production control
14. Quality assurance
15. Supervision of subcontractors
16. Maintenance of buildings, roads, and incidental facilities

When experienced auditors are not available, an audit covering such a wide range of topics tends to become a loose and formalistic one, which cannot be effective. This is why the audit with a predetermined theme is preferred in many companies; these audits become more intensive. There is also a prevailing tendency for the audit to develop from a departmental one into a functional one, with emphasis being given to the functional interrelationship among departments.

Usually the internal quality control audit is done once or twice a year. This is because it is related to annual planning of the company ("policy management"); the schedule of the audit parallels that of the planning.

The auditors often request a short report explaining the current situation of the department that is to undergo audit. This report enables the reporters ("auditees") to rearrange their ideas in a proper form. Although a checklist is sometimes prepared, the audit items do not always follow it. Since this checklist summarizes the ideas and the points of the audit, it is often effective to announce it before the audit.

Although the way of carrying out the audit is flexible, it usually includes a plant tour and a round-table discussion, which take place after presentation of the report about the current situation of the department. It is essential during the plant tour for the members of the auditing team to be very observant in order not to miss any details. To walk through the entire manufacturing process, from the storehouse to the final inspection, for example, is an effective way to locate and "shoot" the troubles. It is also important for the top managers to talk to the foremen and workers to encourage and motivate them; the audit offers a golden opportunity for conversation between them, which can hardly occur in the course of daily work.

Concerning the short report that is read before the discussion, it is advisable to review the actions taken by the department on comments and recommendations made at the preceding audits. The discussion based on the report and on the facts observed during the plant tour is the most important part of the audit.

After the discussion, comments and recommendations are summarized and announced by the leader of the auditing team. The consultant (often a university professor) also contributes suggestions. In addition to the recommendations for the department to take corrective actions, the statement should include the recommendations made for actions by the auditors. It is also important to include not only the faults but also the merits in the performance of the department under audit. Of course, the recommendations made should be seriously considered by the department audited, and the results should be checked at subsequent audits (Itoh 1974).

## *QUALITY ASSURANCE AND NEW-PRODUCT DEVELOPMENT*

**Customer-Oriented Concept.** Quality assurance is the most important company-wide quality control activity in Japanese companies. Several features of the Japanese approach are discussed below.

The first Japanese emphasis is on the requirement that the activities of quality assurance be customer-oriented. While this concept is well known, it is quite common for companies to judge the adequacy of their quality assurance by the amount paid out as a result of customer complaints. In effect, that consists of judging the adequacy of quality assurance by the cost to the company rather than the cost to the customer. The "user's quality cost," as discussed by Gryna (1977), takes account of customer demand and is based on a customer-oriented approach. However, although this user's cost concept is useful, it fails to take account of certain other aspects of customer satisfaction which are not quantifiable in monetary terms but are nevertheless influential in creating customer confidence.

**"Must-Be" Quality and "Attractive" Quality.** Ishikawa (1978) prefers to classify product quality as "backward-looking" and "forward-looking" qualities. Later Kano et al. (1984) gave a detailed consideration on this bidirectional way of perceiving quality, calling the former type "must-be" quality and the latter "attractive" quality. Thus they have a dualistic relationship with each other: some products sell well, even though they are the subject of many complaints, because they are highly attractive to customers, while others that receive few complaints do not sell at all because they lack appeal.

Thus, to obtain positive customer satisfaction, we must not only achieve must-be quality by eliminating defects and customer complaints but we must also give our products attractive qualities. Must-be quality is expressed in terms of indicators such as the defect rate, rework rate, and number of customer complaints. It therefore has the property of universality and may be expressed similarly for different types of products. Attractive qualities, on the other hand, are usually highly individual and are consequently different for different products. Thus, while statistical tools such as control charts are effective in controlling the former type of quality, the latter type is best achieved by learning as much as possible from individual examples of failure and success.

Takenaka Komuten, a Japanese building construction company, made extensive process improvements and succeeded in greatly reducing defects and reworks such as cracks in concrete or water leaks. Takenaka designers raised the question: Is this enough to satisfy our customers? To learn the answer, they visited and surveyed employees in the hospitals they had designed and built. During these interviews, they learned for the first time, for example, that nurses encountered daily troubles with the hospital facilities; that patients on the window side complained of the traffic noise and wished to be moved to quieter rooms, and that serious problems with maintenance of air conditioners were found early every summer. (All this had been going on despite the fact that the hospital director and some physicians reported that they were very satisfied with the building and facilities.) The findings were promptly reported to the design department, which took action to revise the design manuals and checklists. This, in turn, resulted in a remarkable increase in the company's share of the hospital construction market.

**Quality Costs versus the Manufacturer's Conscience.** Quality costs are frequently discussed in the context of corporate quality assurance activities. Among the many proposals made concerning the classification of quality costs, those made by Feigenbaum (1983) are the most significant. He classified quality costs into the following four categories:

1. Prevention costs
2. Appraisal costs
3. Internal failure costs
4. External failure costs

It is desirable to reduce such quality costs to as low a level as possible and to maintain them at that level. However, as implied by Juran's description of such costs as "costs of poor quality" (Juran and Gryna 1988), they relate mainly to must-be quality, and activities to reduce them have little to do with actively furnishing products with attractive qualities. Such activities are therefore useful for reducing costs but are insufficient in themselves to expand the market size and share and to increase profitability. Both of these activities are important because minimum quality costs do not necessarily mean maximum profit.

