

**QC KENTEI (The Quality Management and
Quality Control Examination)**

Grade 4 Textbook



Japanese Standards Association

QC KENTEI Center

Introduction

“QC KENTEI” is an abbreviation of “Quality Management and Quality Control Examination.” This textbook provides a simple explanation of the scope of Grade 4 of QC KENTEI for those preparing to take this Exam. Although there are many types of companies and organizations, quality management is essential at every workplace. This textbook provides easy to understand guidance on the basics of quality management. Quality control (QC) activities have long been a base of the higher quality of products made in Japan, but they also include common approaches and methodologies that everyone should understand, not just to support Japanese industries but also the lives of people around the world for a better future.

This textbook comprises three chapters and an explanation of terminology. Chapter 1 explains the importance of the ideas and ways of quality management to ensure that an organization produces good products and services and also discusses approaches to work and its improvement. Chapter 2 introduces principles of quality improvement activities by explaining how the clarification and steady execution of processes is fundamental to the production of high-quality products; how, to improve processes and quality, it is important to make decisions based on facts and data; and how statistical methods such as the QC seven tools are useful for utilizing data effectively. Chapter 3 explains fundamental approaches to organizational activities for making better products, such as the *Ho-Ren-So* of reporting, contacting, and consulting in an organization; 5W1H; *sangen-shugi* (three real-ism); *5-gen-shugi*; manners as a member of an organization; the 5S (*Seiri, Seiton, Seisou, Seiketsu, and Shitsuke: Sorting, Setting in Order, Shining, Standardizing and Sustaining the Discipline*); and the importance of health and safety in the workplace.

Words and phrases used throughout this textbook with superscript figures attached in the form of ^{*1}, ^{*2}, etc., such as “product^{*1},” are explained in Chapter 4, “Explanation of terminology” as technical terminology. These explanations introduce the definitions and meanings of terms prescribed in standards, etc. in the quality management field and are written in an easy-to-understand way.

In addition, sections such as “rules for ...¹⁾” with superscript figures in the form of ¹⁾, ²⁾, etc., are quotations from related documents or are provided for reference purposes. A list of these is provided in the Appendix under “Citations and Reference Literature.”

People normally work within an organization of some kind, and these organizations include not only companies, but hospitals, schools, etc. In this textbook, the terms “company” or “corporation” may be used to signify organizations. In addition, organizations vary greatly in terms of their operations. They can include manufacturers, supermarkets, convenience stores, hotels, restaurants, banks, and securities companies; however, the fundamental approaches and methods of quality management apply to all these organizations.

These organizations supply customers with products or services. While this textbook may classify “products and services,” please note that their service to a customer can also be interpreted as a product for the customer, and that useful approaches or methods to improve products will often also apply to services.

When an organization manufactures a product or provides a service, it must ensure that it is somehow good for the customer. A good product or service means a product or service of high-quality. It is also essential for an organization to assure that there is no significant variation among the quality of products or services provided to the customers, because if the organization supplies its products or services with different quality at the same price, customers who have purchased them may feel dissatisfied or that they have been treated unfairly. The purpose of quality management is to design organizational activities to ensure that customers feel no trace of dissatisfaction and perceive no unfairness at all with respect to their purchased products or services and continue to feel satisfied and delighted during the life cycle of the products or services. Nowadays every organization does its best every day to get its competitiveness by maintaining or improving customer satisfaction of the products and services. As a result, quality management has become one of the most important methodologies. Everyone who works in an organization needs to learn about quality management and strive to enhance quality and deliver improvements.

We hope that everyone who is planning to join and work in an organization in the future and everyone who has just joined an organization will study quality management and improve their knowledge of it by taking Grades 4, 3, 2, and 1 of the QC KENTEI, in that order.

For details of the QC KENTEI system, information on how to apply to take it, and so on, please refer to the website of the QC KENTEI Center, Japanese Standards Association.

November 2009

Steering Committee for the Quality Management and Quality Control Examination

Tadashi Yoshizawa, Chairman

Information concerning revisions to the Grade 4 Textbook

The QC KENTEI was established with the aim of supporting the general improvement of Japanese industry as a whole by equipping examinees with knowledge of the fundamental approaches of quality management, the purpose of which is to maintain and enhance the quality of products and services and to reduce costs and improve delivery in terms of quantity and delivery dates by leading work and organizational activities in the proper direction that should be taken. Since its launch, the examination has targeted working people and students, providing a means of assessing and certifying their knowledge of approaches, methods of implementation, and techniques relating to quality management as well as their competence to apply that knowledge.

In the decade since the exam was first held in 2005 to the 17th time it was held in March 2014, more than 500,000 applications to take the exam have been received, and in 2013 we received applications from over 100,000 people. This can be regarded as proof that the QC KENTEI is well respected by society and has acquired a certain level of trust. I would therefore like to take this opportunity to extend my deepest gratitude to all the examinees who have made the QC KENTEI such a success, as well as all the people who have supported them.

This, the Grade 4 Textbook, was produced to provide people who are thinking of taking Grade 4 of the QC KENTEI with information on the scope of the exam and guidance comprising straightforward explanations of the knowledge required for Grade 4. Five years have now passed since the last revision in 2010.

Taking on board the opinions of numerous people who have taken the QC KENTEI, and also taking into account the needs of industry in Japan and overseas and the importance of equipping people with “knowledge and competencies required for quality management” and related knowledge, which continue to change in conjunction with the development of quality management and related information technologies, we have decided to periodically review and revise the QC KENTEI Table. In accordance with the latest revision of this table, we have also updated this Grade 4 Textbook.

We performed the revisions after obtaining input from various quarters, including schools and corporations, and collecting various types of information. This included the “Expectations for students taking the QC KENTEI,” which forms part of the section introducing organizations that have actively used the QC KENTEI on the QC KENTEI Center website. From the information we received, we found that not only is this textbook used for preparing for the Grade 4 Exam, it is employed as a textbook for obtaining a basic education and knowledge essential for ordinary citizens.

Therefore, in making the revisions, we made the material covered in Grade 4 of the QC KENTEI Table the core content, but also endeavored to include a range of essential information that not only people taking the Grade 4 Exam but also other people might wish to acquire as baseline knowledge for ordinary citizens. Thus, we maintained the same chapter structure as in the previous edition but also added some extra information.

Quality management is an effective way for enabling personnel to achieve high levels of growth as a key organizational resource. We hope that the fundamental approaches and methods of quality management will become widely applied throughout Japan, not just in certain organizations or departments. “Quality management begins and ends with education”—as this statement indicates, if you want to improve quality, it is essential to provide everyone who belongs to the organization with thorough education on quality management, including education that raises their awareness, on a continuing basis.

We hope that this textbook will provide a starting point for beginning quality management and that it will be of help in your activities in the future.

Additionally, if possible, it is our hope that you will eventually continue past Grade 4 to tackle the challenges presented by Grades 3, 2, and 1 step by step.

For details on the QC KENTEI system, information on how to apply to take it, and so on, please refer to the website of the QC KENTEI Center, Japanese Standards Association.

Steering Committee for the Quality Management and Quality Control Examination

Hiroe Tsubaki

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Chapter 1 What is quality management?

—Making good products in an organization—

1.1 What is quality?

(1) Definition of quality

The **quality**^{*2} of a **product** or **service**^{*1} is normally defined as “**fitness for use**.” However, unless the **customer**^{*3} is satisfied as a result with quality, efforts to achieve good quality will be in vain. So, in a broader sense, the quality is related to the “satisfaction delivered to the customer,” which is sometimes referred to as **customer satisfaction (CS)**.

For example, a customer who is thinking about buying a large screen 4K LCD television that the entire family can enjoy watching in his/her ample living room might want or expect the following features of the television and also of the services bundled with it:

<Demands and expectations concerning the product itself>

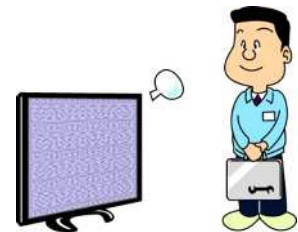
- Image and sound quality that makes you feel like you're really there
- Clearly viewable from any angle in a bright room
- Color and design that matches the furniture
- Many useful functions, such as recording
- Connectable to PCs, game consoles, etc., via wireless LAN
- No need for cables or a power cord
- Can be operated even by elderly people and children without a manual.
- Doesn't break even if handled roughly.
- Won't fall over even in the event of a large earthquake.
- Works even during a power outage.
- Uses much less power.
- Can be moved to any location with ease.



And others

<Demands and expectations concerning services>

- Setup and connection are performed free of charge.
- The television is inspected regularly.
- Someone will come to help immediately whenever there's a problem.
- Service will be provided over the lifetime of the product, covering trade-ins, moving house, disposal.



And others

If demands and expectations like these, which a customer has in advance, are actually met by the product or service provided, the customer will probably be extremely satisfied. Conversely, if such demands and expectations are not met, no matter how much the seller argues that it is a high-quality television, it cannot be so from the customer's point of view.

In other words, quality is the customer's assessment of the product or service provided. So when we think about quality, the starting question is: **who are our customers?** After that, we need to look at whether the demands and expectations of customers are actually being met by providing the product or service.

(2) Targetted quality

If the seller is to deliver the quality demanded/expected by customers, it needs to listen carefully to what customers have to say about each product and service and perform a detailed investigation of how customers are receiving current products and services and how these products and services satisfy them. This is expressed as “listening to the Voice of Customer (VOC)^{*4}.” By analyzing the VOC, the customer’s problems, the environment that surrounds the customer, and so on, we must clearly define the **required state** or the **ideal state** of the product or service from the standpoint of the customer. This is referred to as setting the **targetted quality**.

1.2 What is quality management?

(1) Problems and issues concerning quality

After determining the targetted quality as discussed in the previous section, the next step is **quality management**^{*5}. Quality management refers to the systematic activities conducted by the organization for the purpose of delivering the targetted quality. To deliver targetted quality, it is first necessary to identify the situation concerning the product or service actually being provided as its **current state**, then to investigate whether there is a gap between that and the targetted quality. An obvious **gap** between the two indicates a **problem**^{*6} or **issue**^{*6} with quality, and eliminating that gap is the foundation for quality-related **problem solving**^{*7} and **task (issue) achieving**^{*7}.

Normally, to solve a problem, you identify the characteristics of the problem based on the facts. Then, based on those characteristics, you identify their root causes and relationship with the causes and effects that led to the problem. Then, by taking action to tackle the identified causes or processes, you endeavor to solve the problem. To achieve a task (issue), on the other hand, you make a list, from various angles, of ideas that could deliver the ideal state. You then narrow this list to the ideas that are the most effective means of achieving the objective. After that, you endeavor to achieve the task by increasing the degree to which the means can be executed while taking into account elements that could hinder execution. Activities for improving quality, like the problem solving and task achievement discussed here, play a vital role in ensuring that customers are continuously provided with products and services that truly delight them.

(2) Fundamentals of quality management activities

The history of quality management began with efforts to provide “good things” to customers and to maintain the quality of these things at a certain level. “Good products/services” refer to products and services that satisfy customers with good quality. It is obviously necessary to reduce **variation**^{*8}. This is because if products or services that vary in terms of quality are sold for the same price, it would seem unfair to the customers who purchased them, and the initial objective of providing the same level of satisfaction to every customer would not be achieved.

Some of you might think that all that needs to be done is to alter the price to reflect the variation of quality. Of course, in cases such as the sale of vegetables on an individual basis or the sale of drinks, where the price varies based on quantity rather than quality, it is not difficult to explain why prices are different. But adjusting the price of each and every product or service based on differences in quality is not necessarily easy for the supplier to do. The reason is that it is incredibly difficult to explain the relationship between differences in price and quality to customers in such a way that is acceptable to them. And obviously, the customers that purchase the product or service will not be satisfied if they have to spend time and effort checking the price and quality differences of every single product or service before buying it.

For example, if hamburgers were always sold in such a way that the same size of bun contained the same size of patty cooked to the same degree with the same amount of sauce of the same taste on it, every customer would have the peace of mind that they could eat the same hamburger whenever or wherever they liked.



To ensure that the quality of products and services provided to customers is adequate and to maintain this quality at a certain level, it is necessary, before you start supplying them to customers, to distinguish between good things and bad things, and to take action to ensure that only good things are provided to customers. However, this alone will not eliminate bad things and is not necessarily economical. Things won't go well unless you can make good things to begin with by creating a mechanism for ensuring a fixed level of quality at every phase, from the procurement of materials to the production and sale of the products. Quality management has evolved as an activity for implementing initiatives like these.

However, the following problems often arise on the frontlines of manufacturing:

- Incessant **complaints**^{*9} from customers^{*3}
- Products keep being returned or needing to be repaired.
- **Nonconformities**^{*10} occur even after mass production has begun.
- **Nonconforming items**^{*10} with the same type of nonconformity keep being discovered during delivery inspections.
- Machines and equipment are not being properly maintained, and nonconforming items frequently have to be discarded during the process.
- Lots of parts received often fail inspections, and the line is halted frequently.
- Workers often make careless mistakes.
- Workers keep making the same mistakes.
- Workplace leaders (foremen) and workers focus solely on work periods, delivery dates, and costs.
- Procedures for performing new jobs are vague, and workers all do things in different ways.



Quality management is an activity for solving quality problems like these. To ensure that this activity is conducted effectively and efficiently, it is not enough for each employee to be individually engaged. There needs to be cooperation within each workplace and among workplaces in order to solve problems.

Recently, emphasis has been placed not just on solving current quality problems but on determining issues or tasks and taking action to ensure that these tasks are achieved, with the aim of providing attractive and impressive products and services that actually surpass the demands and expectations of customers.

(3) Fundamentals of quality management in the workplace (PDCA cycle)

For quality management in the workplace, it is particularly important to plan, do, and then make improvements. In other words, you must:

- i . Thoroughly understand the objectives and nature of your work, set goals, and plan the way you are going to work. (**Plan**)
- ii . Decide how you should do it, make preparations, and implement it together. (**Do**)
- iii . Grasp the implementation status, find out whether activities are being conducted appropriately, confirm/analyze whether the results are as expected, and shed light on problems and their causes. (**Check**)
- iv . Based on the causes identified, determine what should be improved, then make the improvements. (**Act**)

The first principle is to execute the above four activities in order. This approach is fundamental for performing work and is normally referred to as **following the PDCA**^{*11} **cycle**. **PDCA** will be explained in detail in section 1.5.

(4) Quality in the broad sense (QCD + PSME)^{*12}

When manufacturing products or providing services, you need to think about things in a comprehensive fashion. In addition to ensuring **quality**, you need to keep **costs** as low as possible, and you need to ensure **delivery** of

the **quantity** of the products promised to the customer on the day (delivery date) promised. Quality, cost, and delivery terms (i.e., quantity and date/time) are referred to as **QCD**^{*12}, and are sometimes also regarded as constituting **quality in the broad sense**.

In addition, when making products in the workplace, productivity (**P**) is emphasized alongside quality. However, what's more important than anything else is safety (**S**) and mental health (**M**: morale, morality). This approach makes people the foundation of everything, with various activities performed within that scope. In other words, the organization as a whole works together to ensure safety. It is important that everyone involved in the activities of the organization remain free of injury, stay healthy, and feel respected as human beings. Activities designed to maintain health (including mental health) and safety are sometimes termed **occupational health and safety**^{*13} activities. Furthermore, activities that guarantee the safety of everyone who interacts with a product (including its users) over its lifecycle (the period from the purchase of the product to its subsequent use and eventual disposal) are also important. This is referred to as **product safety**^{*14} and is another important element in quality management. In addition, activities to **protect the global environment**^{*15} (**E**) have also come to be emphasized recently.



(5) Focal points for improvement (*Muri/Mura/Muda*)

In improvement activities, we are always considering the best working methods to ensure the level of quality demanded for products or services. When making improvements, our focus is on finding and endeavoring to eliminate the **Muri/Mura/Muda**, which stand for the Japanese words **Muri** (unreasonableness), **Mura** (inconsistency), and **Muda** (waste). If there is too much unreasonableness in the way work is performed or in scheduling, the workers will get tired, which will result in quality problems. Meanwhile, work that has inconsistency leads to uneven quality. Finally, work that involves a lot of waste, as well as waste resulting from the repair or disposal of poor-quality products, can lead to higher costs.

1.3 The quality-orientation approach

(1) What is quality orientation?

