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An e-learning Manual for Implementing Total Quality Management

Volume 2

A Roadmap to Quality

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION

Japanese Standards Association

A Roadmap to Quality

An e-learning Manual for Implementing Total Quality Management

Volume 2

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
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Unit 10

QC Circles

Contents

Unit summary

A QC Circle is a small group of frontline employees who meet regularly to try to improve the quality of their work. QC Circle activities are at the core of TQM. They can play a major role in creating a dynamic atmosphere in the workplace.

Please note that some of the texts in this unit will only become useful when you have actually set up QC circles in your company. Note also that several of the charts referred to contain a level of detail that you may feel is not relevant to your company.

10.1 QC Circle activities

QC Circles normally take a problem-based approach to improving the quality of their work. They identify problems in their workplace, usually related to product quality and referred to as "themes", and together they set about finding a solution. They use quality control concepts and techniques, and try to be creative in seeking solutions.

10.2 The human dimension to QC Circles

We all have an innate desire for personal growth. In the right conditions we get a lot of satisfaction from improving our skills, and from using our new skills together with our co-workers to achieve meaningful targets. QC Circles provide the right conditions.

10.3 Introducing QC Circle activities in your company

Be both sensitive and creative in introducing QC Circles in your company, especially since their aims are to encourage the development of employees. Make sure that you take an approach that suits the working environment, and the character and climate of your company.

10.4 How many employees in the company should take part in QC Circles?

Although all employees should take part in QC Circle activities, as these are a component of TQM, some companies allow departments and sections to opt out. A key decision you have to take is the scale of participation within your company.

10.5 Select QC Circle leaders; roles of leaders and members

The QC Circle leaders will be the driving force behind the activities. Select people who can show leadership, who can get members to cooperate in meetings, can gather ideas, and can create an atmosphere where everyone will feel free to express their opinion.

10.6 The QC Story

QC Circles use a 7-step procedure to solve problems related to the five priorities of QCDSM: quality (Q), costs (C), deadlines and productivity (D), safety (S), and morale (M). This procedure uses methods based on facts and data, and aims to prevent the recurrence of problems by identifying the causes and implementing recurrence prevention measures.

10.7 QC Circle meetings

QC Circle meetings help members to work together towards the same goals. Members exchange ideas and information, get to know each other, and develop a spirit of cooperation and a sense of solidarity. But if the meetings are poorly managed, the activities will stagnate and members will become de-motivated.

10.8 QC Circle assemblies

After a QC Circle has completed a theme, it holds a meeting, referred to as a QC Circle assembly or a QC Circle conference, to re-appraise the methods that have been used, and to confirm the circle's sense of achievement. Members give presentations of key points from their problem resolution activities and achievements: their methods, their difficulties, and their creative ideas. A very effective way of doing this is the QC Story (See also Unit 9).

10.9 Evaluation of QC Circle activities

Regular and appropriate evaluation of QC Circle activities will help to motivate members and to revitalize activities. It will identify where improvement is needed, and indicate the corrections that should be made. There are two forms of evaluation: self-evaluation by members, and evaluation by managers.

10.10 The basic procedures for QC Circle activities

Once QC Circles have been set up, there are a wide range of procedures to follow.

10.11 QC Circle training

QC Circle training is aimed at achieving a workplace full of employees who are motivated, creative, and good at solving problems. Training focuses on the value of QC Circle activities, on raising quality consciousness, and on using QC methods.

10.12 Planning future QC Circle activities

Facilitators should prepare plans for desirable QC Circle activities for the future, and promote these as a component of TQM. These plans should prescribe the level of QC Circle activities, their targets, and concrete measures for achieving the targets. In doing so, they should look carefully at the present state of QC Circles and should respect the intentions of work superiors. Such plans are important in energising and consolidating QC Circle activities.

10.13 Create the right environment for QC Circle activities: the role of the CEO

QC Circles can only flourish in the right environment. CEOs, middle managers, promotional staff members, and personnel managers must gain a good understanding of QC Circle activities and create such an environment. The CEO has a key role to play.

10.14 The role of middle management

Middle managers should help establish a working environment in which QC Circle members are allowed to take on a management role in their own work and make improvements on their own initiative, in which their willingness to contribute is respected, and in which they can use their abilities to the full.

10.15 Set up a company-wide organisation to promote QC Circle activities

Set up a company-wide organization to promote and facilitate QC Circle activities. This should include a promotional committee and a promotional secretariat.

10.16 Hold QC Circle exchanges with other companies

When QC Circles always remain within their own work places, members' perspectives may become limited, and their ideas lose freshness. Organize meetings periodically with other circles both within the company and outside. Members of different circles can visit each other, have discussions, and study QC Circle management together, and thereby stimulate each other to further development.

Learning tools

The RADAR questions

As you read each text you will discuss how it could be applied in your company. The RADAR questions will help you to focus this discussion:

R - Are these ideas **relevant** to my company?
A - How would **I apply** each of them in my company?
D - What **difficulties** might I meet and how would I overcome them?
A - Are there any **additional** actions that I might take that are not mentioned in the text?
R - What **resources** would be needed, what would these cost, and how could they be acquired?

There will of course be some discussion points where not all of these questions will be applicable.

The 6-Point Structure

After you have discussed the ideas in the text, you write an action plan in which you present practical proposals for implementing the conclusions you have reached in your discussion. The 6-Point Structure will help you to write your action plan:

1. **Problems:** Problems you have in your company in the area you have just discussed.
2. **Proposals:** Your proposals for improvement.
   a. Be specific and concrete.
   b. Include an implementation plan, with a time schedule and minimum and optimal implementation targets.
   c. Refer to any forms, charts, tables etc. that you would use, and include samples in an appendix.
3. **Obstacles:** Obstacles to implementation in employee attitudes, company organization and culture etc., and how these could be overcome.
4. **Resources:**
   a. The resources required: funds, equipment, materials, man-hours, expertise etc.
   b. The resources available within the company.
   c. Any resources that would have to be found outside the company.
   d. Alternatives that could be used to cover any shortfall in resources.
5. **Assessment:** Ways of assessing the results of implementing these proposals.
6. **Benefits:** The benefits your proposals would bring.

10.1 QC Circle activities

1. A QC Circle is a small group of frontline employees who meet regularly to try to improve the quality of their work. In general their approach is problem-based. They identify problems in the workplace, usually related to product quality and referred to as "themes", and together they set about finding a solution. They use quality control concepts and techniques, and try to be creative in seeking solutions. Broadly, their agenda is to continually improve and maintain the quality of products, and to constantly strive towards self-development and group development. Through the QC activities, they develop quality consciousness, problem consciousness, a willingness to make improvements, and a sense of quality management. Ultimately their activities will lead to increased customer satisfaction.

2. The quality of any product or service is determined by the front-line employees. In the manufacturing industry this will be the employees who prepare blueprints, procure materials, manufacture parts and products, and sell these to the customer. In the service industry, quality depends on those who provide the services, and those who sell the services to customers. In the indirect departments (departments that provide services to other departments and to the company as a whole), quality is determined by those who provide services to other employees. The criteria against which such improvements can be measured are the standards which have been established to meet customer requirements.