There are two main problems with taking quality costs as indicators of quality assurance. The first of these is that, while quality costs address the issue of must-be quality, they take no account of attractive quality. It is therefore impossible for this approach alone to shed light on the conditions needed to produce customer satisfaction.

The second problem is that quality costs represent the amount spent by a manufacturer for maintaining and improving quality; they do not represent the losses or quality maintenance costs borne by customers as a result of poor quality. Although quality is a common concern of both manufacturers and customers, these two parties often view quality from very different perspectives; for example, when complaints are made about quality, the financial losses sustained by customers often far exceed the amount spent by manufacturers for dealing with the complaint. Consequently, while these kinds of quality costs may be useful indicators of a manufacturer's cost-reduction performance, it is doubtful whether they are suitable for measuring the efficacy of its customer quality assurance.

Some attempts have been made to consider quality costs from the user's standpoint as opposed to the costs that must be borne by the manufacturer, mainly in relation to must-be quality. For example, Gryna lists the following seven items as user's quality costs relating to industrial products (Gryna 1977):

1. Cost of repair
2. Cost of effectiveness loss
3. Cost of maintaining extra capacity because of expected failures
4. Cost of damages caused by a failed item
5. Lost income
6. Extra investment cost compared to competing products
7. Extra operating and maintenance costs compared to competing products

These user's quality costs are probably more suitable quality assurance indicators than the manufacturer's quality costs described earlier. Furthermore, because of the recent importance given to environmental issues, it is also necessary to take into account the cost of protecting the environment during manufacturing and use of the product and after the product has reached the end of its useful life (e.g., the cost of scrapping it or recycling it).

Like manufacturer's quality costs, these user's quality costs also focus principally on must-be quality. Since attractive qualities are more product-specific and less immediately obvious than must-be qualities, as described before, it is difficult to assess them in the form of quality costs. However, user's attractive qualities are important product qualities that can create larger markets, bigger market shares, and greater profits for manufacturers, so it is important to take positive steps to develop products that feature them.

More generally, reducing users' quality costs is both an important and necessary aspect of customer quality assurance. However, this alone is insufficient. Ensuring customers' positive satisfaction (including providing them with attractive quality) depends on securing their trust and confidence in the manufacturer, and this is something that cannot be bought with money alone. The first thing that a manufacturer must do to win this confidence is to act conscientiously when it comes to customer quality assurance.

**"Fitness for Use and Environment" and "Surplus Quality."** In Japan the concept of fitness for use is enlarged to include fitness for the environment. For example, room air conditioners are used extensively in the densely populated Japanese cities. Beyond the need for comfortable temperature and humidity are the requirements of quiet operation and low consumption of electricity. At the initial stage of product introduction, some complaints came from neighbors who were disturbed by the noise of their next-door-neighbor's air conditioner.

In the context of manufacturers' and customers' different perspectives regarding quality, a few points about surplus quality are discussed. Surplus quality is divided into the following two categories:

1. Quality that clearly appears excessive to both the manufacturer and the customer.
2. Quality that tends to appear excessive to the manufacturer but that is strongly demanded by the customer.

As far as the first of these is concerned, it is important for the manufacturer and customer to work together in establishing limit samples and controlling these rigorously.

Acceptable items may be found among those that have failed inspection when there are stringent requirements concerning the quality of parts used in a customer's automated production line in order to maintain the productivity of that line. An extremely low defect rate (1 ppm or less) of electronic components was requested when large numbers of parts were being used for television sets in order to maintain the defect rate of the completed sets at an acceptably low level. Although it is also important in such a case to try to reduce the number of components used (e.g., by combining or modularizing them) and to make attempts to automate the inspection process, the most important thing is to minimize the defect rate of the components and, if possible, reduce it to zero.

Particularly today, when the lifetimes of products are decreasing due to the increasingly rapid appearance of new products on the market, it is becoming more and more important to cope with the competition in quality by achieving zero defects right from the start of new production.

Achieving extremely low or zero defect rates, which may appear at first sight to represent excessive quality, demonstrates the success of manufacturers in developing superior technology and high-quality products. Since they have gone to the trouble of developing these new technologies and products, it surely is extremely important for companies to make effective use of them by actively developing new fields of application for them.

**Autonomous Inspection.** Needless to say, the task of manufacturing is to manufacture products whose quality conforms to the quality of design: it is the production of conforming products. This definition of manufacturing includes autonomous inspection, which consists of workers checking their own products to see whether or not they conform. This is the basic premise of autonomous inspection.

Various conditions must be satisfied in order to get autonomous inspection up and running. The most important of these is to decide on the methods by which autonomous inspection is to be carried out (including sampling), clarify the division of responsibility between autonomous inspection and proxy inspection (described below), include the labor-hours used for autonomous inspection in the manufacturing labor-hour figures, provide the measuring equipment needed, and give people the necessary training.