For an entire organization to engage in quality management, the approaches and goals of everyone involved must be aligned based on the view that **quality takes priority**. A quality orientation means that priority is placed not on the pursuit of short-term profits or sales expansion, but on supplying higher-quality products and services. Of course, activities such as reducing costs, trimming inventory, and delivering products on time are also important tasks for the organization, but unless quality, which is essential, is good, all that will happen is that costs will increase, inventory will accumulate, and deliveries will be made late. Normally, a set of principles for action called a **quality policy**^{*16} is formulated to ensure that the whole organization shares this quality-orientation view. Other terms, such as **quality first** or **supremacy of quality**, are also sometimes used to express this quality-orientation approach.

(2) The market-in approach

At the heart of quality orientation is the idea that you don't prioritize the logic of the supplier, but that of the customer. The latter approach is called **market in**^{*17}, while the former is referred to as **product out**^{*17}. Standing in the customer's shoes means that you are customer-oriented in everything you do, including the elements described in section 1.2 (4) that comprise quality in the broad sense (**QCD + PSME**). These are **Q**: the level of product quality demanded by the customer, **C**: the cost paid by the customer, **D**: the delivery terms (i.e., quantity and date/time), **P**: productivity for the customer, **S & M**: the safety and mental health of everyone involved, including the customer, and **E**: the protection of the global environment. The market-in approach is based on achieving these objectives based not on the logic of the supplier, but that of the customer.

We often hear the expression **safety first**, which is based on the notion that because safety relates to human life, it should take priority over everything else. As mentioned earlier, the phrase “quality first” has also been used for many years in discussions of quality. Both are important ideas, but to avoid unnecessary confusion, it has become common when talking about quality to replace the expression “quality first” with “quality orientation.”

1.4 Management activities (maintenance activities and improvement activities)

When we think about what constitutes good work, one important thing is that the work is conducted in accordance with standards and therefore results in the stable and continuous supply of products and services that serve their purpose and exhibit no variation. This is referred to as **maintenance activities**. To ensure that these maintenance activities are properly performed, appropriate standards need to be set and education and training provided. However, because the environment surrounding us is always changing, unthinking adherence to the same method of working and the same standards to stably and continuously produce good products or services will not promote continuous maintenance in the true sense of the word. For this reason, the **SDCA**^{*11} **cycle** which will be described later, needs to be followed at all times.

Other important considerations are reducing the number of mistakes made to improve current levels of quality and reducing costs and changing work methods in ways that make it easier for other departments (particularly those that perform next/downstream processes) to perform their jobs. These are called **improvement activities**. Obviously, though, it is also important to improve your techniques and skills to enable you to work more effectively and efficiently.

So what we should be doing is engaging in activities that continuously maintain favorable circumstances. We also need to engage in activities to improve the quality of our products and services as well as the **quality of our work**, which generates these products and services. These activities are collectively referred to as **management activities**. If management activities such as these can be performed continuously by every organization and every individual, and the quality of work and the **quality of people** can be improved thereby, the QCD of products and services will improve, and, as a result, a **healthy organization** that can efficiently and continuously achieve business objectives such as sales and profits will be established.

1.5 An approach to work (PDCA)

(1) PDCA cycle

To ensure that the objectives that have been set for an organization are achieved, it is important to break down the work that constitutes the means to that end into the following four steps:

P (Plan)

Think hard about and define the purpose of the work, the output of the work, and what sorts of things good work will result in. This is referred to as **articulating goals**. **Objectives/targets** are goals in more concrete form. An objective normally has three components: the objective item, the objective value, and achievement date. Next, you are going to consider what kinds of things you should do to bring about these good circumstances, the methods you will adopt, the actions you will take, the procedures to follow, how you will proceed, and what resources and criteria will be required. Specifically, you will be defining the what, who, where, when, and how. These, along with the original goal (i.e., the why) are referred to as **5W1H**. (**5W1H** is discussed in detail in Chapter 3). This series of activities is called **planning**.

D (Do)

Carefully and in accordance with the plan (5W1H) you formulated, perform activities including the required preparatory activities to ensure that the methods and actions for bringing about good circumstances, as well as actions such as the provision of education and training, are properly implemented. Additionally, continuously monitor the situation as it is implemented. This is called **doing**.

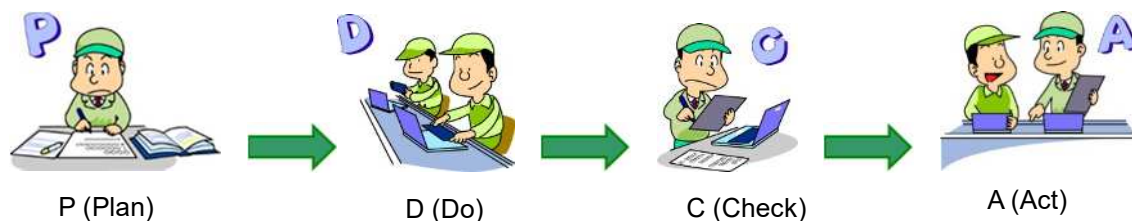
Note that if the Do period is fairly long, things not foreseen during the planning phase will frequently arise, making it necessary to follow small PDCA cycles several times during the Do period.

C (Check) – i.e., confirm, inspect, assess, and reflect

Find out whether the results were good and whether the approach was good by comparing them to the plan, thereby confirming differences between the plan and actual performance. If activities are being conducted in accordance with the plan and results are being achieved in accordance with the plan, then the plan and its implementation can be deemed to have been more or less appropriate. However, if the results differ from the initial aims or if activities could not be performed in accordance with the plan, you need to find out why. You will need to analyze the causes based on facts to shed light on the causes of things that didn't go well and reflect on their poor implementation. This series of activities is referred to as **checking** (i.e., confirming, inspecting, assessing, and reflecting). At the checking step, it helps to prepare numerical **scales (indicators)** that enable you to objectively assess what was good and bad about the results you achieved and the approach you employed. Such indicators, which are designed to assess what was good and bad about your activities, are called **monitoring items**^{*18}. These monitoring items include result-type items and factor-type items, and the cause-type items are sometimes specifically referred to as **check items**^{*18}.

A (Act)

If there is no difference between the plan and the actual results achieved, you can conclude that the working method was appropriate and continue working in the same way as you implement the next plan. However, if a difference is discovered and its cause is clear, you will need to take some sort of action to eliminate that cause and its effects. The cause of a difference is often a problem in the working method or with a mechanism—for example, the way the plan was put together or how it was implemented. If you just leave things the way they are, when it comes to implementing the next plan, you will fall short of the goals of the plan for the same causes. You must do something to keep this from happening over and over again. Taking steps to address the process involved, including the causes of differences between the plan and the results and their impact, is called **acting**. Obviously, you must check the results of the action taken and incorporate them into your next plan (P).



This system of following the four steps of “**P → D → C → A**” in order is called **following the PDCA cycle** or **following the management cycle**. It forms a common foundation for approaching work in every field.

(2) SDCA cycle

In cases where you have enough past experience or for which technology has been established, planning (P) can be replaced with the **standardization**^{*19} of methods proven to be successful, such that you follow a management cycle comprising “**S → D → C → A**.” If work is performed in line with these standards, problems will hardly ever arise. Having said that, on occasion problems will still occur. Such occasions would be cases in which a work method that differs from the standards is employed, cases in which work is performed in accordance with standards but the standards themselves are partly inappropriate, or cases in which the surrounding environment or other circumstances have changed. In cases like these, you must improve the method of implementation or revise the standards themselves.

As **Figure 1.1** illustrates, the true objective of management activities is to raise the level of the work method by following the **PDCA** or **SDCA** cycle on a continuing basis.

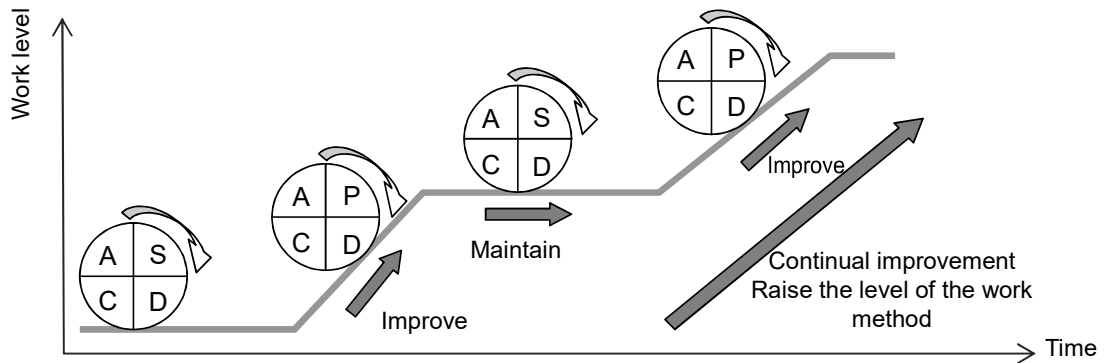


Figure 1.1 Management cycle

1.6 Kaizen and QC story

(1) QC story

Improvement^{*20} in the context of QM/QC is defined as the “activity of continuously reviewing the management system as a whole, or parts of it, in order to improve its capabilities.” The activities involving improvement are called as “improvement activities.” Improvement is an important part of activities in quality control and quality management that have evolved and developed in Japan. **Kaizen** is a well known Japanese word to express improvement activities outside Japan. Improvement activities can also be described as activities whereby you identify problems with your current work, eliminate the causes of these problems, and create a situation in which better work is performed. The problems are identified as the gap between the required state and the current state.

In organizations that engage in a lot of improvement activities, problem-solving procedures are utilized for making improvements. One typical set of procedures is the **QC story**^{*21}, as shown in **Figure 1.2**. A QC story involves more than just simply mastering a series of steps. For example, if, at the “effect confirmation” phase, effects are inadequate and objectives are not being met, you will return to the appropriate phase in the past and repeat the activities. Sometimes, you may even have to redo everything from the planning phase onwards, but it is important to persevere and keep taking action. In other words, it is important that the organization perform activities to improve quality, processes, work, etc., repeatedly and continuously. Such an approach to improvement is referred to as **continual improvement**^{*20}.

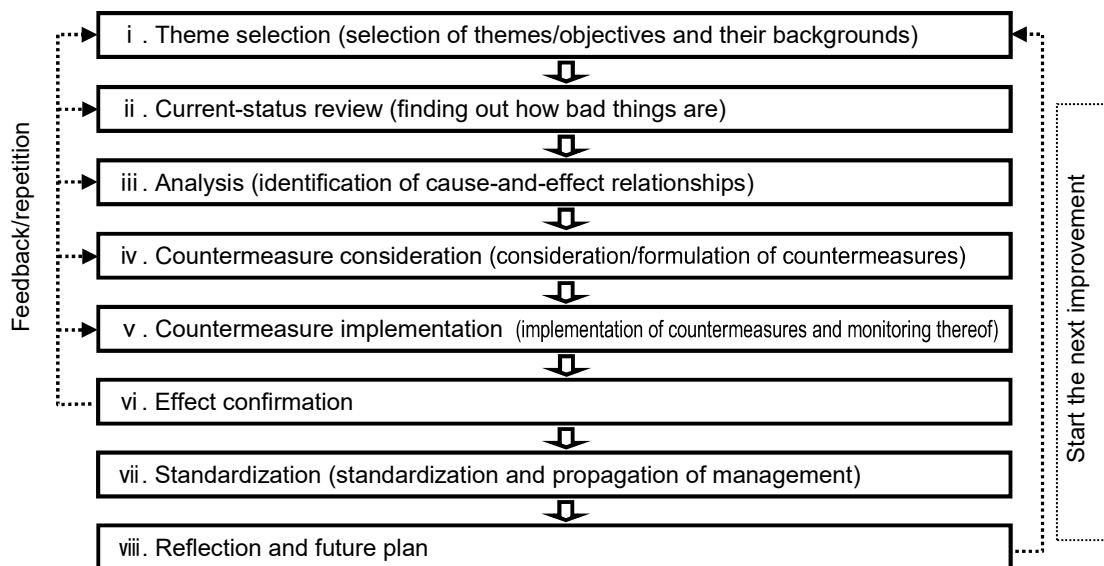


Figure 1.2 Example of QC story

In a broad sense, as pointed out in section **1.2 (1)**, improvement is about more than problem solving. It is also an activity for achieving tasks—i.e., closing the gap between the current state and the ideal state. As a means of doing this, **task-achieving QC stories** have been proposed as a separate measure.

Originally, QC stories were created as a procedure for solving problems, but later, various types of QC stories came to be recommended, so QC stories that specifically indicate a procedure for problem solving are now known as **problem-solving QC stories**.

First, you need to understand that the procedure for a QC story is not necessarily set in stone. For example, the procedure shown in **Figure 1.2** and the procedure shown on p.38 (*21), in the chapter explaining terminology, differ from each other somewhat in terms of content. So QC stories are probably continuously evolving to ensure that improvements continue to be performed effectively and efficiently in the future. For example, depending on the target and scope of improvement, the steps of QC stories are being modified and various new procedures for improvement are being created and devised.

(2) Small group improvement activities (Quality circle activities, QC circle activities)

When performing improvement activities, colleagues in a workplace may form small groups to improve their workplaces. These are referred to as **small group improvement activities**. In Japan in particular, a fundamental principle is that activities are administered independently. Well-known are small group activities called **Quality circle activities**,^{*22} which has goals beyond simply improving the workplace. They are designed to increase ability through studying, revitalizing workplaces, and making work seem more worthwhile. These Quality circle activities are also attracting attention from overseas and are currently being implemented in over 80 countries and territories.

1.7 The priority oriented approach

In the real world, there is generally a strong tendency to begin by improving things that are close at hand rather than making improvements that can produce big benefits. However, given the limited resources available to an organization, in terms of people, time, and funding, it is more effective and efficient for an organization as a whole to focus on high-priority issues, which, though hard to solve, can have a big impact on the organization or on results. This approach, whereby activities are narrowed to target the most important issues, is known as the **priority oriented approach**.



When analyzing factors behind nonconforming items, for example, it is common to identify a few factors that determine most of the results by plotting appearance frequencies and degrees of impact in the form of a Pareto diagram [see section **2.3 (1)**, p.19], and then targeting these elements. This method of analysis is called **Pareto analysis**, and the rule of thumb that a few factors determine most of the results is known as the **Pareto principle**. By skillfully applying the Pareto principle to workplace problems, we can put the priority oriented approach into practice.

1.8 What is standardization?

When several people have to work together to perform a task, unless the method for carrying out the task is clear, each individual will go about things in their own way. This makes it more likely that the task will not be performed as intended or that it will produce inefficient results. To ensure that an assigned task is performed efficiently, it is essential that the most rational method (rules) as perceived at the time is identified and that everyone in the group follows this method. This is what the **standardization**^{*19} of work tasks refers to.

Rules that have been prescribed in accordance with certain rational principles are called the **standards**^{*23}. Some standards relate to work, while others relate to products. Organizational activities become more efficient when the technology and experience possessed by the organization is combined and, with the agreement of everyone involved, work methods and management rules are prescribed with the objectives of harmonization and simplification. In other words, standardization can help stabilize quality, prevent work mistakes, enhance efficiency, make work more reliable, and so on. In addition, standards (product-related standards) include

component standards, design standards, and drawing standards, all of which specify the basic structure of a product, and materials standards, which prescribe the materials required to ensure product quality. So various types of standards suit different purposes.

Standardization is linked to the **SDCA** approach discussed in section 1.5 (2). Specifically, merely producing standards does not constitute standardization. It is essential to understand that standardization is meaningful only if the **SDCA** cycle, which encompasses education and training concerning the standards, compliance with standards, as well checking and acting, is properly followed to ensure consistency in all the activities performed.

1.9 What are inspections?

To provide products and services that are deeply satisfying to customers, not only must processes be carefully managed, the products and services themselves must be checked and unacceptable ones removed before they are sold. This activity is called an **inspection**^{*24}. Inspections involve aspects like the **measurements**^{*25} and **tests** of products and services to judge whether they are appropriate and whether they meet requirements such as product-related standards. Measurements and tests simply involve collecting data; they differ from inspections in that in addition to measurements and tests, they also have a **judgement** function. During the judgement phase of an inspection, a product that meets prescribed requirements such as product-related standards is called a **conforming item**, while one that does not is called a **nonconforming item**. In addition, some inspections target not individual products and services, but groups of products and services (called a **lot**^{*26}). Those that meet pre-prescribed “criteria for lots” are described as **accepted**, while those that do not are described as **rejected**.