3. The QC Circle problem-solving approach seeks to find and remove the root cause of problems through the four stages of the PDCA Cycle – draft plans (plan), implement the plans (do), confirm the results of the implementation (check), and carry out any necessary follow-up action (action) – Plan, Do, Check and Act: the PDCA cycle. (For more details on the PDCA cycle see Unit 3.10.3)

Figure 1.5a PDCA Cycle

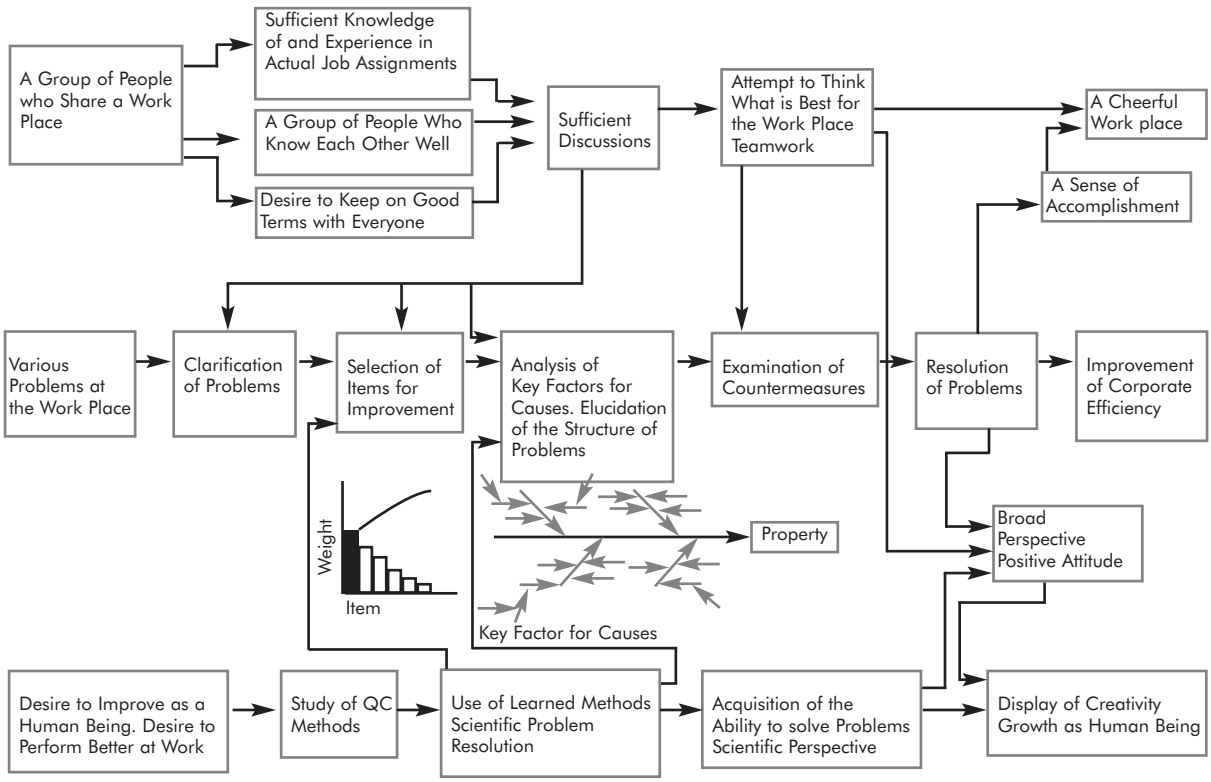
4. The QC Circle approach, and quality management in general, is based solidly on facts. This means first of all getting the facts, and then, wherever possible, converting those facts into numerical values. When they are in numerical form it is easier to analyze them objectively and accurately, and to reach a sound judgement. This data-processing procedure is:
   a. Convert facts into numerical values, as far as possible.
   b. Distinguish causes from results.
   c. Analyze results in a stratified manner (where data is divided according to its sources, e.g. stratified by employees, by machines etc.).
   d. Prioritize items for consideration.
   e. Pay attention to dispersion (How the different items of data are scattered in relation to how they are supposed to be, i.e. in relation to the standard or target values. See Text 9.7.)

5. The methods that QC Circles use include:
   a. Procedures for problem resolution.
   b. The QC Seven Tools.
   c. The New QC Seven Tools.
   d. Other statistical methods as well as IE (industrial engineering) and VA (value engineering).

   When employees start using these methods they will find it easy to understand this approach to improvement. (See Unit 11 and Text 16.6 for descriptions of the QC tools.)

6. QC Circles are also about the quality of our working life. We all have a natural desire to develop our latent abilities and display them to good effect. QC Circle activities give employees the opportunity to fulfil this desire by gaining knowledge, solving problems, and achieving goals. Discussions at QC Circles also help us understand our co-workers better, to develop good relationships, and, in all, to make our work place more pleasant, more cheerful and more dynamic.

Figure 10.1a Mechanism of QC Circles



Discussion

The following questions ask you to think about how the ideas in the text could be applied in your company. Some of these ideas may not be relevant to you. Concentrate on those that are relevant. Keep notes of your conclusions – you will need them to prepare your action plan afterwards. Where appropriate ask yourself the RADAR questions.

Note: Always include in your discussion any figures referred to in the text, ***if*** you feel these are relevant to your company.

a. Parag. 1: To what extent would you say that employees in your company have a sense of quality consciousness, problem consciousness, are willing to make improvements, and have a sense of quality management. What benefits can these qualities in employees bring?
b. Parag. 2: Who are the frontline employees in your company? In what ways is the quality of your products or services determined by the front-line employees? Give one or two examples.
c. Parags. 3, 4 and 5: These paragraphs give a preliminary outline of what QC Circles involve. Some of the terminology will not be familiar to you yet, and more detail will follow in later texts. For the moment consider in general terms how feasible and how useful these ideas would be for your company. How systematic is the approach to problem solving in your company?
d. Parag. 6: Do you agree with this perception of human nature which underlies the QC Circle approach? Give reasons for your opinion.

Action plan

When you have discussed several texts, take the ideas you have found useful in them, and in your discussion, and present them in a well-structured action plan for your company. You might like to follow the 6-Point Structure.

10.2 The human dimension to QC Circles

1. We all have an innate desire for personal growth. In the right conditions we get a lot of satisfaction from studying, from improving our skills, and from using our new skills with our co-workers to achieve meaningful targets. QC Circles provide the right conditions.

2. The aims of QC Circle activities are to:
   a. Fully bring out our latent capabilities. Everyone has considerable ability. As long as we continue to learn, this ability will continue to develop. QC Circle activities provide a framework for learning and developing together with our fellow workers.
   b. Create a happy workplace. Members of QC Circles respect each other, and allow each to display their abilities. When we learn to see things from other people's viewpoint, our relationships with them improve, and the work environment becomes a pleasant place where everyone has a sense of purpose.
   c. Contribute to the improvement and development of the enterprise. QC Circles have become part of the corporate front line. Many companies have entrusted them with the task of determining the quality level of the products and services they provide to customers. They know that if employees find their jobs worthwhile, find their work environment pleasant, and can exercise their abilities to the fullest, then the companies they work for can only improve and grow.

3. To make the most of the opportunities that QC Circle activities provide, we should resolve to:
   a. Bring out our potential abilities through self-development.
   b. Act with good will, and transform ourselves into capable workers.
   c. Seek opportunities to further our development as a group, and to broaden our outlook.
   d. Work together: make sure information is shared with everyone, and leave to the side any personal biases we may have.
   e. Encourage everyone to participate in the group, and show what a force it can be.
   f. Do our best to create a dynamic work environment.
   g. Come up with creative ideas to bring improvements to our work - achieve a work environment that is continually moving forward.
   h. Cultivate quality consciousness, problem consciousness, and a willingness to make improvements.
   i. Make effective use of QC methods to resolve problems, to prevent problems recurring, and to prevent potential problems emerging.
   j. Work towards the goals of TQM.