The practice of autonomous inspection does not mean that the people working in the manufacturing process are required to check for every single quality that they are responsible for building into the product. Some qualities will only be checked for the first time when the product is processed or assembled in subsequent processes, and others would require too much time or skill for the people working in the manufacturing process to check them. Some qualities will be inspected by people in subsequent processes or by special inspection personnel rather than by the people who actually make the product. Since such inspections are carried out on behalf of the people who make the product, they are referred to as "proxy inspections." The results of proxy inspections should immediately be fed back to the people manufacturing the product as a motivational tool and to use in the manufacturing process in a way that confirms the controlled state of the process. At the same time, it is hoped that a spirit of cooperation and teamwork will be fostered between the people of the manufacturing process and the people who inspect it on their behalf.

Autonomous inspections, including proxy inspections, have the following additional features: People are instantly aware of the quality of the products they have made. They feel happy if their products are satisfactory, and will wonder what has gone wrong if their products do not conform or an abnormality is discovered in the manufacturing process. Then, because the results are known immediately after a product has been manufactured, autonomous inspections will definitely stimulate people's curiosity and desire for improvement and will motivate them to try to improve the situation.

**Process Capability and Control Charts.** Needless to say, the following two conditions must be satisfied in order to make products whose quality conforms to their quality of design, that is, for manufacturing conforming products:

1. Create no defects.
2. Permit no abnormalities.

In order to see whether these two conditions are satisfied, process capability indices and control charts are used.

Recent advances in factory automation, on the other hand, have led to the appearance of many automated and mechanized processes with far better process capability indices than ever before. However, this means that there is a danger of people mistakenly believing that because process capabilities have improved and no more defects are occurring, control charts are no longer needed. It is strongly emphasized once again that defects and abnormalities are different.

Cause and effect relationship should also be clarified to identify the possible relationships between product qualities and the various factors thought most likely to influence them. It is necessary to confirm the principal factors affecting product quality by checking correlation in the case of

variables and by stratifying the data in the case of attributes. Rigorously controlling any factors ascertained by these techniques to have a significant effect on quality enables us to reduce product quality variation and decrease the incidence of abnormalities. The skillful execution of this kind of upstream control is extremely important (Ishikawa 1962).

**Creativity and Work Standardization.** Clearly, the desire to work is closely connected to creativity and is in fact inseparable from it. On the other hand, necessity and importance of work standardization is often emphasized from the standpoint of improving work efficiency and assuring quality. Concerning work standardization, however, the following two types of problems are pointed out:

1. Work standardization conflicts with motivation, since it restricts the creativity and ingenuity of the people engaged in the work and reduces their opportunities to exercise those faculties.
2. Even after a lot of time and efforts have been put into standardizing work methods, the standards are actually not often complied with. One survey showed that, although most Japanese companies stipulate in abstract terms that their in-house standards are to be obeyed, more than half of them do not have any definite procedures for ensuring that they are in fact enforced. Preparing standards is known to be a difficult and time-consuming job. Is it so difficult for workers to follow the standards for the work they have been allocated?

To discuss the question of creativity and standardization in more concrete terms, let us examine work standards in a manufacturing process. They usually include the following three items:

1. The aims of the work. In a manufacturing process, this corresponds to the quality standards for the products that the process must produce.
2. Constraints on carrying out the work. The most important restrictions are those designed to ensure employee safety and preserve the quality created in upstream processes.
3. The means and methods to be employed in carrying out the work.

Of these three items, item 1 must always be achieved and item 2 must be scrupulously obeyed by whoever is responsible for doing the work. Clearly, everyone must make conforming products and work safely. But, must item 3 be obeyed in the same way as item 2 regardless of who is responsible for the work? As emphasized previously, establishing and enforcing prescribed means and methods encourages people to avoid responsibility for failure and claim that the failure was not their fault because they followed the stipulated methods. This must be strenuously guarded against.

One of the grounds for asserting that item 3 must be obeyed is that the standardized means and methods are the most productive and efficient, regardless of who uses them. At least the people who drew up the standards think so. However, in view of people's different characteristics and habits, it is highly unlikely that any single standard could be the most efficient for everyone, no matter how carefully it was formulated.

We know that this kind of standardization of action is missing from sports. To excel at a sport, we must first master the basic actions by reading textbooks and taking lessons, but this alone will never allow us to produce a new world record right away. The only way to keep improving our personal best is to build on these basic actions through hard work, that is, by continually practicing and exerting great ingenuity to discover the method that suits us best.

In light of this, item 3 should be regarded as the training manual for beginners, equivalent to the basic actions in sports discussed above, and not as rigid instructions to be obeyed without fail. Item 3 is for helping people understand the basic actions and making the process of learning the job more efficient.