Inspections are normally performed in three main phases. There are the **receiving inspections** or **purchasing inspections** carried out when raw materials, partially processed products, etc., are received; the **in-process inspections** or **intermediate inspections** carried out in the middle of a series of processes; and the **final inspections** or **delivery inspections** carried out on finished products. In addition, methods of inspection include **100% inspections**, where all items are inspected; **sampling inspections**, where a sample is taken from the lot to determine whether to accept or reject the lot as a whole; and **inspections without measurements or tests**, where the decision to accept or reject the lot is based solely on materials provided, with no measurements performed. Furthermore, besides inspections performed using measurement equipment to assess quality characteristics such as length, weight, performance, quantity of active ingredients, etc., there are also **sensory evaluations**, where measurements and judgements are performed based on a person’s five senses, which include touch, taste, hearing, and sight. There are also various other types of inspection, such as **destructive tests**, where measurement leads to the loss of the functionality of the item inspected.

The basic purpose of inspections is to ensure that only good quality items are passed on to the next process, based on a judgement of whether they are good or bad. The results of the good/bad judgement also serve as an **alternative characteristic**^{*27} of activities performed in upstream processes. Thus, we must not forget the importance of providing quality information obtained from inspections as feedback to upstream processes for determining the good and bad elements of a process and for making subsequent improvements.

Chapter 2 Basic knowledge related to quality management activities

2.1 Process

Products do not start out as products. They become products only after passing through various phases. In the quality management field, these phases are called **processes**^{*28}. Processes include not only production processes such as machining and assembly, but various other activities, including the planning and design of products and services, the procurement of raw materials and essential equipment, the standardization of manufacturing and other activities, and the supply, inspection, and improvement of products and services. For an organization to provide products and services, it is essential that the activities required to meet the demands and expectations of customers are properly connected and function as a whole.

When we consider individual processes, we think about **inputs** and **outputs**. In the case of a machining process, raw materials constitute the inputs, while the machined products constitute the outputs. In terms of staff function, aspects like the specific information required to perform a function constitute inputs, while the materials prepared or information analyzed constitute outputs. A process is regarded as an activity that adds value to an input to produce an output.

Work and products are not completed through one process alone. All departments within a company or organization perform their respective work, which is then passed on to the next process, before eventually reaching the customer. Such **process linkages** and **interfaces** are also important. The processes immediately before and after the process in question are particularly important because they are directly connected to that process. These processes are called the **upstream processes** and **downstream processes** (the immediate downstream process is also called the **next process**).

In the field of quality management, the right attitude toward processes can be summed up in expressions like “**Build in quality during processes**” or “**The next processes are our customers**.” Although confirming the quality of work or products by performing inspections^{*24} is important, it is far more important to perform proper work during the processing phase to keep nonconformities from arising. This is the meaning of the statement “Build in quality during processes.” In addition, the statement “The next processes are our customers” reflects the attitude of trying to satisfy all those who work on downstream processes.

Breaking down each process into its constituent elements generally results in four elements, shown in **Figure 2.1**. These are **man**, **machine**, **material**, and **method**. Since all these words begin with M, they are called the “**5M**” of production. To perform good work, you must manage these **4M** properly.

Note that sometimes people add another **M**, **measurement**^{*25}, and talk about the **5M**.

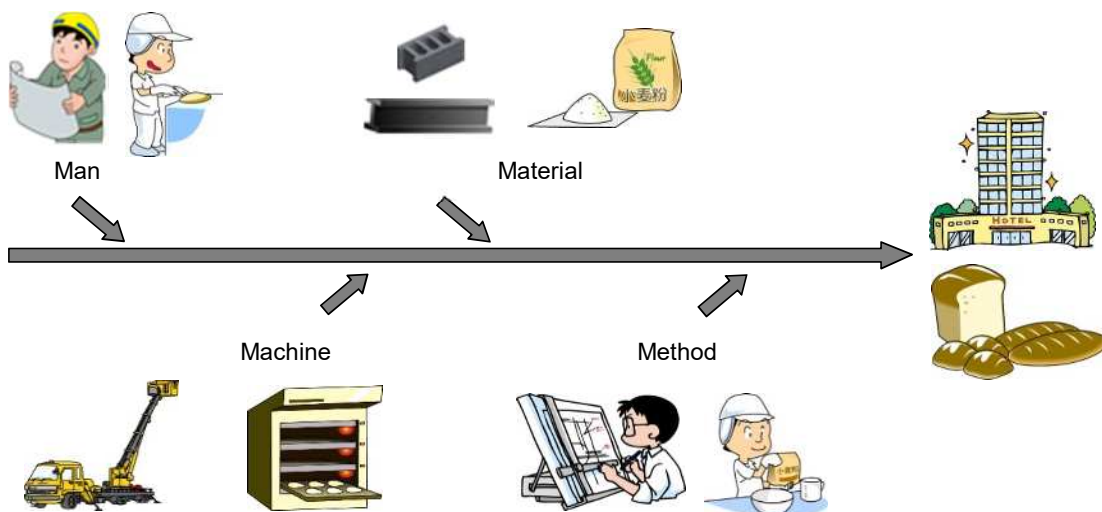


Figure 2.1 Diagram of the 4M

2.2 Decisions based on facts and data

(1) Populations and samples

In the field of quality management, it is important to **make decisions based on facts** and data. In other words, we must not rely on past technology, experiences, or gut feelings, but instead correctly identify facts using **data**^{*30} such as **observed values**^{*29} and **measured values**^{*29} to make objective decisions. Even if you believe you performed an experiment or a work task under the same conditions or circumstances, various factors that are beyond your control inevitably result in variation in the **characteristics**^{*31} of the results. In other words, the data you gather always contain variation^{*8}.

Deciding whether something is good or bad or taking action such as changing manufacturing conditions or reviewing the materials used based on just a few items of data will lead to the wrong action. It is essential not just to accept the results appearing in the data unquestioningly, but to consider whether those results, due to variation in the data, have occurred by chance and whether they are true.

Because variation is a natural characteristic of data, we need to make some sort of judgement about a **population**^{*33} based on data gathered by performing measurements on a **sample**^{*32}. The relationship between a population and a sample is shown in **Figure 2.2**.

For example, suppose a teacher at a Tokyo high school wants to identify trends in the height of the school's students to find out how they are growing. She selects 30 students at random and measures their heights. She determines trends in the heights of all students based on the 30 selected students while also looking at the degree of variation in the data. In other words, she uses data from a sample of people that is smaller than the total number of people. For this example, in the relationship between population and sample, the group of all high school students constitutes the population, while the 30 students selected constitute the sample.

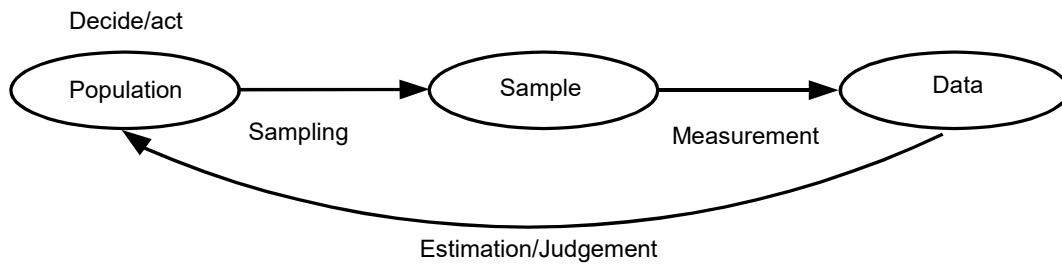


Figure 2.2 Relationship between population and sample

(2) Types of data

Numerical data used in the field of quality management can be broadly classified as **continuous data** (i.e., measurable as a continuous quantity) such as weight, length, time, and temperature, and **attribute data** (i.e., enumerated data that can be counted in the form 1, 2, 3), such as the number of nonconforming items, number of accidents, or number of scratches (nonconformities). **Table 2.1** gives some concrete examples.

Table 2.1 Examples of continuous and attribute data

Examples of continuous data	Concentration of an aqueous solution (unit: %), yield (unit: %), amount of active ingredient in a tablet (unit: g), thickness of a steel sheet (unit: mm), height of a human being (unit: cm), tensile strength of a wire (unit: N/mm ²), commuting time to school (unit: minutes)
Examples of attribute data	No. of times a machine has broken down (unit: times), no. of scratches per 1 m ² of plywood (unit: scratches), no. of bubbles in a sheet of glass (unit: places), no. of nonconforming components (unit: pieces), no. of absences from class (unit: times), no. of people who pass an exam (unit: people), nonconformity rate (unit: %)

Besides these, there is also non-numerical data. Examples include product quality grades such as Grade 1 and Grade 2, the gender and experience level of workers, and the types of machines used.

Note that numerical data is sometimes called quantitative data and that non-numerical data is sometimes called qualitative data.

(3) How to take a sample

If you extract a sample from a population and measure its contents, you can obtain data. Extracting a sample from a population is called the **sampling**^{*32}. The purpose of sampling is to get an idea of the characteristics of the population from the data obtained from the sample. This means the sample must be as similar to the population as possible. It is therefore necessary to take an unbiased, **random** sample. This method of sampling is known as **random sampling**, and it refers to a method whereby all the elements comprising the population have an equal probability of being included in the sample.

In reality, it is extremely difficult to take a perfectly random sample. Even so, it is important, when gathering data, to always ask yourself whether the sampling method you're using might be biased.

Consider a case that involves identifying trends in the heights of high school students, first considered in (1). We assumed that a sample of 30 was taken from the population, i.e., the entire student body. But if we took 25 first graders, with the remaining five from the second and third grades, would the results obtained from the sample allow us to make accurate inferences about the entire population (**Figure 2.3**)? In this case, the inferences concerning height would clearly be biased toward the first graders. We need to select a random sample that is not biased toward any particular grade. One way to do this is to regard each grade as a separate stratum [see section 2.3 (8), p.24] and to take a sample from each.

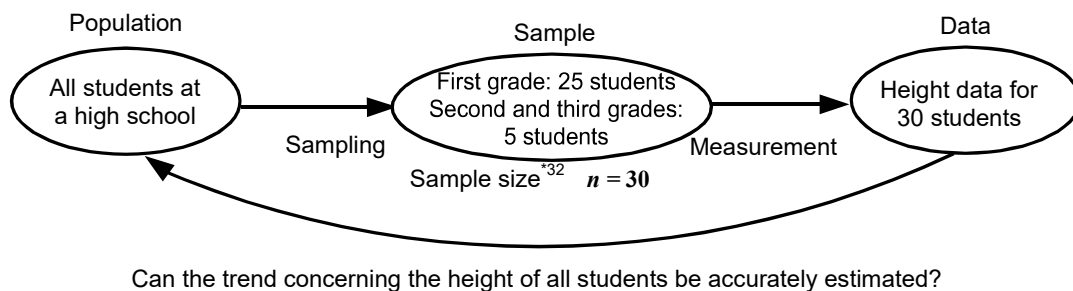


Figure 2.3 Bias in sampling

(4) How to summarize data

Even if you believe you performed an experiment or a work task under the same conditions or circumstances, the data will contain variation. To grasp the situation and trends in the population from the data obtained by performing measurements on the sample, you need to look not just at the location of the data, but also the dispersion of the data.

Let's consider, for example, the time it takes for Boy A to commute to school. Boy A does not use a train, a bus, or a bicycle. Instead, he walks to school every day. Even so, he has noticed that even if he leaves home at the same time, he does not necessarily get to school at the same time every day. Sometimes he arrives well ahead of time for class, whereas at other times he's just in time, and at other times he's actually late. In other words, there is variation in his commuting time.

To confirm his actual commuting times, Boy A obtained data by measuring his commuting time for five days under the same conditions. For example, he made sure that he left home at the same time every day and was carrying the same things. The results are shown in **Table 2.2**.

Note that he actually measured the times in seconds, but to simplify things we present them in minutes.

Table 2.2 Data on Boy A's commuting time

Day	Monday	Tuesday	Wednesday	Thursday	Friday
Commuting time	15 minutes	13 minutes	16 minutes	20 minutes	17 minutes

When using data obtained to investigate commuting time, we normally use the **mean** $\bar{x}$ (x-bar) or the **median** $\tilde{x}$ as location scales (i.e., indicators of the nature of the population) and the **range** R as a scale of dispersion.

$\bar{x}$, $\tilde{x}$, and R calculated from the data obtained by measuring a sample are called **statistics**.

■ Location scales

i . The **mean** $\bar{x}$ is the center of the data and is calculated as follows:

$$\bar{x} = \frac{x_1 + x_2 + x_3 + \Lambda + x_n}{n} = \frac{\sum_{i=1}^n x_i}{n} = \frac{\text{Total of the data}}{\text{Number of data items}}$$

Here, n denotes the number of data items (sample size^{*32}), while $x_1, x_2, \dots, x_n$ denote each data item.

In addition, the total from the first data item to the n th data item is expressed using the symbol $\sum_{i=1}^n$. Here, $i = 1$ and n are sometimes omitted, and just the sigma symbol Σ (sigma) is used. The mean $\bar{x}$ should be rounded to one decimal place less than the measured data—to two decimal places if n is 20 or more.

If we perform these calculations using the data from **Table 2.2**, the result is:

$$\bar{x} = \frac{15 + 13 + 16 + 20 + 17}{5} = \frac{81}{5} = 16.2 \text{ (minutes)}$$

Boy A's mean commuting time is therefore 16.2 minutes.

ii . When the data items are lined up in order of size, the **median** $\tilde{x}$ is the middle value if the number of data items is odd and the mean of the two middle values if the number of data items is even.

Lining up the data from **Table 2.2** in order gives:

13, 15, 16, 17, and 20.

Because the number of data items (five) is odd, the median $\tilde{x}$ is 16 minutes.

If the number of data items had been four (e.g., 13, 15, 16, and 20), the median would have been:

$$\tilde{x} = \frac{15 + 16}{2} = 15.5 \text{ (minutes)}$$

■ Dispersion scales

The following formula is used to calculate **range** R :

$$R = \text{maximum value} - \text{minimum value} = x_{\max} - x_{\min}$$

Here, the maximum value and the minimum value are respectively written as $x_{\max}$, $x_{\min}$.

The data from **Table 2.2** is:

$$R = 20 - 13 = 7 \text{ (minutes)}$$

So, even though he believed he commuted under unchanging conditions, the data for five days shows that there was as much seven minutes in range in Boy A's commuting times.

To make effective use of the results obtained, it is important to consider why the dispersion might exist. Dispersion has causes. In the case of Boy A, the dispersion might be caused by him meeting friends along the way or waiting a long time at traffic lights.

Besides range R , the sum of squares $\mathbf{S}^{*34}$, the variance $\mathbf{V}^{*34}$, and the standard deviation $\mathbf{s}^{*35}$ are also used as dispersion scales.

2.3 QC seven tools

When performing quality management, it is important to gather data, process the data in accordance with the purpose of analysis, and carefully extract information from it. Although the methods of processing data include some that require advanced knowledge, other useful techniques are straightforward. Of these, ones that are highly effective when applied to quality management have been selected and named the **QC seven tools** which are also called **seven basic quality tools**.

To use the QC seven tools to make improvements in workplaces or circles, we must first study them to grasp the purpose of using them. While most of the QC seven tools deal with figures, the **New QC seven tools (N7 or New Quality Management tools)**, techniques for handling **linguistic data**^{*30}, cannot be expressed numerically.

The techniques selected for the QC seven tools are **Pareto diagrams, cause and effect diagrams, histograms, graphs/control charts, check sheets, scatter diagrams, and stratification**. Below in this section, we will provide simple explanations and graphic examples of these techniques using the definitions contained in documents such as the Japanese Industrial Standards (JIS)^{*23}.

(1) Pareto diagrams

A Pareto diagram is a “diagram that stratifies items, arranges them in order of frequency of appearance, and shows the cumulative sum.”⁷⁾

Pareto diagrams are used to confirm the impact on the whole of matters that need to be addressed (i.e., problems), the effectiveness of the improvements made, and so on.

The field of quality management includes an approach called the priority oriented approach (see section 1.7, p.13), which is used when selecting targets for problem solving. When doing this, we must know what is important and what proportion of the whole this accounts for. A Pareto diagram is a tool that clearly shows important phenomena and the causes of such phenomena.