Discussion

The following questions ask you to think about how the ideas in the text could be applied in your company. Some of these ideas may not be relevant to you. Concentrate on those that are relevant. Keep notes of your conclusions – you will need them to prepare your action plan afterwards. Where appropriate ask yourself the RADAR questions.

Note: Always include in your discussion any figures referred to in the text, ***if*** you feel these are relevant to your company.

a. Parag. 1: What do you think of this perspective on people, especially in the work context?
b. Parag. 2: Discuss these aims of QC Circles activities. If QC Circles can achieve what is described here how useful would they be in your company?
c. Parag. 3: Would it be realistic to expect the employees in your company to make such resolutions? How valuable would it be they did, and acted on them? Look at each recommended resolution in turn.

Action plan

When you have discussed several texts, take the ideas you have found useful in them, and in your discussion, and present them in a well-structured action plan for your company. You might like to use the 6-Point Structure.

10.3 Introducing QC Circle activities in your company

1. Be both sensitive and creative in introducing QC Circles in your company, in particular since their aims are to encourage the development of employees. Make sure that you take an approach that suits the working environment, and the character and climate of your company.

2. Those who are promoting QC Circles should find out how employees feel about the circles before they introduce them. If any are opposed, they should listen carefully to their reasons and take time to get their consent. Management should not force QC Circles onto employees, but should rather encourage their spontaneous formation.

3. There are three principal ways to introduce QC Circles:
   a. Introduce them simultaneously in all the work places: offices, manufacturing plants, and departments. This method prompts a sense of togetherness within the organization and encourages QC Circles to work hard in friendly rivalry. Some companies hold a ceremony on the inauguration day and invite the president, plant director, or department manager to announce their introduction.
   b. Form pilot circles: supervisors who have been designated to become leaders form pilot QC Circles. The pilot circles follow the typical procedures: they examine common problems at work and use QC methods to resolve them; they compile their experiences into a QC Story, and after two or three meetings, present their story at a conference. Through these pilot circles the supervisors will gain the leadership confidence to form other QC Circles, to promote their activities and to provide guidance. These pilot circles should be maintained for three to six months.
   c. Inauguration of circles by volunteers (model circles): willing volunteers form QC Circles, and from these, QC Circles gradually spread to other workplaces. These pioneering circles are called model circles because they serve as models for others. After spending three to six months on problem resolution, the model circles hold a meeting and present their achievements to a large number of people. This method encourages others to believe that they too may be able to achieve the same results. This is a process of popularizing QC activities.

   All three ways of introducing QC Circles require supervisors and promoters to constantly monitor circle activities and to provide assistance whenever it is needed.

Figure 10.3a Procedure for introducing QC Circle activities and the roles of those involved.

Discussion

The following questions ask you to reflect on the ideas in the text and consider how you could apply them to bring improvements in your company. Where appropriate ask yourself the RADAR questions.

Note: Always include in your discussion any tables or charts referred to in the text, ***if*** you feel these are relevant to your company.

a. Parag. 2: How do you think the employees in your company would feel about QC Circle activities? Would those assigned to promote QC Circles be wiling to taking this sensitive approach? How could they be encouraged to do so?
b. Parag. 3: Examine these three different ways of introducing QC Circles, and discuss which approach would be most suitable for your company. You may find it useful to apply the RADAR questions to each approach.

Action plan

Take the ideas you have found useful in the text, and in your discussion, and present them in a well-structured action plan for introducing improvements in your company. You might like to follow the 6-Point Structure. Alternatively you may choose to prepare one action plan when you have discussed further texts.

10.4 How many employees in the company should take part in QC Circles?

1. Although all employees should take part in QC Circle activities, as these are a component of TQM, some companies allow departments and sections to opt out. A key decision you have to take is the scale of participation within your company.

2. There are three modes of participation in QC Circle activities:
   a. Participation by all the departments and sections: manufacturing, quality management and inspection, facility and maintenance, general affairs and accounting, procurement and materials, sales and services, design and testing, computer, marketing, research and development, technical services etc.
   b. Participation by everyone in the same workplace: ordinary employees (including long-term and short-term employees and part-timers, and those hired by partner companies), supervisors, subsection and section chiefs and department managers, all take part in the activities.
   c. Participation only by those sections that actually form QC Circles: members attend meetings, expresses their opinions, and performs their assigned roles.
3. Participation by all employees will make them feel good, and give them a sense of confidence and unity. It will allow those in the same work place to display their solidarity and their combined range of abilities. Companies that exempt certain departments, (e.g. the research and development department), should aim to eventually involve all the front-line employees in every department and section.

Figure 10.4a Written report of QC Circle activities

Discussion

The following questions ask you to think about how the ideas in the text could be applied in your company. Some of these ideas may not be relevant to you. Concentrate on those that are relevant. Keep notes of your conclusions – you will need them to prepare your action plan afterwards. Where appropriate ask yourself the RADAR questions.

Note: Always include in your discussion any figures referred to in the text, ***if*** you feel these are relevant to your company.

   a. Parags. 2 and 3: Apply the RADAR questions to these modes of participation in QC Circle activities, and try to decide what form of participation would be most suitable for your company.

Action plan

Take the ideas you have found useful in the text, and in your discussion, and present them in a well-structured action plan for introducing improvements in your company.

10.5 Select QC Circle leaders; roles of leaders and members

Introduction

1. The QC Circle leaders will be the driving force behind the QC activities. Select people who can show leadership, who can get members to cooperate in meetings, can gather ideas, and can create an atmosphere where everyone will feel free to express their opinion.

Selecting leaders

2. Different ways of selecting leaders will be appropriate at different stages of introducing and establishing QC Circles:
   a. During the inauguration phase foremen in the workplace are the most suitable leaders. Unless workplace leaders are at the forefront of this process, quality management will not reach the rank-and-file employees and will not become established in the work places.
   b. Once QC Circle members become used to the activities, they should select as team leader a person with leadership abilities rather than simply accept someone appointed by their superiors.
   c. When activities are well advanced, large QC Circles should divide themselves into sub-groups to tackle separate themes. These sub groups can hold QC Circle meetings on their own or jointly with other sub-groups, and select their own leaders.

3. Points to consider when selecting leaders:
   a. Some QC Circles select leaders on a rotation basis. However this could mean that a member with no leadership abilities becomes leader. Such a leader could really slow down the progress of activities.
   b. QC Circle members who have participated for two or three years, and have gained a sound understanding of the activities and methods, should be made theme-specific leaders. They will be known as theme leaders. They can thus develop leadership skills and lead circles in the future.

The role of leaders

4. The primary role of QC Circle leaders is to keep up the dynamic of the circles, to encourage members to use their abilities to the full, and to support them in doing so. They should:
   a. Find out what improvements their members would like to see in the working environment, identify specific problems, decide how to approach them, and select targets.
   b. Get a good idea of the qualities and skills of the circle members, assign them roles that will allow them to put these to good use, and create an atmosphere that will motivate them to do so.
   c. Introduce ways that members can acquire the knowledge and skills needed to carry out the activities, including giving training themselves.

d. Train successors: demonstrate how leaders should act, and train members to take over from them.
e. Find out what superiors expect from the circles, and then discuss with members how to incorporate these expectations into the activities.

Support from members

5. QC Circle members should support the leaders by carrying out their assigned roles diligently and by acquiring the skills and experience that will enable them to improve the quality of their work and of the work environment. They should:
   a. Give active assistance to the leaders and participate in teamwork.
   b. Attend meetings and speak forthrightly from their own experience.
   c. Carry out the roles assigned to them within the given time frame, including the roles of secretary or of presenter at meetings.
   d. Study engineering technology and quality control and broaden the range of roles they can perform.