In using these manuals, it is also important to make clear to all trainees at the end of their basic training that the working methods they have learned so far are no more than the standard actions that are useful hints for improvement, and that, having mastered them, they should actively try to further develop methods of working that really suit themselves as individuals. They should be told that this will help them to improve their skills, and that the managers actively support and encourage them to do so. Conversely, forcing novices to perform standard actions exactly as they have been taught is

an absurd way to proceed, since it not only leads to shirking responsibility but also prevents them from improving their skills.

If workers are encouraged to improve their skills, they are requested to use their own initiative to develop standard actions into practical working methods, and discover the secrets of performing the work efficiently. Creativity and standardization are thus not mutually exclusive but mutually complementary. By encouraging and promoting the standardization described here, managers will help the people engaged in the work make full use of their creativity, and discover methods of doing the work even better.

**Teamwork Relationship among Departments.** In order to achieve the goal of quality assurance, it is important, even indispensable, first to improve the quality of design to meet the target of fitness for use and environment. Second, the quality of manufactured products should be in conformance with this quality of design.

Although this procedure for assuring product quality is accepted, another general rule emphasized in Japan is teamwork among all departments. In other words, the cycle of plan-do-check-act should be rotated to involve marketing, design, manufacture, inspection, and sales. Quality assurance is one of the most important company-wide functions. It is also important to remember that quality assurance, cost and profit control, and control of factors such as delivery performance, production volume, and productivity are closely interrelated These activities are often regarded as cross-functional management, which consists of the following steps:

1. Making plans for each important corporate function
2. Passing the plans down to the specific line divisions that will implement them
3. Using policy management and daily management within these line divisions to implement the plans, check the results, and take any necessary corrective action
4. Further reviewing the results of implementing the plans from the company-wide standpoint and then taking any necessary corrective actions

The key point of cross-functional management is that the action plans for each of the functions formulated from the company-wide standpoint should not be implemented just by the supervisory head office or operating division department in charge of those functions. They should be passed down to all of the relevant organizational units within the company and be reflected in the duties of each, and they should be implemented, evaluated, and subjected to corrective action through teamwork among the different units. The PDCA cycle is rotated for each function on a company-wide basis by consolidating individual units' implementation results for each function and comparing these with the company-wide cross-functional objectives. Thus the head office or operating division supervising department does not bear the sole responsibility for implementing cross-functional management; it is shared by all of the company's line divisions in accordance with their respective duties.

A company usually sets up supervisory departments such as a quality assurance department within its head office or operating divisions to plan these activities, support their implementation, and evaluate them from the company-wide standpoint. However, these supervising departments usually are not very large.

It is also usual practice to set up a quality assurance committee for each function in order to effectively promote cross-functional management while liaisoning between the different departments. Each of these committees is chaired by the director responsible for the particular function, and the head office or operating division supervisory department responsible for each function acts as the committee's secretariat.

**Teamwork Relationship with Relatively Few Suppliers.** The quality and reliability of modern complex products depend heavily on the quality and reliability of components and parts. This product quality cannot be assured solely by 100 percent inspection. Japanese manufacturers have been trying to establish and maintain a cooperative relationship with their suppliers in order to improve and assure component quality. This requirement will probably become more stringent as the number of new products entering the market increases and their life cycles shrink.

Such strict quality requirements cannot be met by means of suppliers' final inspections or manufacturers' incoming inspections based on the usual types of sampling inspection plans. In addition to implementing automated "screening inspections," manufacturers are placing more and more importance on promoting the type of quality control that extends to the quality assurance activities of suppliers themselves.

As a result, increased emphasis is being placed on establishing cooperative relationships and good teamwork between the suppliers making the components and the manufacturers using them. The establishment of teamwork relationships starts with the selection of suppliers. Questionnaires are distributed and visits made, and the suppliers are screened on the basis of financial status, facilities, basic ideas and policies of top management, enthusiasm for quality improvement, level of education and training of employees, etc. Large Japanese companies usually have an established procedure for this selection and a standardized checklist.

Good teamwork relationships with suppliers are based on mutual trust and confidence and cannot usually be established in the short term; it takes at least a few years. Importance is attached to the basic philosophy and the enthusiasm of the top management personnel. Because of the smaller size of the supplier companies, quality control activities and product quality and reliability are rather rapidly improved under the positive leadership of their top management. Independent ideas and attitudes of the suppliers are emphasized, rather than a dependent relationship to the purchasing company. Positive guidance and quality control educational services are made unsparingly available by the company on the understanding that voluntary efforts will be made by the suppliers. The importance of education and training—which become more effective in the relatively long term—is emphasized.

There is a recent trend in Japan for smaller manufacturers of components and parts to have their own test laboratories for these components so as to ensure that their quality and reliability are adequate before permitting the design department of the purchaser to specify them for use in the final manufactured products. Such test laboratory activities by the parts manufacturers are also effective in the development of new products of their own. It is fairly common in Japan for data on the process capability index and manufacturing process control charts in supplier organizations to be sent to the purchasing company and utilized in the manufacturing, inspection, and design departments in addition to the quality control department. Internal quality control audit by top management is voluntarily carried out by the suppliers. In this audit, appropriate representatives of the purchasing company are sometimes invited to attend the audit and express comments as outside authorities.