For example, let's classify nonconforming items by the nature of their nonconformity and arrange them in order of number of nonconforming items to produce a Pareto diagram. Types of nonconformity for which there is little data and that have little impact are bundled together as “Other” and are drawn last, after the other types. Next, types for which we have lots of data (i.e., types frequently observed) are gradually added together to calculate cumulative sums. Calculating the cumulative percentages of all the data gives us the proportions of the whole for specific nonconformity types and clarify what nonconformity types we should focus on tackling.

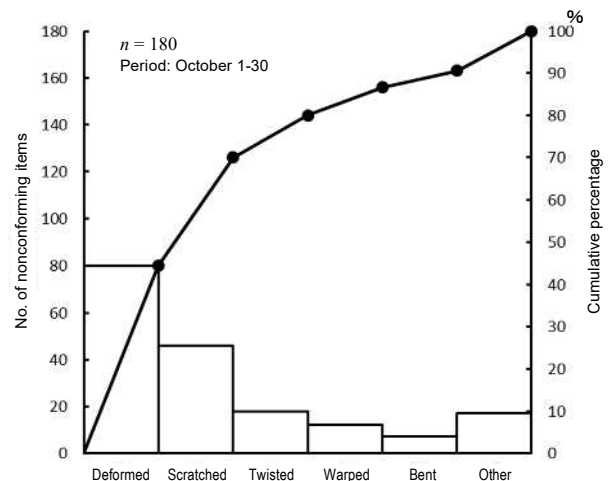


Figure 2.4 Example of Pareto diagram²⁰⁾

The Pareto diagram in **Figure 2.4** shows that the total number of nonconforming items for which the nonconformity is caused by “deformation” or “scratch” accounts for approximately 70% of the total. If we focus on eliminating these types of nonconformities, we should be able to achieve significant reductions in the number of nonconforming items.

(2) Cause and effect diagrams

A cause and effect diagram is a “diagram that shows the relationship between a specific result (characteristic) and the factors behind it in a structured fashion.”⁷⁾

A cause and effect diagram, also known as a “fishbone diagram or Ishikawa diagram,” is useful for organizing the cause-and-effect relationship of a problem to investigate the **(root) causes**^{*36} of the problem. Moreover, by illustrating the connections between results such as quality characteristics^{*31} and nonconforming parts and factors, they show which processes led to such results, thereby allowing us to organize the cause-and-effect relationships underlying a problem, to discover the factors likely to be important, and to take action to address them.

Characteristics (showing results) are placed at the tip of the arrowhead (right end) in a cause and effect diagram (**Figure 2.5**), while factors that have an impact on the results are placed at the bone part. Sometimes factors corresponding to the **4M's** (man, machine, material, and method) are placed on a large bone.¹⁾

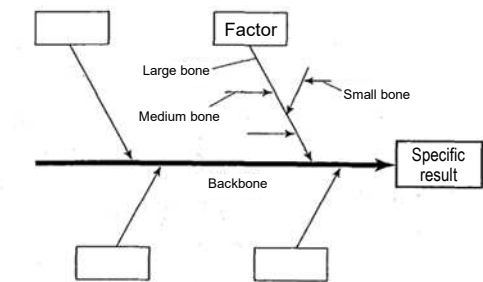


Figure 2.5 Structure of cause and effect diagram

When we prepare cause and effect diagrams, it is important to bring together everyone connected to the problem being investigated and to use methods like **brainstorming**^{*37} to encourage the free sharing of opinions and promote the identification of all possible factors. Another good idea is to circle those factors shown in the cause and effect diagram that are likely to have a significant impact on the results. An example of this is shown in **Figure 2.6**.

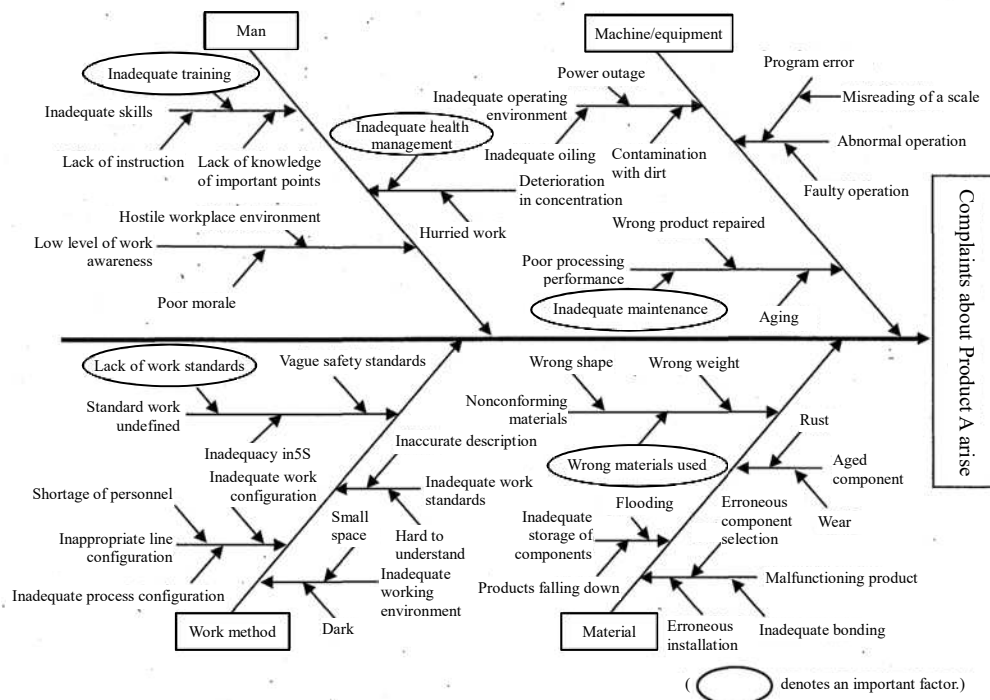


Figure 2.6 Example of cause and effect diagram

(3) Histograms

A histogram is a “diagram in which the range of measured values is divided into a number of classes, with each class serving as the base of a rectangle whose area represents the frequency of measured values belonging to the class.”⁹⁾

A histogram is a type of bar graph, but as **Figure 2.7** shows, it is also a way of displaying a frequency distribution, with a characteristic of continuous data plotted on the horizontal axis. Thus, a distinctive feature of a histogram is that it illustrates the location, dispersion, and distribution pattern of the measured values (how the measured values are dispersed).

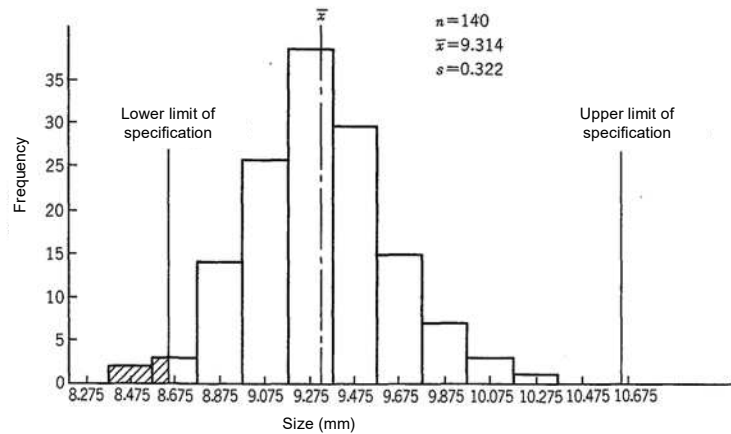


Figure 2.7 Example of histogram²²⁾

Histograms are useful when you want to know, for example, whether the quality of a product is meeting the specification. Furthermore, by calculating other variables such as the number of data items n , the mean $\bar{x}$, the specification deviation s , the maximum value $x_{\max}$, the minimum value $x_{\min}$, and the range R , you can observe patterns in the distribution of the measured values.

When you draw a histogram, you might see one of a variety of distributions, which are shown in **Figure 2.8**, depending, for example, on the quality of the product. Although the histogram shown in **Figure 2.7** has a normal-shaped (bell-shaped) distribution, you can see that the mean is some distance from the center of the specification range and that some measured values exceed the lower limit of the specification.

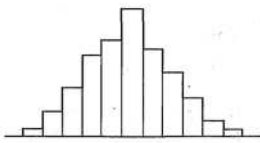
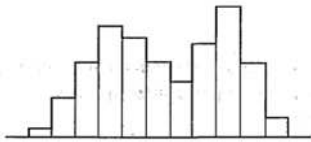
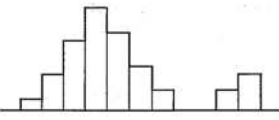
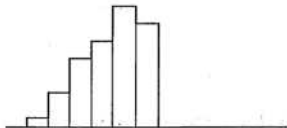
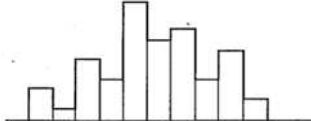
Shape of histogram	Characteristics
	Normal shape (Bell-shaped) • The shape is symmetrical. • This is the shape typically seen. Values tend to cluster around the center, and the number of values gradually decreases as you move further from the center.
	Double-peaked shape • There are two peaks. • There is a peak on the left and the right, indicating that it is possible this is a mixture of two distributions with different means. In cases like this, it's a good idea to attempt to stratify the data [section 2.3 (8), p.24].
	Isolated-peaked shape • There is a small peak some distance from the main peak. • This shape appears when data from a different distribution is mixed.
	Truncated shape • One side appears to be missing. • This shape often appears when items not meeting specifications are excluded.
	Comb shape • The frequency of each class increases and decreases alternately. • This shape appears when there is a problem with the measurement method or when the classes have not been determined appropriately.

Figure 2.8 Various histogram shapes

(4) Graphs

A graph is “a diagram that shows sizes of data graphically or shows changes in size of data in a visually appealing way to make the data easy to understand.”⁷⁾

There are various types of graphs. Some of the most common are bar graphs, which compare quantities; line graphs, which illustrate changes over time (**Figure 2.9**); and pie charts, which break down data into categories (**Figure 2.10**).

Organizing data in the form of a graph makes it easier to grasp information in ways that might not be apparent from viewing the data table alone. It is therefore important to consider what your argument is and what you want people to focus on and to choose a graph that fits your goals.

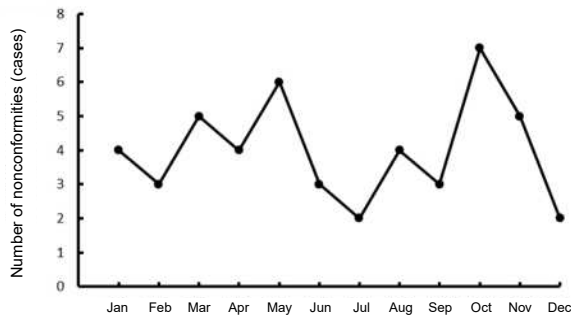


Figure 2.9 Example of line graph

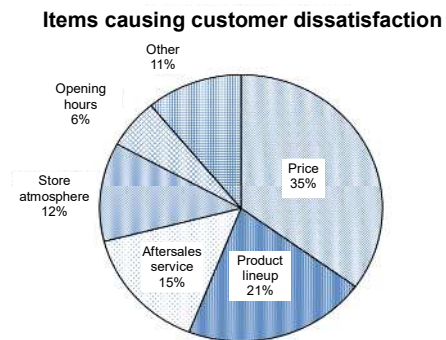


Figure 2.10 Example of pie chart⁷⁾

(5) Control charts

A control chart is “a diagram that contains an upper control limit line and/or lower control limit line and shows continuously observed values or statistics of a **subgroup**^{*38}, which are normally plotted in order of time or in the order of sample number.”⁷⁾ In addition, a control chart also “contains a centre line for investigating the tendency of the plotted values to move toward one of the control limits.”¹⁰⁾

Control charts are used to detect process abnormalities by making visible changes or trends in processes over time. Data from the process is collected and plotted in the form of a line graph. A control chart contains three control lines: a **centre line (CL)**, an **upper control limit (UCL)** line, and a **lower control limit (LCL)** line.

If **out of control signal**^{*39} is present—e.g., if one or more dots lie outside the control limit lines or a series of dots is successively plotted above or below the centre line—it is deemed that “**the process is out of control**.” A situation like this indicates that the variation in the results has occurred due to an **assignable cause**^{*40}.

Although there are various types of control charts, the most common one is the $\bar{X} - R$ control chart, an example of which is shown in **Figure 2.11**. An $\bar{X} - R$ control chart shows the mean and range of the characteristic values.

In the control chart in **Figure 2.11**, the point for subgroup number 22 in the $\bar{X}$ control chart exceeds the **UCL**, based on which it is deemed that “the process is out of control.”

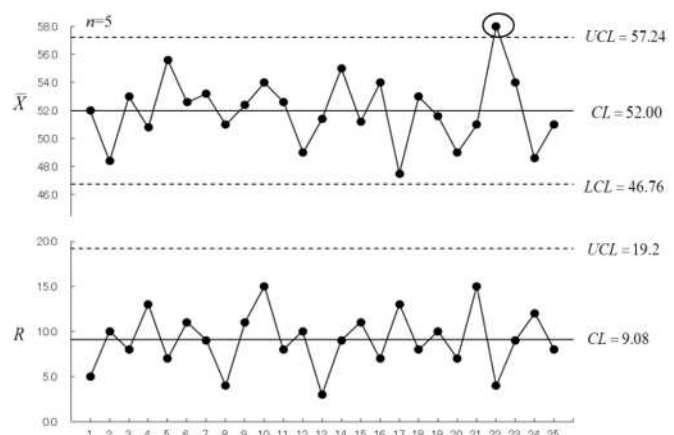


Figure 2.11 Example of $\bar{X} - R$ control chart

(6) Check sheets

A check sheet is “a table or diagram that makes it easy to see into what categories data is concentrated after attribute data is gathered.”⁷⁾

In the case of a check sheet, to make it easier to collect and organize the data, we print the categories and diagrams we will need when collecting data on a form in advance. We can then record the data in a simple way. For example, data, results, inspection results, etc., can be recorded as figures or symbols such as circles, crosses, or checks.

As you prepare a check sheet, it is important to think hard about what kind of data you want, what kind of data you should collect, what format will make the data easy to collect, and so on.

A check sheet lets you gather data in an organized fashion and without omissions. Processing the data after collection is also easy.

Check sheets come in various formats, depending on the purpose of the investigation, but they can be broadly classified into recording/surveying check sheets (**Figure 2.12, Figure 2.13**), which are used to collect data to achieve a particular goal, and inspection/confirmation check sheets (**Figure 2.14, Figure 2.15**), which are used to investigate whether inspection criteria determined in advance have been met.