Discussion

The following questions ask you to think about how the ideas in the text could be applied in your company. Some of these ideas may not be relevant to you. Concentrate on those that are relevant. Keep notes of your conclusions – you will need them to prepare your action plan afterwards. Where appropriate ask yourself the RADAR questions.

Note: Always include in your discussion any figures referred to in the text, ***if*** you feel these are relevant to your company.

a. Parag. 1: How difficult do you think it might be to identify such leaders in your company?
b. Parags. 2 and 3: How feasible do you think these ways of selecting a leader would be in your company?
c. Parag. 4: How challenging do you think it will be for QC Circle leaders in your company to carry out these actions? How do you think they should go about doing so?
d. Parag. 5: How willing do you think employees in your company would be to carry out these functions. How much encouragement and support would they need to do so? How could this be provided?

Action plan

Take the ideas you have found useful in the text, and in your discussion, and present them in a well-structured action plan for introducing improvements in your company. You might like to follow the 6-Point Structure. Alternatively you may choose to prepare one action plan when you have discussed several texts.

10.6 The QC Story

1. QC Circles use the QC Story to solve problems related to the five priorities of QCDSM: quality (Q), costs (C), deadlines and productivity (D), safety (S), and morale (M). This procedure uses methods based on facts and data, and aims to prevent the recurrence of problems by identifying the causes and implementing recurrence prevention measures.

2. A QC Story consists of the following eight steps:
   a. Select a theme to work on.
   b. Clarify the problem and set targets.
   c. Get a clear understanding of the effects that the problem has caused.
   d. Investigate the causes: analysis.
   e. Devise and implement recurrence prevention measures.
   f. Confirm the effects of these measures.
   g. Standardize the new methods.
   h. Reflect on the problems left unsolved and consider future recurrence prevention measures.

   You will find detailed guidelines on using the QC Story in Texts 9.9, 9.10 and 9.11.

10.7 QC Circle meetings

1. QC Circle meetings help members to work together towards the same goals. Members exchange ideas and information, get to know each other, and develop a spirit of cooperation and a sense of solidarity. But if the meetings are poorly managed, the activities will stagnate and members will become demotivated.

2. If meetings are to be effective:
   a. They should be well planned.
   b. All members should attend.
   c. Roles should be distributed: moderator, secretary, presenter and others.
   d. The purpose of the meeting should be agreed.
   e. Brainstorming sessions should be held to generate new ideas.
   f. All members should give their opinions.
   g. Minutes should always be taken.

3. To plan meetings, you need to decide on their duration, frequency, timing and place:
   a. Duration: The length of meetings will vary according to such factors as work place conditions, the agenda, and their frequency. However the average meeting will last for 30 to 60 minutes.
   b. Frequency: The number of meetings per month will vary according to their average duration. However, they should take place at least twice a month. It is best to set a target number of meetings to be held in the next one-month period and try to keep to this target.
   c. Timing: The times when meetings are held will vary according to work requirements and the other demands on QC Circle members' time. When they meet during regular working hours, they must obtain the approval of a manager in advance. It is advisable to:
      i. Include QC Circle meetings in the monthly operational schedule.
      ii. Set up specific dates for meetings.
      iii. Use a message board to determine when all members can meet.
   d. Place: Meetings should be held in one of the following places:
      i. The work place.
      ii. Conference rooms near the work place.
      iii. Dining rooms or rest areas.
      iv. Outdoor locations within the factory grounds.
      v. Locations away from work, such as recreational areas, coffee shops, and educational facilities.

Figure 10.7a Form for minutes of QC Circle meetings

Discussion

The following questions ask you to think about how the ideas in the text could be applied in your company. Some of these ideas may not be relevant to you. Concentrate on those that are relevant. Keep notes of your conclusions – you will need them to prepare your action plan afterwards. Where appropriate ask yourself the RADAR questions.

Note: Always include in your discussion any figures referred to in the text, ***if*** you feel these are relevant to your company.

a. Parag. 1: Describe briefly the worst meeting you have ever participated in, and the best. What made them so bad and so good?
b. Parag. 2: What obstacles could be met in trying to conduct meetings in this way and how could they be overcome?
c. Parag. 3: Apply the RADAR questions to these guidelines for arranging QC Circle meetings.

Action plan

Take the ideas you have found useful in the text, and in your discussion, and present them in a well-structured action plan for introducing improvements in your company. You might like to follow the 6-Point Structure. Alternatively you may choose to prepare one action plan when you have discussed several texts.

10.8 QC Circle assemblies

1. After a QC Circle has completed a theme, it holds a meeting, referred to as a QC Circle assembly or a QC Circle conference, to re-appraise the methods that have been used, and to confirm the circle's sense of achievement. Members give presentations of key points from their problem resolution activities and achievements: their methods, their difficulties, and their creative ideas. An effective way of doing this is the QC Story, which is described in detail in Unit 9.

2. When a QC Story is being presented the following should be included:
   a. Introduction – introduce your company, your work place, and your QC Circle.
   b. Outline – give a brief outline of the tasks you carried out, and their relationship to preceding and subsequent tasks.
   c. Reasons for selecting a theme - give the reasons for selecting a particular problem, and the circumstances surrounding it, etc.
   d. The situation – describe the state of the problem at the time using data.
   e. The targets – describe the targets selected and the basis for selecting them.
   f. Action plan – present the action plan including the assignment of roles.
   g. Analysis of key factors – present your hypothesis on the key factors, your data-based analysis, and your verification of the hypothesis.
   h. Present the recurrence prevention measures that were taken and how they were implemented.
   i. The effectiveness of the recurrence prevention measures – compare the situation before and after the recurrence prevention measures, the level of target achievement, and also the intangible and secondary effects.
   j. Standardization – the items and methods that were standardized.
   k. Reviews and future plans – summarize the points that needed effort, the points that were raised in reflection, the lessons that were learned, your circle's aspirations and its future plans.

3. Presenters must:
   a. Rehearse their presentations so that they will be able to give them confidently.
   b. Use pauses in their speech to highlight the objectives and the development of the QC Story.
   c. Speak clearly and avoid ambiguous expressions.
   d. Allow the audience time to take in any charts and tables that they present.
   e. Keep their listeners engaged.

4. Advisors must keep their comments after the presentation brief, usually about two minutes. The question and answer session should also be about two minutes. They should touch briefly on the good points and on the points that could be improved, point out to the audience the lessons to be learned, and show their appreciation of the presenters and give them encouragement. It is important that they clearly indicate the points that need to be corrected.

5. QC Circle assemblies are an occasion for mutual development. They offer lessons both to the QC Circles that make presentations, and to those who listen to them.
    a. Presenters and the QC Circles they represent:
        i. Learn to express their ideas clearly, improve their communication skills, and gain confidence in giving presentations.
        ii. Become skilled at organising ideas and information so that people can easily understand what is being presented.
        iii. Experience the sense of satisfaction that comes from public acknowledgment.
    b. Listeners:
        i. Learn about dynamic activities in other work places and expand their own horizons.
        ii. Learn the practical applications of QC methods, creative thinking, and ways of organising information and ideas.
        iii. Learn that creative ideas that emerge in QC Circles can be applied again in the future.