"Ten Principles for Vendee-Vendor Relations from the Standpoint of Quality Control" were established in 1966 and presented by Ishikawa (1969) at the International Conference on Quality Control 1969, Tokyo, as follows:

*Preface:* Both vendee and vendor should have mutual confidence, cooperation, and high resolve of "live and let live" based on the responsibilities of enterprises for the public. Following the above spirit, both parties should sincerely practice the following "Ten Principles."

*Principle 1:* Both vendee and vendor are fully responsible for quality control application with mutual understanding and cooperation on their quality control systems.

*Principle 2:* Both vendee and vendor should be independent of each other, and esteem the independence of the other party.

*Principle 3:* Vendee is responsible to bring clear and adequate information and requirements to the vendor, so that the vendor can understand what should be manufactured.

*Principle 4:* Both vendee and vendor, before entering into business transactions, should conclude a rational contract between them in respect of quality, quantity, price, delivery term, and terms of payment.

*Principle 5:* Vendor is responsible for the assurance of quality that will give full satisfaction to vendee. Vendor is also responsible for submitting necessary and actual data upon the vendee's request, if necessary.

*Principle 6:* Both vendee and vendor should decide the evaluation method of various items beforehand, which will be admitted as satisfactory to both parties.

*Principle 7:* Both vendee and vendor should establish, in their contract, the systems and procedures through which they can reach amicable settlement of disputes whenever any problems occur.

*Principle 8:* Both vendee and vendor, taking into consideration the other party's standing, should exchange information necessary to carry out better quality control.

*Principle 9:* Both vendee and vendor should always perform business control activities sufficiently, such as in ordering, production and inventory planning, clerical work, and systems, so that their relationship is maintained upon an amicable and satisfactory basis.

*Principle 10:* Both vendee and vendor, when dealing with business transactions, should always take full account of the consumer's interest.

These principles were formulated through enthusiastic cooperation and thorough discussions among purchasers and suppliers. Their meaning is obvious, although they have not always been adhered to. It is hoped that they will further be utilized as much as possible as a basic guideline for improving the manufacturer-supplier relationship.

**Quality Information—Quality Complaints versus Systematic and Positive Collection of Quality Information.** In a paper on quality design, Aiba (1966) emphasized the importance of securing external quality information from customers in the marketplace. Such raw information is then converted into measurable quality characteristics.

In this connection, external quality complaints, while demanding prompt and remedial action, are collectively a poor index of quality. They reflect must-be quality—the poor quality of product dissatisfaction. In addition, quality complaints are subject to the following kinds of problems as a measure of quality:

1. Complaints are influenced by the unit price of the product.
2. Any kind of information, not only that on complaints, can very easily become distorted when transmitted orally.
3. Complaints are also affected by the type of customer and the economic climate.
4. Some complaints vanish en route to the manufacturer.

Quality complaints might be expressed as sporadic and passive information on must-be quality. However, they are still a valuable source of information that we should use to improve the quality of our products.

In tandem with this process, the systematic and positive collection and utilization of external quality information on the following are also important:

1. Customer demands, i.e., how the commodities are used by the customers and the conditions of use
2. Quality of similar commodities manufactured by competitors
3. Actual conditions of transportation and storage by distributors' channels and by retailers
4. Present and future market trends

At the Cotton Underwear Division of Gunze Co., Japan, the division director received a letter from an elderly male customer expressing his hearty appreciation for the excellent quality and durability of Gunze cotton underwear, stating he had been wearing the same articles for more than 10 years. This customer also urged the director to develop new products of such high durability. The director requested a consultant's opinion about the development of such new products. The consultant asked, "How long do customers usually wear your underwear?" Since the division had not investigated the life span of the underwear, it conducted a market survey. When the results were summarized in the form of a histogram, the distribution of life span clearly was well approximated by a normal distribution curve, with a mean of about 3 years and a standard deviation of about 0.5 years. It became evident from this histogram that the number of customers who continue to wear the

same underwear for longer than 4.5 years was 1 to 2 per 1000. The data suggested that the market for a new product of much higher durability was very limited.

To avoid possible adverse consequences of reacting to sporadic customer information, it is necessary to collect market quality information on a systematic basis. Such systematic collection is comparatively easy for products of high unit price, as in the case of the Takenaka Komuten construction company, mentioned earlier. With products of low unit price, some ingenious methods are necessary. A questionnaire card is often enclosed with the product, asking customers their reasons for purchasing, the name of the retailer, impressions of product performance, conditions of use, etc. In Japan customers often mail this card immediately after their purchase and before using the product. Hence their comments about quality and reliability are meaningless. Furthermore, only a small proportion of the cards are usually sent back to the manufacturer. A better way is to utilize the returned cards to design follow-up surveys and then to apply sampling techniques based on types of customers and conditions prevailing during use. Interviews with the customers are usually far more fruitful than mailed questionnaires.

Apart from special situations, the external quality information is usually collected by regular company sales or marketing personnel. However, although the collection and feedback of external quality information is an important part of their quality assurance task, it is not their only job, and they usually have to squeeze it into the gaps in their busy and complicated daily sales and service schedules.