Check sheet for nonconformities in package seals for powdered milk							
Product name: Powdered milk M5		Machine name: MC-K1		Lot no.: MF5			
Process name: Filling/packaging		Measurement method: 100% visual		Period: October 1-6, 2009			
Month/date	10/1	10/2	10/3	10/4	10/5	10/6	Total
Torn edges	///	///	///	///	///	///	21
Powder stuck	///	///	///	///	///	///	14
Creased seal	///	///	///	///	///	///	15
Defective seal temperature	///	///	///	///	///	///	5
Other	///	///	///	///	///	///	3
Total	11	10	7	14	7	9	58
Checker	Tsuchiya	Miyamoto	Kishimoto	Tsuchiya	Kishimoto	Tsuchiya	

Figure 2.12 Example of recording/surveying check sheet²⁴⁾

Processing precision frequency distribution survey check sheet																				
No.	Class	Lot no.	1	2	3	4	5	6	7	8	9	10	Total	Frequency						
													0	5	10	15	20	25	30	
1	45.1~45.4																			
2	45.4~45.7		/										1	/						
3	45.7~46.0		/	/	/	/	/	/	/	/	/	/	5	///						
4	46.0~46.3		/	/	/	/	/	/	/	/	/	/	3	///						
5	46.3~46.6		//	/	/	/	/	/	/	/	/	/	8	///	///	///	///	///	///	
6	46.6~46.9		//	//	/	/	/	//	//	//	//	//	27	///	///	///	///	///	//	
7	46.9~47.2		///	/	/	/	//	/	///	//	//	///	30	///	///	///	///	///	///	
8	47.2~47.5		//	/	//	/	/	//	/	/	/	/	13	///	///	///	///	///	///	
9	47.5~47.8		///	///	//	/	/	/	/	/	/	/	11	///	///	///	///	///	///	
10	47.8~48.1		/	/	/	/	/	/	/	/	/	/	2	//						
11	48.1~48.4																			
Total																				

Figure 2.13 Example of recording/surveying check sheet²²⁾

Work standards compliance check sheet															
(Name of process: Rolling)					July										
(Twice a week, one hour after start of work, patrol)					Name of checker Assistant Manager Fuikawa										
Name of work	Check item	Time	Month/date		July 10		July 13		July 16		July 19		Month Day	Month Day	Month Day
			9:00	14:00	9:00	14:00	9:00	14:00	9:00	14:00					
Mixing	Have the period for retaining kneaded rubber used and the passing rubber no. confirmation signature been entered?		○	○	○	○	○	○	○	○	○	○			
	Does the rolling temperature comply with the standard?		△	○	○	○	○	○	○	○	○	○			
Heating	Does the injected rubber rolling temperature comply with the standard?		○	○	○	○	○	○	○	○	○	○			
	Does the calendar surface temperature comply with the standard?		○	○	○	○	○	○	○	○	○	○			
Gauge	Does the calendar setting width meet the requirements?		○	△	○	○	○	○	○	○	○	○			
	Does the sheet thickness meet the requirements?		○	○	○	○	○	○	○	○	○	○			
Winding	Has the control chart been completed?		○	○	○	○	○	○	○	○	○	○			
	Visual inspection of sheet, checking for presence of air		○	○	○	○	○	○	○	○	○	○			
Winding	Does the calendar speed comply with the standard?		○	○	○	○	○	○	○	○	○	○			
	Sheet width		○	○	○	○	○	○	○	○	○	○			
Winding	Has the sheet width/length confirmation F been completed?		○	○	○	○	○	○	○	○	○	○			
	Does the cooling method comply with the standard?		○	○	○	△	○	○	○	○	○	○			
	Is the sheet winding temperature 40°C or lower?		○	○	○	○	○	○	○	○	○	○			
	(Problems/Matters requiring guidance)		△: Rolling temperature	△: Cooling temperature	△: Control chart not completed	△: Abnormally detected?									
○: OK, ×: Requires attention			△: Requires investigation/improvement												

Figure 2.14 Example of inspection/confirmation check sheet²³⁾

Quality circle activity status interview sheet				
No.	Question item	Interview topics	Point	Rating
1	Are circle activities autonomous?	1. How to raise topics 2. How meetings are organized 3. Preparing activity plans 4. How objectives are determined	5	4
2	Group activities in which everyone participates	1. What kinds of steps are being taken to ensure that everyone participates? 2. When a meeting is held, does everyone speak? 3. How are study meetings administered? 4. Have relationships among employees improved?	5	5
3	Circle meetings	1. Are meetings being held in an organized fashion? 2. Are appropriate preparations for meetings being made? 3. Are meetings administered effectively? 4. Are minutes prepared when necessary? 5. How is homework performed?	5	4
4	Background to circle activities	1. What is the most difficult thing to administer? How has that difficulty been addressed? 2. Have you ever run into a wall but subsequently achieved a breakthrough? 3. How do you think circle activities should be administered in the future?	5	4
5	Methods of self-development and mutual development	1. Have you ever participated in gatherings or presentations inside and outside the company? 2. Do you read books about QC?	5	5
6	Results of activities	1. How many of the annual topics have been resolved? 2. How interested is your superior in the circle activities? 3. Do you have annual objectives for circle activities? If so, are they being achieved?	5	4
Total points for activities			30	26
Comments				

Figure 2.15 Example of inspection/confirmation check sheet²⁰⁾

(7) Scatter diagrams

A scatter diagram is “a diagram in which two characteristics constitute the horizontal (x) and vertical (y) axes and the observed values are plotted as a graph.”⁷⁾

Scatter diagrams are used to investigate the interrelationship between two contrasting (paired) characteristics (i.e., variables).

When looking at a scatter diagram, you need to answer questions like the following:

- Does the way the dots are arranged indicate a trend?
- Is the trend linear or curved?
- How much deviation is there from the trend?

You must also carefully check the following:

- Are there any **outliers**^{*41)}?
- Are there clusters of dots? If so, should they be stratified [see section 2.3 (8), p.24]?

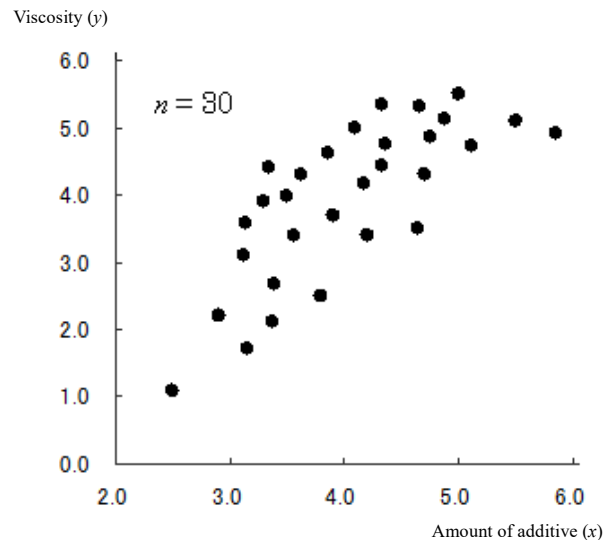


Figure 2.16 Example of scatter diagram

Figure 2.17 shows scatter diagrams with typical data distributions. In (a), the correlation between two characteristics x and y is that y increases as x increases; there is a “positive correlation” between x and y . In (c), y decreases as x increases; there is a “negative correlation” between x and y . In (b), an increase in x does not appear to have any effect on y , so there is “no correlation” between x and y .

In the scatter diagram shown in **Figure 2.16**, when the amount of additive (x) increases, the viscosity (y) also rises, so there is a positive correlation between the amount of additive and viscosity.

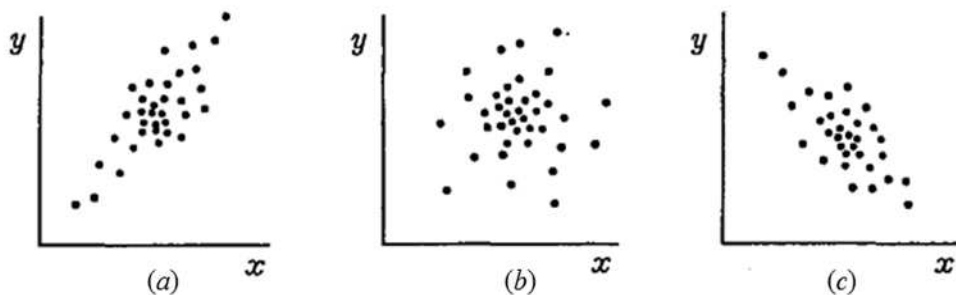


Figure 2.17 Relationships between two characteristics²¹⁾

(8) Stratification

Stratification is the process of slicing the population into a number of strata. The strata are a type of **subpopulation**^{*33)}. They do not share any components, and when all strata are assembled, the result is equivalent to the population.¹⁰⁾ It is therefore important to define strata such that each stratum is uniform in relation to the characteristics being studied.

Stratification is useful for investigating differences in distribution among different strata, distributions within a stratum, and the causes of variation. It is particularly effective when used in conjunction with Pareto diagrams, histograms, scatter diagrams, control charts, etc. However, collecting vast quantities of data is not of itself sufficient to identify causes and to determine appropriate actions for addressing causes. When investigating a problem, you can obtain clues about causes by asking yourself whether there are any differences in characteristics depending on the machine used for manufacturing, the materials used, the worker performing the job, and so on,

then dividing the data, and processing it by turning it into a graph, etc. for comparison.

The word “classification” is also used with a meaning similar to stratification. Classification is “the process and method of sorting a sample into categories that have been prepared beforehand;”¹⁴⁾ be careful to avoid using the terms interchangeably.

In **Figure 2.18**, the histogram for all data is double peaked, and the upper limit of the specification (S_U) is exceeded. Histograms stratified for each worker were prepared. Stratification shows that while Worker A meets the specification, the mean is skewed toward the lower limit of specification (S_L). In the case of Worker B, meanwhile, we see that the mean is close to the upper limit of the specification and that in some cases the upper limit is exceeded.

The total scatter diagram in **Figure 2.19** shows the results of manufacturing using two machines. From the total scatter diagram alone, we cannot tell whether there is a correlation between the amount of additive and production volumes; but when we produce a scatter diagram for each machine, we see a positive correlation between the amount of additive and production volumes for both machines.

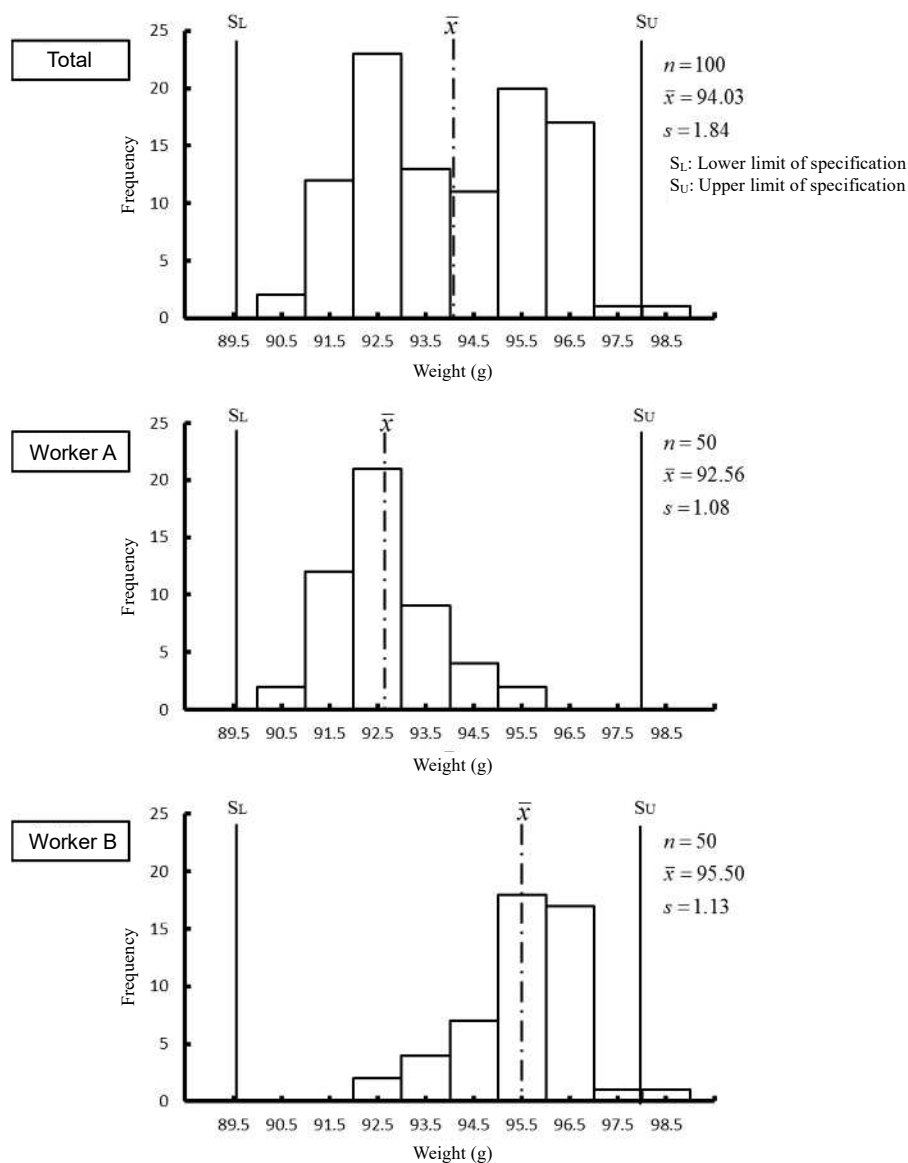


Figure 2.18 Example of stratification (histograms)

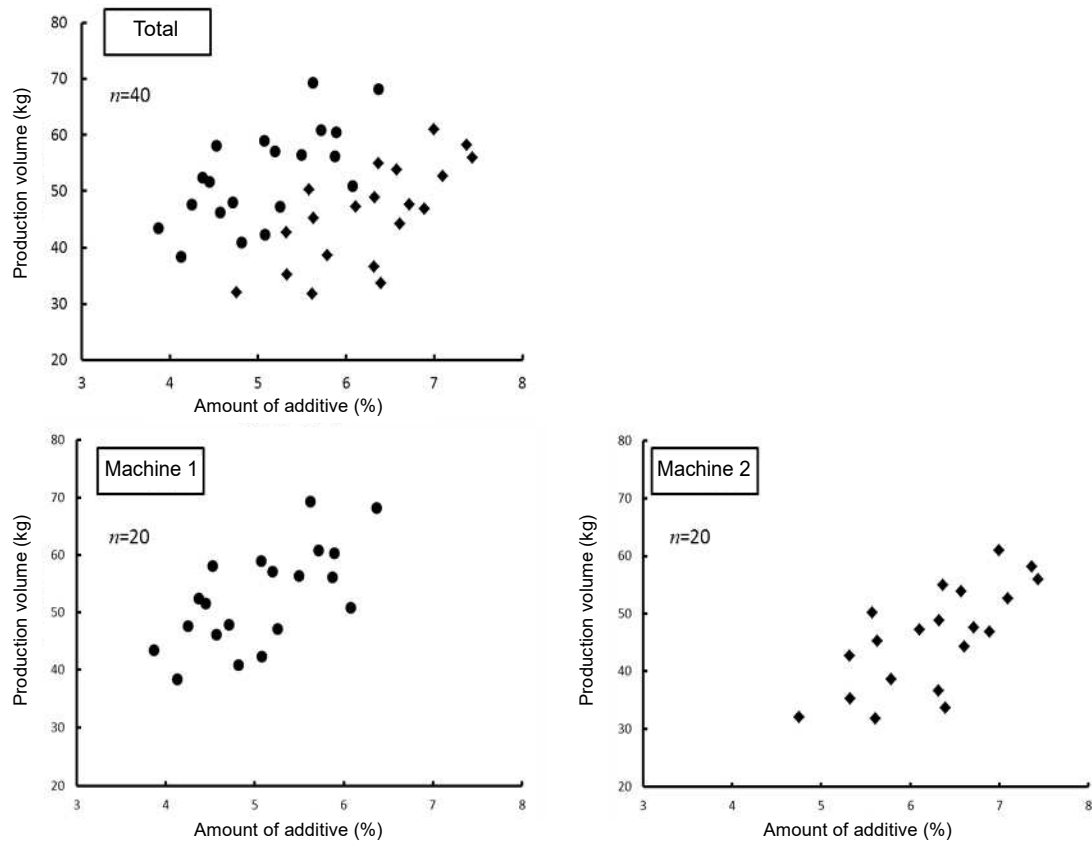


Figure 2.19 Example of stratification (scatter diagrams)

(9) Utilizing the QC seven tools

In quality management, it is important to identify problems based on facts, to determine what is good and bad about a process, and to make improvements while following the PDCA cycle. To that end, it is essential to choose the QC tools best suited to the objectives of an analysis and to gather information on the processes that constitute the population. For example, based on the data obtained from a sample, you will want to identify the mean, the extent of the variation, and so on.

The QC seven tools are essential and fundamental weapons for objectively grasping facts and phenomena. It is comparatively easy to use each technique to present data graphically, but the most important thing is to read and comprehend the information shown. Presenting the data obtained in the form of a diagram or table is not the be-all and end-all. You must look at the diagram or table and ask yourself: “What could I say about this?” You need to formulate your own opinions. This is especially true in the case of data collected for a specific purpose. It is important to consider that purpose and ask: “What have I learned?” Then, you should ask yourself: “What should I do next?” Finally, you need to translate the answers to those questions into future action.

The QC seven tools are just that: tools. Each is nothing more than a single technique. Your goal is to use these tools to collect and analyze data and to solve problems or achieve tasks. To that end, you need to use the QC seven tools to obtain accurate information about a process and carefully answer this question: “What should I do about this process?” Then you need to make the specific answer to that question your next action.

Chapter 3 Preparation and action for making better products

3.1 *Ho-Ren-So* (reporting, contacting, and consulting)

An organization normally comprises a large number of employees who perform tasks based on instructions and orders issued by their superior. The *Ho-Ren-So* serves as a kind of lubricant to make the workflow smoother. *Horenso* is shorthand for the Japanese words **hokoku** (reporting), **renraku** (contacting), and **sodan** (consulting).