6. After the presentations, managers and facilitators* (in the case of in-house conferences), and advisors and members of the screening committee (in the case of external conferences) review the presentations. They should pay attention to the following:
    a. Disregard monetary achievements, and stress achievements that improved work processes.
    b. Consider whether achievements are based on the principle of quality first as a component of TQM.
    c. Consider willing participation as the most important point for evaluation.
    d. Consider whether all the circle members participated with a sense of awareness.
    e. Examine how presentations related to the higher policies of the company.
    f. Appraise QC Circles according to their degree of growth.

Figure 10.8a Detailed check sheet for QC Circle conference experiences

* The term "facilitator" is used with a broad meaning. It may be in anyone in the company who is helping to organise QC circle activities.

Discussion

The following questions ask you to think about how the ideas in the text could be applied in your company. Some of these ideas may not be relevant to you. Concentrate on those that are relevant. Keep notes of your conclusions – you will need them to prepare your action plan afterwards. Where appropriate ask yourself the RADAR questions.

Note: Always include in your discussion any figures referred to in the text, ***if*** you feel these are relevant to your company.

a. Parag. 2: If you have already examined the QC Story in Unit 9, take the theme you chose there and decide how you would present it.
b. Parag. 3: How important do you think each of these guidelines are for giving a presentation? Are there any others that you would add to the list?

c. Parag. 4: Why do you think these particular points are emphasised? Are there any other points that you would add?
d. Parag. 5: Look at each of these lessons to be learned from QC Circle assembly presentations. How valuable do you think each lesson is to the presenters and listeners, and to the company? Can you think of any other lessons that may be learned?
e. Parag. 6: Do you agree that each of these points is important? Why?

Action plan

Take the ideas you have found useful in the text, and in your discussion, and present them in a well-structured action plan for introducing improvements in your company. You might like to follow the 6-Point Structure. Alternatively you may choose to prepare one action plan when you have discussed several texts.

10.9 Evaluation of QC Circle activities

1. Regular and appropriate evaluation of QC Circle activities will help to motivate members and to revitalize activities. It will identify where improvement is needed, and indicate the corrections that should be made. Evaluation should address the following questions:
   a. Are QC Circle activities in line with the action plans and targets?
   b. How are the activities being conducted?
   c. What abilities are employees developing?
   d. Are the activities achieving satisfactory results?
   e. How do the activities of this circle compare with those of other QC Circles?

   There are two forms of evaluation:
   a. Self-evaluation by the members themselves.
   b. Evaluation by managers.

2. Self-evaluation by QC Circle members:
   a. Self-evaluation after a problem has been resolved: QC Circle members reflect on all the steps they have taken to resolve the problem, evaluate them, recognise any unsatisfactory points, and try to identify and correct the causes.
   b. Self-evaluation of all QC Circle activities at the end of the term and the year: QC Circles are ongoing – when they have solved one problem, they start planning to solve a new one. At the end of the term and the year, the members should review and evaluate all their activities.
   c. Limits of self-evaluation: QC Circle leaders and members can be expected to evaluate their activities willingly. However, self-evaluations tend to produce liberal ratings. To establish a greater sense of objectivity, QC Circles should also be evaluated by managers and facilitators. These evaluations will give members a better understanding of their problems and the direction they should take.

3. Evaluation by managers and facilitators:
   a. Evaluate activities: immediate superiors at work must receive written or oral reports on QC Circle activities, evaluate these reports, and give the circles appropriate instructions and advice as each step of the problem resolution procedure is completed. Their instructions should be appropriate to the level of the circles, and should be encouraging. The purpose is to help members to appreciate the things they are doing well, and improve those that could be better.
   b. Evaluate presentations at QC Circle presentation days and conferences: these are key events to promote QC Circle activities.
   c. Evaluate all QC Circle activities for the term and the year: managers evaluate all QC Circle activities over the past year or for a fixed period and give recognition to the circle's accomplishments. This is the most important type of evaluation because of the emphasis on continuity in QC Circle activities.

4. While they are giving instructions on the development of QC Circle activities, CEOs, managers, and facilitators should not forget to show appreciation of the hard work that the members put in, and to praise their achievements:
    a. After they have given evaluations, they should reflect on the instruction methods they have been using, and make improvements to these.
    b. They should recognise that evaluations and public acknowledgments give QC Circle members a sense of achievement and satisfaction, making them more highly motivated and more competitive in relation to other circles.
    c. They should reflect on the problems addressed by QC Circles and re-evaluate their own day-to-day management procedures.
    d. They should try to take a broad view of the problems that QC Circles are tackling and the improvements they are introducing.

Figure 10.9a Check list for evaluation of QC Circle activities (for themes)
Figure 10.9b Check list for evaluation of QC Circle activities (year round)
Figure 10.9c QC Circle activity evaluation table (for management organization)
Figure 10.9d Table of QC Circle activity scores
(Please note that all of these tables are very detailed. You may prefer to examine them when you have completed all the texts in this unit.)

Discussion

The following questions ask you to think about how the ideas in the text could be applied in your company. Some of these ideas may not be relevant to you. Concentrate on those that are relevant. Keep notes of your conclusions – you will need them to prepare your action plan afterwards. Where appropriate ask yourself the RADAR questions.

Note: Always include in your discussion any figures referred to in the text, ***if*** you feel these are relevant to your company.

a. Parag. 1: Are there any other questions that you feel evaluation should address?
b. Parag. 2: How willing would your employees be to carry out such self-evaluation? How competent would they be to do so? Apply the RADAR questions to introducing these guidelines for self-evaluation by members.
c. Parag. 3: Apply the RADAR questions to these guidelines for evaluation by managers.
d. Parag. 4: How willing and able would your CEOs and managers be to follow these guidelines? How could they be encouraged to do so?

Action plan

Take the ideas you have found useful in the text, and in your discussion, and present them in a well-structured action plan for introducing improvements in your company. You might like to follow the 6-Point Structure. Alternatively you may choose to prepare one action plan when you have discussed several texts

10.10 The basic procedures for QC Circle activities

1. Once QC Circles have been set up, there are a wide range of procedures to follow. These are presented in Figure 10.10a. These procedures involve quite a commitment by the company and by the QC Circle leaders and members. To maintain a good level of motivation and keep QC Circles going, the basic requirements are that:
   a. Leaders understand the basics of QC Circle activities.
   b. Leaders actively exercise the function of leadership.
   c. Members are guided to an awareness of the need for QC activities and are willing to participate.
   d. An environment is created that encourages the willing participation of employees.
   e. Leaders and members keep the objectives of activities in mind as they carry them out.
   f. Members study QC methods.
   g. The leader finds a good point at which to bring a meeting to a close.
   h. Members carry out a self-evaluation of their activities.

Discussion

The following questions ask you to think about how the ideas in the text could be applied in your company. Some of these ideas may not be relevant to you. Concentrate on those that are relevant. Keep notes of your conclusions – you will need them to prepare your action plan afterwards. Where appropriate ask yourself the RADAR questions.

Note: Always include in your discussion any figures referred to in the text, ***if*** you feel these are relevant to your company.

a. Parag. 1: How important do you think each of these guidelines would be for keeping QC Circles going in your company? Are there any others you would add?
b. Figure 10.10a: This list of procedures for QC Circle activities is very comprehensive. Read through it and tick any points that could be difficult to implement in your company. Discuss how these difficulties could be overcome. Then apply the RADAR questions to how you would use this list in your company.
c. When you have read and discussed all the texts in this unit, come back to the list in Figure 10.10a, read through it again and decide how much of it to incorporate in your final action plan for introducing QC Circles in your company. (See the action plan after Text 10.16.)