Consequently, the enthusiasm of these people for collecting external quality information at the request of design and engineering departments easily tends to evaporate if the purpose for which it is being collected is unclear, if hard won information is left idle and not utilized for new-product development or quality improvement, or, if after having worked so hard to collect the information, they are not informed of the benefits achieved through its utilization.

As users of this external quality information, which has taken so much effort to collect, the engineering and design departments should therefore provide positive feedback to the sales people responsible for collecting it. They should tell them how effective it has been and how they would like it to be improved. If, through poor communication, the sales personnel collecting the external quality information receive no reaction from the departments requesting it no matter how much information they pass on, they will feel that their efforts are not valued. Conversely, if the quality information that they have spent so much time and trouble gathering is used effectively within the company and they are given information on how it can be improved, this will increase their enthusiasm for collecting it. This is very important both for motivation and for the smooth operation of a quality information system.

**New-Product Development.** Since Japan has few natural resources of its own, the only way it can survive and grow is by obtaining the necessary foreign currency by profitably developing, manufacturing, and exporting high-value-added products that satisfy customers' actual and potential needs and that they are delighted to use. It is impossible to achieve this in regard to product quality simply by reducing user's quality costs relating to must-be quality. It also requires action to satisfy customers in positive ways, including the development of new products. Through this, we aim not just to minimize quality costs but to maximize corporate profits.

Quality function deployment (QFD) (Kogure and Akao 1983; Akao et al. 1987), a "design approach" based on deductive reasoning, has recently been widely adopted as an effective technique for new-product development, with eye-opening results. At the same time, however, we must not forget that the analytical approach using the quality control story is also highly effective. It is important to make positive use of the valuable lessons that past successes and failures have taught us, and not just discard them because the present project happens to be different from previous ones.

We know that we can increase the likelihood of a project's success if we appoint as team leader someone who has already succeeded with previous projects, even if they were different from the present project. This is because such people not only have confidence in their ability to succeed but also know how to make use of their past experiences in the present project—in other words, they follow the PDCA cycle.

Many companies try to prevent the repetition of new-product development failures by collecting examples of past failures and having those involved in current projects study them. This is also an

attempt to utilize the analytical approach based on the quality control story. However, as long as they are collecting examples of failures, it is equally important to try collecting examples of past successes and make use of these. The reason for the success of a project is not usually the opposite of the cause of its failure; the two are often different. Publishing compendiums of failure case studies certainly reduces the chance of making similar mistakes, but it is doubtful whether it increases the possibility of success.

Companies that are good at new-product development and enjoy a high success rate usually appoint their deputy CEO or a senior director as their new-product development manager. It is often said that the enemies of new-product development are to be found within the company. When the work of developing a new product or technology begins, some people will always come out with negative comments like, "There's no point in doing that," or "We already know it can't be done." A new idea is like a flower bud—it is easily squashed, but we do not know how good it really is until it has been allowed to develop to some extent. The most important duty of the new-product development manager is to foster these ideas he or she believes are important and are likely to prove useful in the future, shield them from criticism within the company, and make something of them.

In many Japanese companies new products are classified into the following groups on the basis of their novelty:

1. New in the world
2. New in Japan
3. New in the company
4. Model change of a current product, etc.

Such a classification is effective for determining the steps and stresses in new-product development. For a new-product of class 1, the quality, including safety, and the reliability should be most strictly assured even though time and money are needed. The new users of these products should also be broadly pursued and developed.

It is frequently stressed that the development of new applications must not be ignored when thinking about new-product development. In view of the many new materials that have been developed recently, it seems that the development of the material precedes the development of uses for it. In short, the development is "seeds-led", with the development of needs lagging behind. An example of this is the recent development of a brassiere employing shape-memory alloys that is selling well, particularly in the American market. This illustrates how important it is, in developing new applications, to be thoroughly familiar with the quality characteristics of newly developed materials or technology, to identify latent customer needs that existing technology has been unable to satisfy, and to pool ideas to come up with ways of resolving the situation.

In contrast, for new products of classes 3 and 4, the emphasis is on promptness, so that product development cycle time can be shortened in order to cope with competition in the market.

During quality design, there is a need for conversion of true quality characteristics requested by customers into measurable substitute characteristics (Aiba 1966). The QFD technique mentioned above is being widely used for this purpose. After converting the true quality characteristics into the measurable substitute characteristics, it becomes easier to determine the quality specifications for each item.

The measurable substitute characteristics thus evolved become the focus of various checkpoints in the manufacturing and inspection processes. During the design and pilot stages of the manufacturing process, a "quality control process chart" is established for assurance of quality in the manufacturing process. Figure 41.4 shows an example of such a process chart, which, as may be seen, uses substitute characteristics. Thus the quality function is implemented throughout the whole company (Kogure and Akao 1983).