Once instructions and orders have been issued, it is important for the performance of work that superiors or customers are swiftly informed about how things are going and what the results are. In other words, an instruction is issued or a request is made, and then a **report** is made in response.

Unforeseeable accidents may occur on the frontlines. Contacting the necessary departments to inform them of such day-to-day changes in the situation on the frontlines is important for minimizing the harm caused by unexpected incidents. The function of independently providing the necessary people with the necessary information, even when no instructions to do so have been issued by one's superior, is known as **contacting**.

Each organization inevitably has responsibilities and authority that have been delegated to it, while each individual belonging to the organization is also assigned responsibilities and authority. The organization and each individual comprising it perform their work on a day-to-day basis within the scope of the responsibilities and authority assigned. However, events in the real world do not occur conveniently within such predetermined scopes of responsibilities and authority. It is often the case that you can't make a judgement on your own or that you do not know how to respond within the scope of your own authority. In such situations, it's crucial that you do not make a judgement call and take action independently, but instead go to the person who can make the judgement call or the person who can make the decision in order to **consult** with them.

This organizational practice of reporting, contacting, and consulting by the individuals that comprise the organization is a vital action principle for administering the entire organization in an organic fashion.

If *Ho-Ren-So* is properly applied, it leads to effective communication with superiors and seniors, which in turn results in better work efficiency. To that end, it is necessary to grasp the key points using the **5W1H** framework (see section 3.2, p.28) and to ensure that the reporting, contacting, and consulting are accurate, concise, clear, and specific. It is also better to express things numerically wherever possible rather than using vague expressions such as "usually" or "about."

(1) Key points concerning reporting

When you have completed the work you have been assigned, report the results to the person who issued the instruction or order without delay. If the work takes a long time to complete, make interim reports on your progress, your future actions, and so on. If it does not look as though you will be able to keep the predetermined deadline for delivery or if you have made mistakes or a problem has emerged in the course of performing the work, it is important that you swiftly report this to your superior or supervisor and follow their instructions.

When making a report, try to convey the key points accurately and in an easy-to-understand fashion. You can do so orally or in writing, but you are going to start by briefly stating your conclusion. Depending on the situation, it is often helpful to use actual articles, materials, diagrams, etc.

The attitude of the person receiving the report is also important. If we grow angry and begin complaining that so and so hasn't arrived with their report or that they are late in submitting the report, this is basically our problem. It is also unhelpful to lose one's temper and to scream and shout after receiving a bad report. To receive accurate reports in a timely fashion, the most important thing is to establish an atmosphere in which people feel comfortable making reports. We must remain acutely aware that a key factor in enhancing the quality of reports is



the readiness and attitude of the recipient. Everything hinges on this.

(2) Key points concerning contacting

Contacting means sharing information that should be shared with the relevant people. When doing this, try to leave out your own opinions or conjecture. When you are contacting, choose a method that reflects the situation at the time—e.g., the person you are contacting, the information you are going to convey, the importance, the urgency, etc. In addition, by maintaining close contact, you can prevent problems or accidents; if a problem or accident should occur, you can minimize the damage that results.

If possible, it is a good idea for the organization to determine what kinds of information should be conveyed and to establish rules for the workplace that prescribe which departments and people should be contacted if such information is obtained and within what time frame and using what contact methods. This is the same as the emergency telephone trees most organizations prepare for use in the event of an emergency.

(3) Key points concerning consulting

As you perform your work, problems that you had not foreseen may arise, and events may arise for which you cannot determine countermeasures yourself. At times like this, it is important not just sit to there and think about what to do on your own, but to first consult your superiors or seniors (although sometimes a superior may consult his or her subordinates). When consulting, it is important to be clear about the nature of the advice you want, and if necessary, to prepare materials, data, etc. Furthermore, if you come up with your own ideas or measures for solving the problem, you will be able to receive more appropriate advice.

As with reporting, the attitude of the person being consulted is incredibly important. If someone comes to you for advice but your mind is elsewhere and you do not listen, or if you look away and act as if it has nothing to do with you, the consultation function will break down. When asked for advice, you must remain keenly aware that you are in a position to be consulted and to offer advice from a place of empathy.

3.2 5W1H

We should take the view that our actions comprise the six **5W1H** elements. However, when a person observes or focuses on a certain action, he or she can overthink things and notice only the elements that make a particularly strong impression or seem very important. For this reason, when you investigate a situation, it is easy to overlook problematic behavior and to plan and take unnecessary actions as a result. Before we take action, it is important to always take a fresh look at the action we are thinking of taking and ensure that it incorporates the six **5W1H** elements, without omissions.

What: the object

When: the date/time, the time period

Who: the person/people

Where: the place, the organization

Why: the goal, the reason, the background

How: the method, the degree

Sometimes “how much” (cost) is added to this list to give **5W2H**.



3.3 Sengen-shugi

Sangen-shugi is a Japanese term for the three “*gens*,” which are *genba* (actual place), *genbutsu* (actual article), and *genjitsu* (reality). When a problem occurs, or when efforts are being made to make improvements in a workplace, it's important to visit the work site, to look at actual articles, and to think in realistic terms. *Sangen-shugi* reflects this approach to action.

Specifically, the meanings of the three *gens* are as follows:

- i . **Genba** means the place where the phenomenon is happening. It can also refer to the act of going to that place.
- ii . **Genbutsu** means the product (article) that is the subject of the phenomenon.
- iii . **Genjitsu** means the actual situation (i.e., what is actually happening).

By making these three *gens* core principles for your behavior, you will be able to solve problems and make various improvements in a steadier fashion.

3.4 5-gen-shugi

Sometimes another two *gens* (*genri* and *gensoku*) are added to *sangen-shugi* to give **5-gen-shugi**.

On the frontlines, it's impossible to discover and recognize problems exactly by only looking at them. But as you implement *sangen-shugi*, if you make comparisons with principles and look at things based on certain criteria, problems will come into focus, and you will be able to observe the facts clearly. This is why *5-gen-shugi* has been advocated.

- i . **Genri** means “basic principles through which phenomena and recognition thereof occur.”¹⁸⁾
- ii . **Gensoku** means “basic rules and laws that apply to most situations.”¹⁸⁾

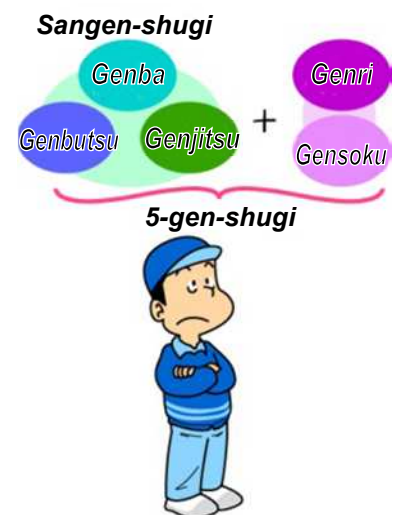
Genri, which includes things like the “principle of leverage” and “Archimedes’ principle,” is universal rules that apply to things and go beyond human wisdom. As a result, while it can be used, it cannot be changed intentionally. *Gensoku*, on the other hand, includes formulations like “the three rules for preventing food poisoning,” “corporate accounting rules,” and so on. These are rules created by people based on past experience and values. For this reason, it can be changed in response to the conditions applied and can also be altered intentionally.

Consider the example of welding process. The *genri* is “amalgamation by using the heat generated by passing a strong electric current through iron to melt the iron, applying pressure, cooling, and causing crystallization.” The *gensoku*, meanwhile, is to “pass an electric current of XX ampere for YY seconds so that the iron reaches melting temperature.”

In addition, basic rules or approaches that people engaged in various activities within organizations and society should follow are also sometimes described as *gensoku*. Take the example of garbage disposal. The idea that “garbage should be disposed of as close as possible to the place where it was generated—i.e., that it should not be transported to a distant location”—can also be described as *gensoku*.

3.5 Manners

In workplaces in which many people work, rules are prescribed to ensure that the organization is administered smoothly or to make the time spent at work more comfortable. When codified in writing, these rules take the form of rules of employment, health and safety rules, and so on. The specifics of these rules differ from workplace to workplace. The people who work in the organization obviously have to comply with these rules, but other rules,



while not codified in writing, are regarded as common sense for those in their professional lives. These rules, which we refer to as “manners,” facilitate smooth human relationships and are tacitly understood. In Japan, basic manners that absolutely must be followed are described below:

(1) Be a responsible member of society

The most fundamental business manner of all is being aware that you are a member of society. You must regard yourself as a professional who is paid for your work and must therefore perform it responsibly. Rather than waiting for someone around you to tell you what to do, you must learn, think, and take action on your own. This is the quickest route to becoming a professional. Beyond this, you must remain aware at all times that you are a member of an organization. Refrain from acting selfishly. Report in a timely and proper fashion on how you are progressing. It is also important to understand that not only are you a member of your organization, you are also a member of society. By adhering to rules as a member of society, you will gain trust from various quarters.

A related word is **compliance**. Compliance is defined as “adhering to demands and orders and, in particular, adherence by companies to laws, social norms, and corporate ethics.”¹⁷⁾ Compliance, sometimes called “legal compliance,” is essential to ensuring that organizations pursue sound business activities.

(2) Be on time

If one person is late, the whole job can get delayed, resulting in significant repercussions to the organization. Don't think that it's enough just to be on time. Rather, you should always behave with the attitude that you could even do things before the designated time. For example, you could arrive your workplace at least five minutes before work begins so that you are ready to get to work right away. It is also important to make a clear distinction between break times and working time.



(3) Exchange greetings

Greeting others is about approaching people openheartedly. To maintain smooth relations with others in your workplace, it is important to be proactive in greeting them. Get into the habit of looking people in the eye and greeting them confidently. Greetings are the starting point for establishing good communications.

(4) Pay attention to the words you use

Respecting other people and using words with care is fundamental to forging good human relations. If you approach an interaction with the intent to respect and value the other person, you will choose the right words as a matter of course. It's assumed that you will speak to your superiors and seniors politely; but the same should hold true, even if you are talking to someone younger than you. Being careful with the words you use should be common sense for all members of society.

(5) Wear the right clothes

Appearance matters. So important, in fact, that an individual's appearance affects the way their organization is perceived. Regarding appearance, the most important thing is to be clean and not make other people feel uncomfortable. It's not about being stylish. Furthermore, if you are performing dangerous work, proper outfit (overalls, a hat, boots, etc.) must be prescribed and worn in accordance with these hazards.

(6) Don't mix business with personal matters

Do not use property belonging to the organization for personal ends. Don't use workplace equipment for personal matters or order junior employees to do things for you in a personal capacity. Avoid activities involving your personal life, like emailing or calling friends, during work hours. Engaging in activities like this can damage the

atmosphere in the workplace and interfere with discipline.

(7) Be organized and tidy (*seiri* and *seiton*)

Desks and lockers in the workplace are not personal possessions. You are borrowing them from the company. Keeping them organized and tidy at all times lets both you and those around you happily focus on your work (see section 3.6).

(8) Protect the environment

This might seem obvious, but be sure to properly sort the garbage before disposal. Be proactive in activities related to environmental awareness, like minimizing garbage volumes. Creating a pleasant environment in this way is also an example of good manners.

3.6 5S

The **5S** stand for the Japanese words ***seiri*** (organized), ***seiton*** (tidy), ***seisou*** (clean), ***seiketsu*** (hygienic), and ***shitsuke*** (disciplined). They denote desirable characteristics for workplaces and can be said to form the foundations for every type of work. The 5S are actually the 4S with “*shitsuke*” added. The fifth S was added to help people fully internalize the 4S and to implement them without actively thinking of them. Furthermore, since “discipline” conjures up feelings of being told to do something from those above, “*shukan*” (habitual) is sometimes used instead of *shitsuke*. Depending on the workplace, “safety” or “speed” may also be used as an alternative **S**.



The 5S are normally used with the following meanings:

- i . ***Seiri*** (organized) is about deciding on things you need and throwing away the things you don't.
- ii . ***Seiton*** (tidy) is about putting things in their designated places to ensure they are always available for use.
- iii . ***Seisou*** (clean) is about cleaning all the time to keep the workplace clean.
- iv . ***Seiketsu*** (hygienic) is about keeping things *seiri*, *seiton*, and *seisou*.
- v . ***Shitsuke*** (disciplined) is about acquiring the habit of properly following rules.

The concept of the 5S is known worldwide and their meanings are sometimes described by the following expressions:

- i . ***Seiri*** : Sorting
- ii . ***Seiton*** : Setting in Order
- iii . ***Seisou*** : Shining
- iv . ***Seiketsu*** : Standardizing
- v . ***Shitsuke*** : Sustaining the Discipline

3.7 Health and safety activities

In workplaces, various steps are taken to ensure that time spent in the workplace is spent safely. For example, problems in the working environment must be eliminated to ensure safety, particularly in factories. In addition, action must be taken to prevent employees from having traffic accidents while commuting, health examinations are conducted periodically, and special health examinations are conducted on workers engaged in specific types of jobs. Moreover, during events called “safety weeks,” everyone helps perform different safety inspections each day and takes action to address areas with hazard risks. Events are also held to educate employees about safety. Of course, safety isn't just something to work on during safety events. It's important to ensure safety on a day-to-day basis.

At factories and construction sites, you often see flags and posters carrying a green cross. This is a safety campaign symbol intended to raise awareness among employees of health and safety. The green cross is also often used alongside the slogan “**safety first.**” In workplaces, many activities are conducted to ensure proper health and safety management. They include activities for preventing industrial accidents and achieving **zero disasters**. Specific activities include **near-miss activities**, **KY activities**, and **pointing and calling method**.

A near miss (incident) is a term used to describe dangerous situations or actions that arose but ultimately did not result in harm or damage. When a near miss occurs, you report it by completing a form based on 5W1H. You also describe the action you are going to take to prevent a recurrence. It is important to share this information on near misses in the workplace and to think of how to eradicate the causes. KY activities, meanwhile, refer to *kiken* (hazard) *yochi* (prediction) *katsudo* (activities); the abbreviation **KYK**^{*42} is sometimes used instead. These activities involve predicting/forecasting dangerous places or actions and taking action to prevent incidents before starting work.

Kiken yochi training (**KYT**^{*42}) is a training activity in which workers use illustrations or photographs of their workplace to visually identify dangerous places or actions. After that, they consider measures to tackle these dangers.

Pointing and calling method is a type of KY activity intended to confirm safety. You point at objects and call out the name of the action you should take in a loud voice. Calling out specific names is important; the technique is useful for preventing accidents resulting from **human error**.

One approach to preventive management and industrial accident prevention is Heinrich’s Law. Heinrich, a safety engineer in the United States, investigated many accidents and concluded that “for every accident that causes a major injury, there are 29 accidents that cause minor injuries and 300 accidents that cause no injuries (near misses or incidents).” It can therefore be said that activities designed to eliminate the causes of the near misses that occur on a daily basis on the frontlines will be effective in preventing accidents that cause actual injuries. These activities are sometimes called **300 campaigns**. At any rate, it is important to identify dangerous places and actions and eliminate them before they cause problems.



Chapter 4 Explanation of terminology

This chapter introduces the definitions and meanings of some of the terms used in Chapter 1 through Chapter 3 and provides simple explanations of these terms. The terms selected are not obvious specialist terminology used in the standards for quality management, specialist terms specified by the Japanese Society for Quality Control (JSQC), and so on.

Read this chapter to learn more about terms such as **product**^{*1} with attached superscript figures in the form ^{*1,*2}, etc., that appeared in Chapter 1 through Chapter 3. Definitions and meanings from the JSQC are provided, along with explanations that will give a deeper understanding of the content of the main part of the textbook.

Superscript figures displayed next to each definition [] in the form of ¹⁾ are included in the Appendix under “Citations and Reference Literature.”

*1 Product (products and services, products/services)

[Something that is the result of a process, is supplied to customers, and generates value]¹⁾

Products come in various forms, including hardware, materials, software, services, energy, and information. Few of the products we handle day to day come in just one of these forms. Most are a mixture of one or more forms. Services, a type of product, are activities that occur between customers and organizations (suppliers) that provide benefits to the customer. In this textbook, when we want to refer to services explicitly, we add the word “services” (e.g., “products and services” or “products/services”).