Figure 10.10a Basic procedure for QC Circle activities

No.	Procedure		Items for Checking
1	Formation of Groups		❍ As a rule, people sharing a job assignment at the same work place form groups. ❍ Depending on the problems, people belonging to different sections form cross-sectional groups. ❍ Select group leaders. ❍ Workers are allowed to divide a group into sub-groups and to select different themes for them.
2	Registration of Groups		❍ Groups should be registered with the in-house secretariat.
3	Planning	Discovery of Themes	❍ Select themes that improve job performance, by making jobs easier or quicker to perform. ❍ Hold discussions with superiors at work to make sure that the themes correspond with their policies and targets.
		Authorization and Registration of Themes and Targets	❍ Obtain authorization from superiors at work and register themes and targets with the secretariat.
		Preparation of Plans	❍ Clarify the roles of each member. ❍ Prepare such plans that enable the PDCA (plan-do-check-action) cycle to be completed in four to six months.
4	Implementation	Group Meetings	❍ In principle, groups should meet at least twice a month. ❍ Limit each meeting to one hour when possible. Make effective use of meetings at work places.
		Morning and Evening Meetings	❍ Primarily designed for reports on the progress of group activities, explanations, and the enhancement of group consciousness. ❍ Limit the duration to five to ten minutes. Use five-minute meetings in the morning and other available occasions.
		Activities Other than Meetings	❍ Make concrete management and improvement activities connected with daily work. ❍ Compile data using breaks during working hours. ❍ Plan and execute events and study sessions aimed at boosting harmony among members and stepping up teamwork.
5	Checking	Intermediate Checks	❍ Superiors at work check on the progress of group activities between processes and propose better methods to members. ❍ Leaders examinant activities for themselves.
		Confirmation of Achievement	❍ Confirm the achievement and effectiveness of each and every countermeasure. ❍ Compile both tangible and intangible effects. Tangible effects refer to achievements that can be translated into numerical figures, intangible effects refer to accomplishments that cannot. ❍ Carry out standardization, make achievements known to everyone, and prepare a check sheet as a preventative countermeasure. ❍ Attempt horizontal penetration of each countermeasure to similar product items and similar operations.
	Action		❍ Review activities and incorporate them into the next action plan. ❍ Compile activities, achievements, and points for improvement in the form of written reports, and submit the reports to the secretariat via superiors at work. ❍ Make reports at in-house conferences and offer reference data to other circles.

10.11 QC Circle training

1. QC Circle training is aimed at achieving a workplace full of employees who are motivated, creative, and good at solving problems. Training focuses on the value of QC Circle activities, on raising quality consciousness, and on using QC methods.

2. Members and leaders should be trained in:
   a. An understanding of the basic ideas behind QC Circle training:
      i. The objectives and value of company wide efforts to promote QC Circle activities.
      ii. QC perspectives and ways of thinking.
   b. Management methods for QC Circle activities:
      i. Procedures for advancing QC Circle activities.
      ii. The roles of QC Circle leaders and members.
      iii. How to run effective meetings.
   c. Methods for improving problem resolution:
      i. The steps involved in problem resolution, the methods used at each step, and how to apply them to actual problem resolution in the work place.
      ii. The Seven QC Tools: Pareto Diagram, Cause and Effect Diagram, Check Sheet, Histogram, Control Chart, Scatter Diagram, Stratification. (See Unit 11, Statistics)
      iii. The VE method (value engineering), IE method (industrial engineering), and others.

3. Methods of study:
   a. For participating in QC Circle activities:
      i. Read books and learn from them: textbooks on QC Circle activities, magazines, and other publications.
      ii. Listen to others and learn from them at QC Circle conferences, lectures, seminars, and other occasions.
      iii. Learn from discussions at meetings held at the work place, study sessions, and other places.
   b. For advancing and managing QC Circle activities:
      i. Read books and learn from them: textbooks describing how to run meetings, and to select and present themes, and magazines and other publications.
      ii. Learn from past activities, including QC Circle conferences, presentations, documented cases, meetings to exchange experiences and ideas, and other concrete examples.
      iii. Learn from practice: experience is often the best teacher for QC Circles. Circles should develop ingenuity in making improvements.

Figure 10.11a Training plans

Discussion

The following questions ask you to think about how the ideas in the text could be applied in your company. Some of these ideas may not be relevant to you. Concentrate on those that are relevant. Keep notes of your conclusions – you will need them to prepare your action plan afterwards. Where appropriate ask yourself the RADAR questions.

Note: Always include in your discussion any figures referred to in the text, ***if*** you feel these are relevant to your company.

a. Parag. 1: How does your workplace at present compare with this rather ideal description? How challenging do you think it will be for QC Circle training to achieve these objectives in your workplace?
b. Parag. 2: Apply the RADAR questions to these guidelines for QC Circle training.
c. Parag. 3: Apply the RADAR questions to these guidelines for study related to QC Circle activities.

Action plan

Take the ideas you have found useful in the text, and in your discussion, and present them in a well-structured action plan for introducing improvements in your company. You might like to follow the 6-Point Structure. Alternatively you may choose to prepare one action plan when you have discussed several texts.

10.12 Planning future QC Circle activities

1. Facilitators should prepare plans for desirable QC Circle activities for the future, and promote these as a component of TQM. These plans should prescribe the level of QC Circle activities, their targets, and concrete measures for achieving the targets. In doing so, they should look carefully at the present state of QC Circles and should respect the intentions of work superiors. Such plans are important in energising and consolidating QC Circle activities.

2. To draft the plans:
   a. Clearly define the type of QC Circle to be developed, based on the fundamental principles of the company, department or section.
   b. Consider problems that currently exist within the company, department or section.
   c. Decide the target level of QC Circle activities over a given period (short-term, mid-term or long-term), as well as target figures, and the concrete steps to be taken.
   d. Prepare plans based on these concrete factors.

3. Points to pay attention to:
   a. Get a good understanding of the present situation, and make sure that the plans can be implemented and inspected.
   b. Make sure that the plans cover all the QC Circle activities including management, studies, and the resolution of problems in work places.
   c. Make sure that the plans correspond with the characteristics of the company, department or section. Sample characteristics include operating on a shift basis, automated work places, and having employees with different educational backgrounds working together.
   d. Make sure that the plans correspond to management plans: show how they relate to corporate, departmental or sectional policies.
   e. Clarify the relationship between the plans and TQM promotion plans in the company.
   f. Establish targets on a solid foundation. For example, prior to introducing activities, planners should study past activity records, training courses, conferences, exchange-meetings, and reference materials, and especially the situation in other companies.
   g. Identify concrete ways of achieving the target figures.
   h. Fix management inspection items that can be checked to see if the target has been achieved, and the methods for inspecting these.

Figure 10.12a Procedure for QC Circle activity promotion plans, and examination and confirmation items

Discussion

The following questions ask you to think about how the ideas in the text could be applied in your company. Some of these ideas may not be relevant to you. Concentrate on those that are relevant. Keep notes of your conclusions – you will need them to prepare your action plan afterwards. Where appropriate ask yourself the RADAR questions.

Note: Always include in your discussion any figures referred to in the text, ***if*** you feel these are relevant to your company.

a. Parag. 1: Why are these plans important in energising and consolidating QC Circle activities?
b. Parags 2 and 3: Apply the RADAR questions to these guidelines for drafting promotion plans for QC Circle activities.

Action plan

Take the ideas you have found useful in the text, and in your discussion, and present them in a well-structured action plan for introducing improvements in your company. You might like to follow the 6-Point Structure. Alternatively you may choose to prepare one action plan when you have discussed several texts.