The steps in new-product development are roughly as follows:

1. Market research
2. Conceptualization
3. Experiments, market research

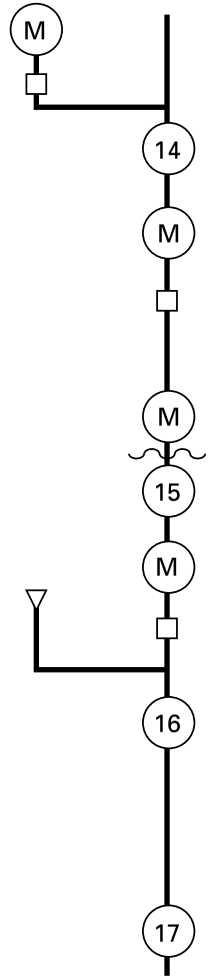
| NAME OF PART | FLOW CHART | NAME OF PROCESS | OPERATION MANUAL | ITEM | METHOD | PERSON | SAMPLING | MEASUREMENT |
|---|---|---|---|---|---|---|---|---|
| | MATERIAL PROCESS / MAIN PROCESS | | | | | | | |
| Lead chip |  | Preforming | 32-2-RC-1 | T.W. | X-R Chart | Mr. F | Every lot, random n = 5 | Autobalance |
| | | | | T. dia. | Check sheet | Mr. F | Every lot, random n = 10 | Gauge |
| | | | | Appearance | p-Chart | Mr. F | Every lot, total n = 300 | Eyes |
| | | | | Temperature | | Mr. F | Twice a day | |
| | | | | Speed constancy | | Mr. F | Twice a day | Drum |
| | | Preheat | 22-RCG –005 –006 | Temperature | Check sheet | Mr. S | Twice a day | |
| | | Forming | 222-RCG | L-dimension | X-R chart | Mr. S | Every lot, random n = 5 | Slide calipers |
| | | | | Temperature | Check sheet | Mr. S | Once a day | |
| | | | | Pressure | Check sheet | Mr. S | Once a day | |
| | | Aging | 222-RCG 6-1 | Temperature | Check sheet | Mr. S | Once a day | |



**FIGURE 41.4** A QC process chart for a solid resistor. (*Source: Ishiwara 1975.*)

4. Application for patent
5. Quality design
6. Pilot-scale manufacturing and qualification testing
7. Process design
8. Full-scale production testing and sales
9. Mass production
10. Termination of initial warning system
11. Termination of mass production

These steps and the company departments involved may be summarized by a chart of the quality assurance system, an example of which is shown in Figure 41.5. This chart will vary with the novelty of the products.

Development of new products is usually a time-consuming undertaking, involving many trial-and-error procedures. However, the procedures of evaluation, qualification, review, etc. carried out during the various steps can be standardized, which becomes the first step in introducing quality control to new product development.

**Market Research and Hypothesis Testing.** Two stages of market research are shown in the above-listed steps of new product development (steps 1 and 3). The preliminary market research is rather general in character and may lead to an idea for a new product. The later market research is to confirm the effectiveness of this idea.

For example, in the late 1960s (Yoneyama 1969), the half-size camera was becoming popular in Japan. The first manufacturer was company A. At company B, there was discussion among top managers about developing a new half-size camera to compete with that of company A. Mr. Y. was appointed a senior member of the development team. First, he collected statistics on monthly camera sales from the relevant government report and classified them into sales of half-size and full-size cameras. He found that total sales were rising mainly because of the increased sales of half-size cameras. When fitting the increase in demand for half-size cameras to a logistic curve, it became clear that this increase was not likely to slow down. From this study, top management decided to develop a new camera.

The second market research program (step 3) was then launched. It happened that company B was also selling color film, which was ultimately developed at the company's central laboratory. It was found from the analysis of developed film that the pictures taken indoors by half-size cameras were often blurred. It was decided on the basis of this fact that the new camera should be equipped with a better lens.

Mr. Y went out every Sunday with two counters in his pockets. He strolled in downtown Tokyo and then in suburban resorts and counted the number of people who carried a camera; he pushed one counter for each full-size camera and pushed the other counter for each half-size camera. He found that the ratio of half-size to full-size cameras was lower downtown than in the suburbs. It became clear that the customers were buying the carrying convenience and light weight of a half-size camera. It was then further decided that the new camera should be lighter than the camera of company A.

These two features of company B's new half-size camera became very profitable sales points. It should be noted that the ideas conceived in step 2 above need to be examined and confirmed in the market research of step 3. Systematic and positive collection of quality information from the market is also important for determining test conditions in qualification and for improving the items subject to design evaluation and review in the intermediate stages.