*2 Quality

[The degree to which the object concerned (e.g., product/service, process, system, management, corporate climate, etc.) satisfies explicit or implicit needs]¹⁾

In a diverse and mature market, it is important not only to satisfy needs clearly stated by customers, but to proactively identify and satisfy latent customer needs. In other words, it is important to deliver customer satisfaction by engaging customer emotions. Needs are sometimes limited to customer needs, but the needs of society, etc., are sometimes also included. Be careful when using this term.

Sometimes elements of quality such as functionality, performance, usability, availability, economy, reliability, safety, and eco-friendliness are simply referred to as “quality.” Quality in Japanese, *hinshitsu*, is sometimes reworded to “*shitsu*” when speaking of the quality of intangible objects rather than tangible products (e.g., quality of work, quality of medical care, and quality of service) especially in the service sector.

*3 Customer

[The organization or person that receives a product/service]¹⁾

In the field of quality management, a great deal of attention is paid to the recipients of products and services. The term “customers” is not used in the narrow sense of only the direct purchasers who pay for products and services supplied by organizations. It encompasses a wide range of people, including consumers, end users, clients, retailers, beneficiaries, and potential customers. Furthermore, it is regarded to include not only customers external to the organization, but customers inside the organization, such as other departments and people who perform downstream processes (i.e., the next process) of the process done by your own department. This view is summed up in the expression, “The next processes are our customers.” Based on this approach, the entire organization performs quality management activities, allowing it to effectively and efficiently produce and provide products/services that meet the needs of customers.

***4 Voice of Customer (VOC)**

[What customers require from products]⁸⁾

This term refers to the raw opinions of customers (e.g., something should be easy to use, clean, etc.), gathered with the goal of identifying the diverse needs customers have with regard to products/services, including quality. These opinions are analyzed and translated into quality requirements (portability, high resolution, etc.) to shed light on the products/services that should be offered and to identify problems and issues from a quality assurance perspective. The Voice of Customer, abbreviated **VOC**, is alternatively referred to as source information, source data, or linguistic information.

***5 Quality management, quality control**

[Activities for effectively and efficiently delivering product/service quality to meet the needs of customers/society]¹⁾

The goal of quality management is to meet diverse needs, like needs for product/service safety, operability, reliability, economy, and eco-friendliness. To that end, it is important to articulate the quality targeted and to steadily implement management of the processes to deliver this quality.

When articulating quality, take into account the users, potential customers, target market, society, and so on. Management (control), meanwhile, is about following the **PDCA**^{*11} cycle—in other words, it refers to all activities related to planning and implementing the optimal use of operational resources like people, things, money, and information in accordance with management objectives to meet these objectives continuously and efficiently.

***6 Problem, issue**

Problem: [a gap between a predetermined objective and reality that needs to be tackled and overcome]⁷⁾

Issue: [a gap between a to-be-determined objective and reality that needs to be addressed]⁷⁾

In everyday life, we often don't distinguish between problems and issues, regarding them all as problems. But in the field of quality management, these two terms are sometimes used with different meanings. In such cases, a problem is a gap between an objective and the reality that has occurred as a result of determining an objective, deciding on the process for achieving that objective, and then performing that process. An issue, however, is a gap between a new objective that is going to be set and reality, or between a future "ideal state" and reality. For example, you can regard the gap between a current product and the current standards for that product as a problem, and the gap between a new standard slated to be set to deliver customer satisfaction and the current standard as an issue.

***7 Problem solving, task (issue) achieving**

Problem-solving: [A series of activities for addressing a problem; involves specifying the cause, taking action, and confirming the effectiveness of that action]¹⁾

Task (issue) achieving: [A series of activities for achieving an objective; involves defining a new objective and designing processes and/or systems for achieving that objective]¹⁾

Sometimes people don't distinguish between problems and issues and use the phrase "problem-solving" to include the achievement of tasks (i.e., the resolution of issues). A typical procedure for problem-solving is a problem-solving QC story; one for task-achieving is a task-achieving QC story (see section **1.6 (1)**, p.13).

***8 Variation**

[The observed values or measurement results are uneven; also used to refer to the degree of unevenness]¹⁰⁾

Even if you perform the same tasks using the same work procedure, the data^{*30} obtained will not be uniform. There will inevitably be variation. This is because the numerous factors that affect the outcome are never constant.

The degree of variation can be expressed using statistics such as standard deviation^{*35}, but, in this textbook, we use "range" (*R*), which is the difference between the maximum and minimum values in the data obtained. Please refer to section **2.2 (4)** (pp.17-19) for more details.

*9 Complaint

[An expression of dissatisfaction from a customer or other interested party to a supplier (or to a third party who can influence the supplier) due to a product/service or organizational activity that does not meet the needs of the customer or other interested party]²⁾

A complaint refers to an expression of dissatisfaction about a supplier or third party (consumer organization, regulatory body, etc.). “Dissatisfaction” refers to the feeling that something doesn’t meet one’s needs. For example, the unpleasant sensation caused by a loud noise from a construction site is a form of dissatisfaction; when a complaint is about it is made to the authorities, the issue becomes a complaint. Among complaints directed at suppliers, those that include a demand for compensation or restitution are referred to as claims (for damages). In fact, the term “complaint” is sometimes used to describe a simple gripe. You may need to distinguish between the two terms on occasion.

“Needs” refer to expectations concerning functions and performance specifications, which are clearly stated in catalogs, instruction manuals, etc., as well as tacit expectations such as safety as a matter of course. They also refer to the provision of products/services (e.g., finished buildings) themselves and the process of achieving that provision (e.g., noise generated during construction).

*10 Nonconformity, nonconforming item

Nonconformity: [Non-fulfillment of a requirement]¹⁰⁾

Nonconforming item: [An item with one or more nonconformities]¹⁰⁾

If a component, etc., is processed and inspected and the results of that inspection^{*24} reveal that the component does not meet criteria or standards, the situation is called a nonconformity. The term “nonconforming item” is used for nonconforming articles like components.

In the past, *futekigohin* (nonconforming item) was referred to as *furyohin* (nonconforming or defective item), but nowadays a distinction is made between the two terms. *Futekigo* (nonconformity) refers to a failure to meet prescribed requirements, while *furyo* (defect) refers to a failure to meet requirements for use.

*11 PDCA, SDCA

[An approach for improving processes by continuously following a cycle comprising planning, doing, checking, and acting]¹⁾

PDCA is also referred to as the “PDCA cycle,” the “management cycle,” or the “management circle.” It is a version of the cycle of product processes described by the statistician W.E. Deming (design–manufacture–inspection/sale–service/survey) expanded for general use.

A similar approach to PDCA called “plan–do–see” existed in the past, but the “see” element was misunderstood as meaning that all one needed to do was look at results. Therefore, “see” was broken down into “check” and “act” to emphasize the importance of remedying problems and preventing recurrences. (In the past, “action” was used in place of “act” in Japan.)

The **P** in PDCA includes the notions of “planning to break free of the current situation” and “planning to maintain the current situation.” Because PDCA is implemented with the latter as the basis for defining standards that prescribe work methods or standard procedures essential for performing day-to-day tasks in the workplace, the approach is sometimes called “SDCA,” in which the **S** stands for “standardize.”

*12 QCD, QCD + PSME

QCD, which stands for Quality, Costs, and Delivery (production volume, delivery date, work period, etc.), is a term used to refer to quality in the broad sense.

In the workplace, it is customary to add **P** (productivity), **S** (safety), **M** (morale/morality), and **E** (environment) to give **QCD + PSME**, which provides an even broader notion of quality and for monitoring items^{*18} to be established and controlled for each element.

The following table shows some examples of monitoring items:

Category	Examples of monitoring items
Q	Nonconforming item ratio for each process, number of nonconforming items occurring with each worker, etc.
C	Proportion of cost reduction target achieved by each component, variance between the workplace's budget and its actual performance, etc.
D	Ability to deliver on time, inventory trends, etc.
P	Production volume per person per day, production value per hour, etc.
S	Number of accidents, number of continuous operation hours without an accident, etc.
M	Absence rate, work attendance by each worker, number of improvements proposed by each worker, etc.
E	Carbon dioxide (CO ₂) emissions, specific environmental risks pointed out (the E is sometimes used to refer to ecology or education), etc.

*13 Occupational health and safety

[Conditions and factors that affect or could affect the health and safety of employees, other workers (including temporary workers and subcontractors), visitors, and all other people in the workplace]¹⁶⁾

Occupational health and safety covers everything concerned with maintaining the health and safety of all those involved in the business activities of the organization, including physical and mental safety in the workplace, safety while commuting to and from work, and health examinations. The Industrial Safety and Health Law stipulates that organizations must safeguard the health and safety of workers in the workplace and promote formation of a pleasant working environment. To achieve these objectives, business operators have a duty to establish hazard-prevention standards for preventing occupational accidents, to clarify responsibility systems, to promote voluntary activities, to implement comprehensive and strategic measures, and so on. It is not enough simply to abide by standards for preventing occupational accidents. The Act requires workplaces to offer peace of mind, comfort, and a pleasing atmosphere to strengthen health and safety. It must also not be forgotten that business operators have occupational health and safety responsibilities for those not directly involved in their operations. For example, they must take action to prevent the pollution of the atmosphere, water, etc. Events promoting these activities, such as National Safety Week in July and National Industrial Health Week in October, are held nationwide each year.

*14 Product safety

[Measures taken to ensure the safety of products from a PLP (product liability prevention) perspective. Refers to measures taken to prevent the occurrence of accidents that lead to product liability claims, i.e., corporate activities for the creation of safer products.]³⁾

The term “product safety” is sometimes abbreviated **PS**. In addition, PLP stands for “product liability prevention”; PL alone stands for “product liability.”

*15 Global environmental protection

[Refers to environmental protection related to phenomena affecting the entire global environment or a large part of it, such as global warming resulting from human activity, the progressing destruction of the ozone layer, marine pollution, and reduced biodiversity. Global environmental protection contributes to the welfare of mankind and helps citizens lead healthy and culturally fulfilling lives.] (from The Japanese National Basic Environment law)

This term refers to protecting the earth's environment and making it safe. As a result of growing industrialization, which began about 250 years ago with the industrial revolution, numerous global-level environmental problems have emerged. These include the destruction of the ozone layer, acid rain, global warming, the depletion of resources such as fresh water and forests, desertification, air and marine pollution, and waste. Protecting the earth and making it safe has become a pressing task for mankind, and concerted action on a global scale is urgently required.

To protect the earth's environment, it is important to think in broad terms about various issues, including the adverse environmental impact of factories that emit pollutants externally, the environmental impact that occurs during phases in which products are used and disposed of, the environments that affect people who work in an organization, and the impact of the environment surrounding products during the manufacturing phase.

***16 Quality policy**

[Policy related to quality]⁵⁾

A quality policy is a formal expression by top management of the organization's overall intention and direction concerning the quality of products and services. It forms part of, or is consistent with, corporate policy and operating policy and is a key policy for determining direction when maintaining/improving quality or building/maintaining an ISO^{*23}-compliant quality management system.

***17 Market in, product out**

Market in: [An approach that places priority on identifying the needs of customers/society and supplying products/services that meet those needs]²⁾, [an activity whereby a manufacturer plans, designs, manufactures, and sells products that meet the needs of the market]¹³⁾

Product out: [An approach whereby you sell as many of the products you have produced as you can]³⁾

“Market in” and “product out” are opposites. “Market in” refers to an approach whereby you consider everything from the customer's standpoint and make decisions and take action accordingly; “product out” refers to an approach whereby you ignore the other person's point of view and act with the goal of enabling the organization to supply its products/services from a one-sided standpoint.

***18 Monitoring items (management points, control points), check items (checkpoints)**

Monitoring items: [Items selected as evaluation scales for managing the achievement of objectives]⁶⁾

Check items: [Those monitoring items that are used for checking causes]³⁾

Monitoring items are evaluation scales used for determining whether a process is being implemented as intended and, if not, for identifying causes and taking necessary action such as measures to prevent recurrences (see the table in *12 for examples of monitoring items).

Monitoring items, which can be split into items for checking results (referred to as result-type monitoring items, etc.) and items for checking causes (referred to as check items, checkpoints, cause-type monitoring items, etc.), are used to determine numerical targets, control limits, frequency of checks, etc. Normally, managers employ monitoring items for checking results, while rank-and-file employees use monitoring items for checking causes.

***19 Standards, standardization**

Standards: [(1) Rules prescribed for the purpose of harmonization/simplification in order to ensure that all parties involved can profit or benefit fairly. (2) Methods or things that express quantities used as criteria prescribed to ensure universality in measurement]⁴⁾

Standardization: [Activities involving the setting and utilization of rules for facilitating common and repeated use with the aim of ensuring effective and efficient organizational administration]¹⁾

The goal of standardization is to prevent disorderly complexity and to achieve rational simplification and harmonization. Standardization promotes mutual understanding and communication, ensures quality, enhances usability, ensures compatibility, increases productivity, and promotes maintenance/improvements. Standards are of two types: i . objects/bodies, performance, capability, layout, condition, operation, steps, methods, procedures, duties, responsibilities, authority, approaches, concepts, etc., and ii . prototype kilogram, standard hardness, etc.

***20 Improvement (continual improvement)**

[A repeatedly performed activity whereby standards for products, services, processes, systems, etc., are set at a higher level than they are now, problems and issues are defined, and problems are solved and tasks are achieved]¹⁾

Improvement (*Kaizen* in Japanese) is a key characteristic of Japanese-style quality management. It is important to make improvements rationally, scientifically, efficiently, and continuously based on procedures for problem-solving (problem-solving QC stories) and task achieving (task-achieving QC stories). These are more specific forms of the PDCA approach, which lies at the heart of *Kaizen*.

***21 QC story**

[A basic procedure for rationally and scientifically conducting improvement activities in effective and efficient ways based on data]²⁾

QC stories originated as a way to provide easy-to-understand explanations of actual examples of improvements at meetings of Quality circles and other forums. The term derives from Quality circles. Later, QC stories became widely recognized as an effective procedure for solving problems (problem solving method by QC approach) and came to be used for a wide range of improvement activities, not only for presenting examples of actual improvements. This situation continues to this day.

The QC stories used for improvement activities by Quality circles generally comprise eight steps: theme selection, status quo review and goal setting, analysis, countermeasure consideration, countermeasure implementation, effect confirmation, standardization (brake of an effect standardization for effect mar), and reflection and future plan. However, besides problem-solving QC stories like these, task-achieving QC stories have been developed as an effective procedure for tackling the challenge of new tasks, adapting to new business operations, and making great leaps forward. Recently, even newer forms have emerged, such as policy-implementation-type and prevention-type QC stories.

In addition, various improvement procedures have been devised in the United States. These include the KT method (Kepner-Tregoe method) and Six Sigma.

***22 Quality circle**

[A small group for enabling frontline workers to continuously maintain, improve, and innovate the quality of products/services or processes that relate to their work]¹⁾

The basic philosophy of Quality circle activities comprises three elements: i Unleashing the capabilities and unlimited potential of people; ii respecting humanity and creating fulfilling, cheerful workplaces; and iii contributing to the improvement and development of the company constitution. Quality circles run voluntarily. They utilize QC approaches, techniques, etc., to foster creativity and promote self- and mutual development. The activities of Quality circles seek to improve the abilities of their members, enabling them to achieve self-actualization, making the workplace fulfilling, cheerful, and full of vitality, improving customer satisfaction, and contributing to society.

Quality circle activities are one of the best-known small group improvement activities. The purpose of small group activities, the way they are administered, and so on vary greatly depending on the organization. The forms they take and the names used for them also vary, as they reflect these differences. Examples are JK (*jishu-kanri*: self-management) activities, *Kaizen* activities, ZD (zero defects) programs, CFTs (cross-functional teams), and project teams.

ZD programs, which seek to eliminate work defects, involve individual employees exercising care and ingenuity. CFTs are put together to achieve a specific goal. Comprising members from the different departments involved in working toward the goal, they are typically disbanded once the goal has been achieved.

***23 Standards(kikaku), Japanese Industrial Standards, international standards**

Standard(*kikaku*): [*Hyojun* (standards) prescribing technical specifications relating to products. However, “*kikaku*” is often used instead of *hyojun*, e.g. *sagyo kikaku* (work standards), *kokka kikaku* (national standards), *dantai kikaku* (industry-body standards), etc.]³⁾

Japanese Industrial Standards: [Japanese national standards established in accordance with the Industrial Standardization Law]³⁾

International standards: [Standards that can be used by the public and have been adopted by international bodies for standardization and standard setting]¹⁹⁾

Japanese Industrial Standards, which are referred to as JIS, are applied to the development, production, distribution, and use of industrial products in sectors other than food, agriculture, and forestry.