10.13 Creating the right environment for QC Circle activities: the role of the CEO

1. QC Circles can only flourish in the right environment. CE0s, middle managers, promotional staff members, and personnel managers, must gain a good understanding of QC Circle activities, and of their own roles in supporting them. The CEO has a key role to play.

2. CEOs must clearly indicate what they expect of QC Circles, and their position within the company. They should:
   a. Indicate their policies on TQM and implement these policies.
   b. See the value of introducing the activities in realising corporate principles, implementing long-term management plans and furthering company-wide quality management (TQM).
   c. Clarify the company's policy for introducing QC Circles and announce it to all the employees.
   d. Position QC Circle activities clearly within the company.
   e. Take an interest in the introduction of QC Circle activities and get a good understanding of what they are doing.
   f. Establish an organization to promote QC Circle activities, and indicate the direction that this promotion could take. (See Text 10.15.)
   g. Ensure that regulations are drawn up for QC Circle activities, for evaluation and merit acknowledgment, for QC Circle conferences, and for inter-company QC Circle meetings to exchange experiences and ideas.
   h. Ensure that company-wide training is provided in QC Circle activities for CEOs, managers, and circle leaders and members.
   i. Ensure that an education budget is established and meeting facilities are provided.
   j. Ensure that a system is set up to evaluate and present awards for QC Circle activities.
   k. Ensure that employees who are willing to do so are encouraged to take part in external activities (conventions outside their companies, exchange-meetings with circles from other companies and seminars).
   l. Be pro-active in providing instruction and assistance to QC Circles.

Figure 10.13a Roles of QC Circle members and management personnel. (This table gives a detailed summary of the roles of all those involved. You may prefer to examine it later when you have completed all the texts of this unit.)

Discussion

The following questions ask you to think about how the ideas in the text could be applied in your company. Some of these ideas may not be relevant to you. Concentrate on those that are relevant. Keep notes of your conclusions – you will need them to prepare your action plan afterwards. Where appropriate ask yourself the RADAR questions.

Note: Always include in your discussion any figures referred to in the text, ***if*** you feel these are relevant to your company.

a. Parag. 1: How feasible do you think it will be to get all these people in your company to take an interest in QC Circle activities? How would you go about gaining their interest?
b. Parag. 2: Apply the RADAR questions to these actions to be taken or initiated by the CEO.

Action plan

Take the ideas you have found useful in the text, and in your discussion, and present them in a well-structured action plan for introducing improvements in your company. You might like to follow the 6-Point Structure. Alternatively you may choose to prepare one action plan when you have discussed further texts.

10.14 The role of middle management

1. Middle managers should help establish a working environment in which QC Circle members are allowed to take on a management role in their own work and to make improvements on their own initiative, an environment in which their willingness to contribute is respected, and in which they can use their abilities to the full.

2. Middle managers should:
   a. Practise management control activities for TQM.
   b. Respect QC Circle activities where members are willing to contribute, and create a supportive atmosphere.
   c. Keep up to date with the status of QC Circles, and provide instructions and advice as the activities progress.
   d. Get a good understanding of the company's policy on introducing the circles, and communicate it accurately to their subordinates.
   e. Get a good understanding of QC Circle activities.
   f. Support the promotional organization.
   g. Implement the promotional plans through team efforts.
   h. Try to grasp and resolve the problems presented by the introduction of QC Circles.
   i. Inform CEOs of the status of QC Circle activities and help them to appreciate the value of the activities.
   j. Inform their subordinates of introduction courses that CEOs have decided on, and of the related policies that their department will adopt.
   k. Set up educational programmes to provide members with the knowledge and skills they need to conduct QC Circle activities.
   l. Allow as much time as is needed for giving instruction and assistance:
      i. Actively provide advice and instruction on QC Circle formation, management, themes, and action plans.
      ii. Take an interest in the progress of circle activities, especially when there is stagnation or delay, and take whatever action is necessary.
      iii. Exercise ingenuity and consideration in finding time for meetings, and take part in meetings whenever necessary.
   m. Generate opportunities for members to work together to achieve development.
   n. Evaluate QC Circle activities.
   o. Practise quality management activities themselves.

3. The involvement of middle managers changes as QC Circles develop. Figure 10.14a shows how (page 35).

Figure 10.14b Assistance from middle managers and facilitators provided at each step (This is a very detailed list of the functions of middle managers and facilitators in assisting QC Circles.)

Figure 10.14a The involvement of middle managers in QC Circles

Period	**Introductory period:** newly inaugurated QC Circles; middle managers take the initiative.	**Development period:** QC Circles undergoing development; a certain degree of initiative is developed.	**Stabilization period:** fully developed QC Circles, a full sense of group initiative is established.
Leaders	Responsible individuals in work places.	Responsible individuals in work places or their deputies.	Leaders could change on a rotation basis.
Themes	Familiar easy-to-resolve problems.	Familiar problems in work places. Problems related to original tasks in work places.	Most problems are linked with original tasks in work places. Few familiar problems in work places.
Methods for problem resolution	Primarily discussions (study and application of elementary QC methods).	Elementary QC methods (Pareto diagram, cause and effect diagram and others).	Seven QC tools, IE (industrial engineering), VE (value engineering), new QC seven tools.
Attitude taken by middle managers	Middle managers take the initiative and provide instructions and assistance to QC Circles.	Middle managers direct QC Circle members to themes that correspond to the capacity of their circle and help them to develop spontaneity.	Middle managers distance themselves from QC Circles and provide advice only when a problem arises.
Independence of QC Circles	Weak.	Grows stronger.	Fully established.

Discussion

The following questions ask you to think about how the ideas in the text could be applied in your company. Some of these ideas may not be relevant to you. Concentrate on those that are relevant. Keep notes of your conclusions – you will need them to prepare your action plan afterwards. Where appropriate ask yourself the RADAR questions.

Note: Always include in your discussion any figures referred to in the text, ***if*** you feel these are relevant to your company.

a. Parag. 1: How challenging do you think it would be for middle managers in your company to give encouragement and support to QC Circles? What support would the managers themselves need in doing this?
b. Parags. 2: Apply the RADAR questions to this list of functions of middle managers.
c. Figure 10.14a: This table describes the typical progress of QC Circles and the changing involvement of middle managers. How would you apply it in your company? Apply the RADAR questions

d. Figure 10.14b gives a much more detailed description of the assistance that middle managers can give to QC Circle activities. If you feel it would be useful to do so, examine it and consider how you would apply it in your company.

Action plan

Take the ideas you have found useful in the text, and in your discussion, and present them in a well-structured action plan for introducing improvements in your company. You might like to follow the 6-Point Structure. Alternatively you may choose to prepare one action plan when you have discussed several texts.

10.15 Set up a company-wide organisation to promote QC Circle activities

1. A company-wide organization should be set up to promote and facilitate QC Circle activities. Since the activities are conducted as a component of TQM, it is important to establish three systems:
   a. A top-down system, by which corporate policies and TQM policies are communicated accurately to QC Circle members.
   b. A bottom-up system, by which the various problems that QC Circles confront are communicated accurately to management.
   c. A system by which QC Circles receive the instructions and assistance they need in order to conduct their activities correctly and energetically.

2. To set up the promotional organisation:
   a. Establish a QC Circle promotional committee, chaired by a top executive and staffed by department managers.
   b. Establish a QC Circle promotional secretariat within the TQM promotional secretariat.
   c. Establish voluntary operational organizations for QC Circle activities (such as QC Circle leaders' councils).
   d. Establish in-house registration and reporting systems for QC Circles.
   e. Draft company-wide or operation-wide plans for promoting QC Circle activities.