**Design Reviews—Corrective Action on Physical Objects and Process.** Design review, evaluation, and qualification done at proper stages of development, such as steps 5, 6, and 8, are prevalent in Japanese companies. These evaluations aim at determining whether

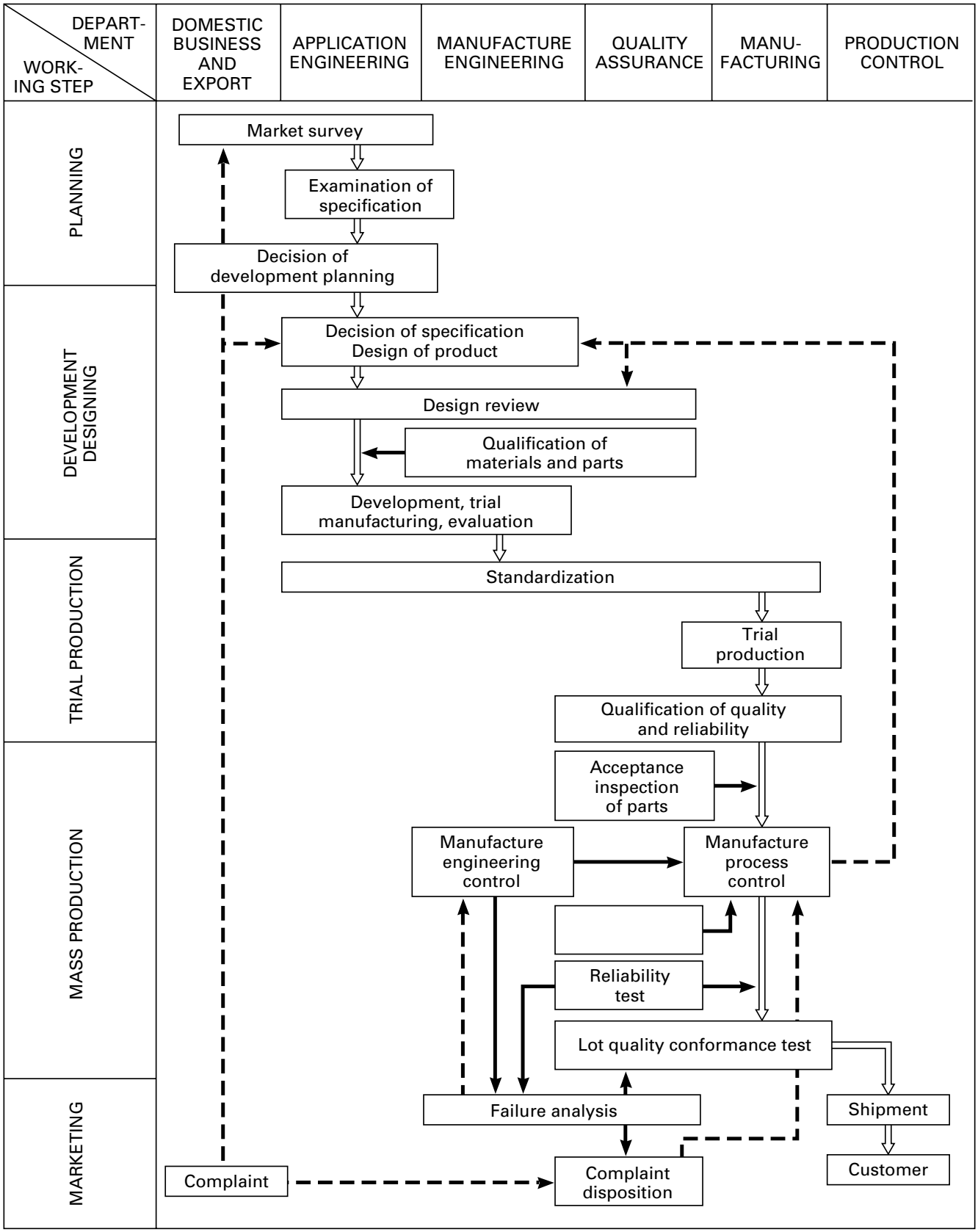



**FIGURE 41.5** Chart of quality assurance system. (*Source: Takanashi 1978.*)

1. The quality of design was appropriate
2. The design of the foregoing procedures was adequate

With regard to exported goods, quality information from foreign markets is extremely important because environmental conditions (temperature, humidity, dust, etc.), laws, weights and measures, customs, conditions of use, physical constitution of customers, etc. are quite different compared to the domestic market. Although these data in foreign markets cannot be anticipated in the earlier stages of foreign trade, records of previous failures of various kinds are accumulated and utilized as much as possible to prevent recurrences. Those corrective actions that improve the design, testing, and evaluation procedures are most effective.

**Full-Scale Production Testing.** The aim of the full-scale test (or trial), which is the final stage of new product development, is not always clear. It is often carried out by skilled workers, with quite satisfactory results. When mass production starts, however, the manufacturing department is always worried about problems in the manufacturing process. The reasons are clear: They reflect the differences in the skill of the workers engaged in the full-scale test run and in mass production. The distribution of the quality of components and parts is also sometimes different. The true aim of the full-scale test should then be clearly defined and achieved. One of its most important purposes is to thoroughly eliminate weaknesses in manufacturing and take corrective actions before the start of mass production.

Taking this approach even further, we arrive at the concept of upstream management discussed previously. Not only should we eliminate all remaining problems before the start of mass production by performing full-scale production testing under mass production conditions, but we should also investigate those problems closely to determine whether or not they could have been discovered only at the full-scale production testing stage or whether they could, in fact, have been discovered in earlier processes and prevented from occurring in the first place. We should also think about how the development process could be improved in order for this to happen. We should put these improvements into effect, check the results, and identify any remaining problems. Thus we will continue to rotate the PDCA cycle.

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