International standards refer to standards set by such bodies as the ISO (International Organization for Standardization) and the IEC (International Electrotechnical Commission).

The ISO and IEC are both nongovernmental organizations. The latter sets international standards in the field of electrical and electronic engineering, while the former does the same for other fields.

***24 Inspection**

[The act of determining whether one or more characteristic values concerning a product or service meets prescribed requirements through measurement, test, comparison with a gauge, etc.]¹⁾

Inspections are designed to prevent nonconforming items (rejected lots) from being passed on to downstream processes or customers. They involve comparing results of measurement on the product, which have been obtained using some sort of measurement method, with acceptance criteria to determine whether a single product or a group of products (called a “lot”) is conforming or nonconforming and taking appropriate action based on the results.

Inspections can be classified into various types based on method of inspection, manufacturing phase, type of production (i.e., mass or many kinds in small quantities), location of the inspection, lot, and so on. It is important to consider the cost and adopt an inspection system that meets your objectives. Inspection methods include 100% inspections, sampling inspections, and inspections without tests or measurements. In terms of inspection characteristics, inspections can be classified as destructive, nondestructive, sensory, etc.

***25 Measurement**

***Keisoku* (measurement/instrumentation):** [In accordance with specific objectives, selecting and implementing a method/means of quantitatively assessing an article and using the results to meet desired objectives]¹¹⁾

***Sokutei* (measurement):** [Comparing a quantity with a standard quantity and expressing that quantity using a figure or symbol]¹¹⁾

“*Keisoku*” and “*sokutei*” have similar meanings. Measurement refers to perceiving things quantitatively. Whereas instrumentation targets objectives, measurement is an operation unrelated to objectives. It is simply one means of *keisoku*.

For example, when you use a thermometer to determine the temperature of a room, it’s *sokutei*; when you use a thermometer to check whether the room temperature is appropriate or needs to be adjusted, it’s *keisoku*.

***26 Lot**

[Definite part of a population constituted under essentially the same conditions as the population with respect to the sampling purpose]¹⁰⁾

A group that is used as a unit for the production or shipping of products, components, or materials. The term “lot” can also be used for a group of services provided under the same conditions. In the case of sampling inspections, the lot is the bundle of products, materials, or services submitted for testing. The number of articles contained in one lot is referred to as the “lot size.”

***27 Alternative characteristic**

[Another quality characteristic that is used to perform the same or a similar assessment when it is difficult to directly measure the required quality characteristic]²⁾

It is sometimes technically difficult to measure and assess a quality characteristic because doing so would

necessitate the destruction of the object of testing, would take a long time, would cost a lot, etc. In cases like this, the quality characteristic that you measure instead is referred to as an “alternative characteristic.”

For example, to check whether welding has been performed properly, you could try pulling the welded pieces apart to test the strength. But doing so could result in destruction. So, instead, you might conduct ultrasonic tests and measure the echo height or transmission pulse amplitude. Quality characteristics resulting from the translation of linguistic information such as the Voice of Customer (VOC^{*4}) into product/service performance requirements, quality objectives, etc., are also alternative characteristics.

In the case of alternative characteristics, the required quality characteristics are not being directly measured. It is therefore necessary to adequately confirm the relationship between the required quality characteristics and the alternative characteristics.

***28 Process**

Process: [Set of interrelated or interacting activities that use inputs to deliver an intended result]⁵⁾

Kotei (process): [The source of the creation of products or services]¹⁰⁾

A process is an activity whereby you obtain the materials, information, energy, etc. that will form the basis for the output, add value to them, and produce them as output. This activity is performed using management resources such as people, equipment, technology, know-how, and money. The definition, “a series of interrelated or interacted activities for converting inputs into output” indicates a group of actions, each of which has its own role to play in achieving a specific objective.

The concept of a “*kotei*” originated in the manufacturing field, then began to be used in the fields of clerical works, sales, and service. But people in these fields were unfamiliar with it, so the term “process” came to be widely used instead. In the business world, process and *kotei* are regarded as synonymous. They refer to all the steps through which factors^{*36} such as the 4M (man, machine, material, and method) that affect the various characteristics of products/services interact with each other over time to produce the final output. It is important to strive for high quality by identifying important factors in a process (*kotei*), restricting variation^{*8} in these important factors, and making them the target for maintenance, improvement, and innovation.

***29 Observed value (measured value)**

[Obtained value of a property associated with one member of a sample]⁹⁾

[The characteristic values of a sample obtained by performing observations for a prescribed period under prescribed conditions]¹²⁾

The value for a characteristic of an article obtained as a result of a single measurement. Examples are the size, weight, and strength of a component. The term “measured value” is used synonymously with “observed value.”

***30 Data (numerical data, linguistic data)**

[Information gathered for a specific purpose]³⁾

There are various types of data, including numerical data, which are expressed as figures, and linguistic data, which cannot be expressed as figures.

Numerical data is typically divided into two categories, continuous and attribute. Continuous data comprises values obtained by measurement using some sort of benchmark and is usually used in conjunction with a unit (kg, m, etc.). It is a continuous quantity (i.e., it is connected in the form of an infinite chain with no points of separation). Attribute data, meanwhile, comprises values obtained by counting. It is expressed using integers (i.e., whole numbers that are counted in the order of 1, 2, 3, etc.). Examples would be numbers of people, numbers of sheets of paper, or numbers of nonconforming items. It is a discrete quantity (i.e., only discrete numbers exist). This means that when, for example, the number of nonconforming items is divided by the number of products manufactured (to calculate the proportion of products that are nonconforming), the denominator and numerator consist of attribute data (i.e., discrete numbers). The data obtained as a result is basically discrete numbers and treated as attribute data even if the quotient is not an integer. In addition, items arranged in order based on some sort of criteria such as quality or size, which are given a score or a rank, are also treated in a similar way as numerical data.

Linguistic data, on the other hand, is data that is expressed using words instead of figures. If the article or phenomenon concerned is perceived using human senses, and described using adjectives such as being beautiful, large, happy, etc., it is called sensibility data. If the article or phenomenon concerned is simply given a specific name, such as bird, cat, or moon, to distinguish it, explain it, or classify it, it is called nominal data. So there are various types of linguistic data. Some people are under the impression that compared with numerical data, linguistic data is less objective and not particularly useful, but it is important to understand that the Voice of Customer (VOC^{*4}), is valuable linguistic data that shows what the market actually thinks about the quality of products/services and therefore provides us with a lot of useful information. It takes the form of expressions such as “this camera is easy to use,” “this television has a great picture,” and “this cake is sweet” that describe how the product/service feels to use, its design, its color, and so on.

*31 Characteristic

[Distinguishing feature]⁵⁾

There are various types of characteristic, including ones that can be expressed numerically and ones that can't, such as noncontiguous changes in an attribute. Examples of types are functional (e.g. distance flown by an aircraft), behavioral (e.g. politeness, directness, honesty), sensory (e.g. smell, touch, taste, sight, and hearing), temporal (e.g. accuracy of time, reliability), material (e.g. mechanical, electrical, chemical, biological), and ergonomic (e.g. matters relating to human safety).

*32 Sample, sampling, sampling units, sample size

Sample: [Subset of a population made up of one or more sampling units]¹⁰⁾

Sampling: [Act of drawing or constituting a sample]¹⁰⁾

Sampling units: [one of the individual parts into which a population is divided]¹⁰⁾

Sample size: [Number of sampling units in a sample]¹⁰⁾

In the case of discrete items, it is the number of products in the sample. If the sample is obtained from a liquid, powder, etc., it is the number of sampling units taken.

*33 Population, population size

Population: [Totality of items under consideration]⁹⁾

Population size: [The number of sampling units contained in the population]¹⁰⁾

The term “population” normally refers to the object to which action is going to be applied based on the sample. In the case of a sampling inspection, the inspected lot is the population, and when a sample is taken from a process in order to manage it, the process is the population.

The former is described as a finite population because the number of samples contained in the population is limited, whereas the latter is described as an infinite population because as long as production isn't suspended, an unlimited number of samples can be obtained. Sometimes, the term “infinite population” is used to describe a population of unlimited size that cannot be restricted, and the term “finite population” is used to describe a situation in which the number of objects is limited.

In addition, the term **subpopulation** is sometimes used for a group defined as part of the population.

*34 Sum of squares, variance

Sum of squares: [The sum of the squared difference between each the mean]¹⁵⁾

Variance: [Moment of order r where r equals 2 in the centred probability distribution of the random variable]⁹⁾

The sum of squares is calculated by taking the difference (deviation) between each measured value and the mean, squaring it, and adding them all together. It shows how much variation there is in the measured values. Obviously, if the set of measured values obtained (i.e., the sample) changes, the sum of squares will also change, as it is based on those measured values. It therefore changes stochastically.

Regarding the variance, as you can see from the definition above, it is not calculated directly from the measured values. It refers to the “value that would be expected if the test were performed an infinite number of times” and is determined based on the nature of the population. This means that when you don’t know the nature of the population, the variance is unknown. If you want to know what it is, all you can do is take a sample from the population and make an estimate based on that. In such cases, it is known that if you take n measured values from the population, calculate the sum of squares, divide it by $n - 1$, and use that value, the estimate of the variance will not be biased. This is known as the “unbiased variance.” Obviously, the unbiased variance changes stochastically based on the sample taken.

Note that as long as it doesn’t lead to confusion, the unbiased variance is often simply referred to as the “variance.”

*35 Standard deviation

[A scale of the degree of dispersion in the data]³⁾

The difference between individual measured values and the mean is referred to as the “deviation.” It constitutes basic information for expressing the degree of dispersion in the data. However, if the deviations are summed, the net result is ± 0 (zero). Because of this, the deviations are squared and averaged to provide a scale of dispersion. The square of the deviation is known as the “squared deviation,” and the total of the squared deviations for all the measured values is known as the “sum of squared deviations” (S). Dividing that by $n - 1$ gives the “unbiased variance” (V), and the square root of this is the “standard deviation” (s). Because the standard deviation is the square root of the unbiased variance, the scale for dispersion is aligned with the dimension of the measured values.

Some of you may be wondering why we divide by $n - 1$ instead of n when averaging the squared deviation. The reason is that dividing by $n - 1$ can be expected to produce a value that is closest to the variance of the population as a whole (called the “population variance”). The structure of the formula means that the smaller dispersion there is in the data, the smaller the standard deviation will be.

The true variance of the population, which is known theoretically, and the variance of the population as a whole are referred to as “population variance” (written as σ^2 and pronounced “sigma squared”), and the standard deviation thereof is referred to as “population standard deviation” (written as σ and pronounced “sigma”).

*36 Factor, cause/root cause

Factor: [(1) Something that may result in a certain phenomenon or a variable that is likely to influence the outcome (2) A variable that is the object of an experiment or discussion]¹⁾

Cause/root cause: [(1) A source from which a certain thing happens (2) A factor that has been determined as the cause of a certain phenomenon. Note: Definition (2) is useful for problem solving.]¹⁾

The terms “factor” and “(root) cause” have similar meanings, and in everyday life hardly any distinction is made between them, so please make sure you are aware of the difference between them in the context of quality management. The term “factor” is used to mean something that influences or may influence the outcome, so it has the same meaning in both everyday life and in a quality management context. However, in a quality management context a clear distinction is made between a “factor” and a “(root) cause.” Something that may influence the outcome is referred to as a “factor,” while “(root) cause” refers to a factor that has a clear cause-and-effect relationship with the outcome.

*37 Brainstorming

[A technique for considering matters as a group that is aimed at developing creativity. It is a method whereby people at a meeting express their opinions and thoughts freely in order to extract good ideas]¹⁷⁾

Brainstorming, sometimes abbreviated as **BS**, is a method of “triggering a storm in the brain” developed by A. F. Osborn in the United States. It's frequently used at meetings such as Quality circle meetings and as a means of generating ideas. Normally, five to ten people get together and follow four rules: don't say whether an idea is good or bad (withhold criticism), encourage the free expression of ideas (welcome wild ideas), encourage people to express a large number of ideas (go for quantity), and take advantage of other people's ideas (combine and improve ideas).

*38 Subgroup

[A block forming part of a process classified temporally according to the order of production, e.g., day, work shift, processing lots]³⁾

Blocks constitute a process that has been broken down temporally so that the elements of the process have comparatively uniform conditions. To form a subgroup rationally, it is important to assume that variation within the block (referred to as “within subgroup variation”) is the result of a chance cause and that variation between blocks (referred to as “between subgroup variation”) can be detected and is due to an important, assignable cause.

In an $\bar{X} - R$ control chart, the size of the subgroup (n is usually used for the number of observed values in a subgroup) is often $n = 2, 4, 5$, and is normally written at the top left of the $\bar{X}$ control chart. So the size of the subgroup in the $\bar{X} - R$ control chart in **Figure 2.11** (p.22) is $n = 5$.

*39 Out of control signal

This is used as a criterion for determining whether or not a process^{*28} is out of control using a control chart.

On rare occasions, even if the dots on a control chart are within the control limit lines, the way the dots are arranged or scattered cannot be considered normal. This means the process is out of control. For example, when the control limit lines lie ± 3 standard deviations from the centre line, if the dots are continuous and 9 dots are on the same side of the centre line, if 6 dots (including both sides) are increasing or decreasing, if 14 dots are increasing and decreasing alternately, if 2 out of 3 dots are within ± 2 and ± 3 standard deviations, if 4 out of 5 dots are beyond ± 1 standard deviation, if 15 dots are within ± 1 standard deviation of the centre line, if 8 dots are not within ± 1 standard deviation, etc., you must suspect an abnormality in the process.

*40 Assignable cause/Special cause

[A causal factor that can be detected and identified as the cause of a change in a quality characteristic or process level]¹⁰⁾

An assignable cause is a cause of a change in a characteristic or process level that can be identified and eliminated or that must be eliminated. Assignable causes are also described as “causes that cannot be ignored,” “causes with reasons,” and “avoidable causes.” If the assignable cause is in the process, the dots on the control chart will be outside the control limit lines, or there will be some sort of out of control signal in the way they are arranged or scattered.

Chance cause/Common cause/Random cause

[A causal factor that is a cause of variation. Normally, there are many of them, but they are relatively unimportant. They have not necessarily been identified, but even if they have been, it is difficult for technical or economic reasons to eliminate them.]¹⁰⁾

A chance cause is a cause that is difficult to identify and eliminate or the elimination of which is pointless. Chance causes are also described as “unavoidable causes.”

To ensure that a process can maintain quality at a certain level, it is important to decide whether change is an unavoidable variation^{*8}, which is always occurring, or variation that is the result of a cause that is unusual and cannot be ignored. In the case of the former (chance cause), no special action needs to be taken; in the case of the latter, the cause must be pinpointed and eliminated. By performing such activities on a continuous basis, it is possible to ensure the stability of processes.

***41 Outlier**

[An observed value in a group of observed values so different from the other observed values that it may have come from a separate population or may be the result of measurement error.]⁹⁾

***42 *Kiken yochi katsudo* (KYK) (hazard prediction activity), *kiken yochi* training (KYT)**

Kiken yochi katsudo (KYK) is a safety management tool for eradicating accidents. It includes such activities as workers themselves identifying work-related hazards that are hidden in the workplace and eliminating them before they result in an accident. KYK improves the ability to predict accidents (*kiken yochi*) as well as the ability to focus on safe work procedures. This makes work safer and ensures that workers don't have accidents. The term is often abbreviated to "KYK" or "KY activities."

KYK is useful for many things. It sharpens individuals' sensitivity to dangers, promotes a shared awareness of unseen dangers residing in work practices, fosters teamwork based on the notion that "we protect our safety by ourselves," and gets everyone to voluntarily abide by rules that they have discussed and agreed on together.

KYK is often performed close to the work frontline and comprises four rounds: status quo grasping, investigation of the essence, formulation of measures, and goal setting. It is often bundled in with the pointing and calling method, and touching and calling activities that are performed before starting work and at the end of work.

Kiken yochi training (KYT) refers to education and training in safety management for the purposes of properly performing KYK. It is often abbreviated "KYT."

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