Figure 10.15a Organisational chart for promoting QC Circle activities
Figure 10.15b Concrete roles of QC Circle facilitators (This table provides very detailed guidelines.)

Role of the QC Circle Promotional Secretariat

3. The QC Circle promotional secretariat:
   a. Prepares the mechanism for getting QC Circle activities going within the company.
   b. Communicates with external parties and collects and disseminates information.
   c. Conveys the policies and decisions of CEOs and the promotional committee to employees, and in language that is easy to understand.
   d. Gets a good understanding of the policy for introducing QC Circle activities and prepares detailed, concrete plans to implement it.
   e. Gets a good understanding of QC Circle activities.
   f. Together with the QC Circles, tries to grasp and resolve the problems presented by the introduction of QC Circles.
   g. Keeps up to date with QC Circle activities, provides whatever assistance is required, and reports on the status of activities to management.
   h. Helps to prepare an environment conducive to QC Circle development, and assists circles to achieve their goals.

i. Performs administrative duties for QC Circle committees and meetings.
j. Plans and supports QC Circle education.
k. Prepares in-house reference materials, including handbooks and educational texts.
l. Publishes QC Circle news and other relevant public relations materials.
m. Performs administrative duties for the appraisal of QC Circles and the acknowledgment of meritorious service.
n. Provides indirect assistance by offering advice to managers, and to QC Circle leaders and members.

Figure 10.15c This table gives a very detailed set of roles and tasks of the secretariat.

Discussion

The following questions ask you to think about how the ideas in the text could be applied in your company. Some of these ideas may not be relevant to you. Concentrate on those that are relevant. Keep notes of your conclusions – you will need them to prepare your action plan afterwards. Where appropriate ask yourself the RADAR questions.

Note: Always include in your discussion any figures referred to in the text, ***if*** you feel these are relevant to your company.

a. Parags. 1 and 2: Apply the RADAR questions to these guidelines for establishing a company-wide organization to promote and facilitate QC Circle activities.
b. Parag. 3: Apply the RADAR questions to this list of functions of the QC Circle promotional secretariat.

Action plan

Take the ideas you have found useful in the text, and in your discussion, and present them in a well-structured action plan for introducing improvements in your company. You might like to follow the 6-Point Structure. Alternatively you may choose to prepare one action plan when you have discussed several texts.

10.16 Hold QC Circle exchanges with other companies

1. When QC Circles always remain within their own work places, members' perspectives may become limited, and their ideas lose freshness. Organize meetings periodically with other circles both within the company and outside. Members of different circles can visit each other, have discussions, and study QC Circle management together, and thereby stimulate each other to further development.

2. Inter-company QC Circle exchange-meetings have several benefits:
   a. They provide new ideas for activities, and for ways of carrying them out.
   b. They provide new information, tips and techniques to help resolve management problems and revitalize activities.
   c. They facilitate communication, improve human relations, and remove the walls that divide work places.

3. The basic procedure for inter-company QC Circle exchange-meetings:
   a. Step 1: Clarify the objectives of the exchange and send written requests to those in charge in the other circle.
   b. Step 2: Select 5 to 10 participants, including leaders.
   c. Step 3: Ask the secretariat to arrange the date, time, place and agenda of the meeting. Decide who will be in charge of paperwork, and appoint delegation leaders and individuals to be in charge of reception.
   d. Step 4: In conducting exchange-meetings:
      i. Greet each other.
      ii. The receiving group describes the status of quality management implementation in their company, and their promotional organizations for QC Circles, and the status of their activities.
      iii. Conduct a study tour of the business facilities.
      iv. Hold discussions on the main themes. Observers should, as far as possible, refrain from giving their opinions.
      v. Express appreciation and close the meeting.
   e. Step 5: After returning to the company, report the contents of the exchange-meeting to superiors, and share them in QC Circle leaders' councils and QC Circle meetings. The secretariat should record the reports.
   f. Step 6: Send an official letter of appreciation within about two days of the meeting. The secretariat should mail minutes to its counterpart on the other side and express their appreciation.

Figure 10.16a Sample programme of an inter-company QC Circle exchange-meeting

Time	Mins	Contents	Individuals in charge
13:00-13:05	5	Greetings	Circle representatives of both companies
13:05-13:20	15	Outline of the companies and explanations of QC Circle activities	Receiving party
13:20-14:00	40	Case presentations, questions and answers	One case per company
14:00-15:00	60	Study tour of business facilities and related questions and answers	Receiving party
15:00-16:35	95	Group discussions, presentation of discussions, contents	All participants
16:35-16:55	20	Questions and answers	All participants
16:55-17:00	5	Closing addresses	Circle representatives of both companies

(Note: Use a simpler procedure to conduct QC Circle exchange-meetings within your own company.)

Discussion

The following questions ask you to think about how the ideas in the text could be applied in your company. Some of these ideas may not be relevant to you. Concentrate on those that are relevant. Keep notes of your conclusions – you will need them to prepare your action plan afterwards. Where appropriate ask yourself the RADAR questions.

Note: Always include in your discussion any figures referred to in the text, ***if*** you feel these are relevant to your company.

a. Parag. 1: Does your company have much interaction of this kind with other companies? Do you think it would be a good idea? What benefits could you see it bringing to your company?
b. Parag. 2: Do you agree that these benefits would come from inter-company QC Circle exchange-meetings? Do you see any obstacles that might have to be overcome? Are there any other benefits that such meetings might bring?
c. Parag. 3: Apply the RADAR questions to these guidelines for holding meetings with other companies. Include the sample programme in your discussion.

Action plan

Bring together all the action plans that you have written after previous texts in one final action plan presenting your concrete proposals for introducing QC Circles in your company. Folllow the 6-Point Structure.

Test

Answer these questions using only the information given in the text. For each question one, two or all three answers may be correct. Tick the answer or answers you think are correct for each question. Each question carries 3 points – you get one point for each correct answer that you tick, and one point for each wrong answer that you do not tick.

10.1 QC Circle activities

1. The criteria against which improvement in the quality of work will be measured are:
   - ☐ a. CEO demands.
   - ☐ b. Supervisor demands.
   - ☐ c. Customer demands.
2. PDCA stands for;
   - ☐ a. Plan, do, correct, act.
   - ☐ b. Prepare, do, check, act.
   - ☐ c. Plan, do check, act.
3. Discussions at QC Circles help employees to:
   - ☐ a. Understand their managers better.
   - ☐ b. Build better relations with colleagues.
   - ☐ c. Make the workplace more cheerful.

10.2 The human dimension to QC Circles

4. The basic ideas behind QC Circle activities are to:
   - ☐ a. Fully bring out employees' latent capabilities.
   - ☐ b. Contribute to the improvement of the company.
   - ☐ c. Make the world a better place to live in.
5. To make the most of QC Circle activities participants must resolve to:
   - ☐ a. Bring out their potential through self-development.
   - ☐ b. Seek opportunities for development as an individual and as a group.
   - ☐ c. Come up with creative ideas to bring improvements in work.

10.3 Introducing QC Circle activities in your company

6. Promoters of QC Circles should ... check how employees feel about them before introducing them.
   - ☐ a. Always.
   - ☐ b. Sometimes.
   - ☐ c. Never.
7. The three principal ways to introduce QC Circles include:
   - ☐ a. Introduction at each workplace in turn.
   - ☐ b. Formation by leaders or supervisors.
   - ☐ c. Inauguration by volunteers.

10.4 How many employees in your company should take part in QC Circles?

8. The three models of possible participation in QC Circle activities include:
   - ☐ a. Participation by all departments and sections.
   - ☐ b. Participation by everyone in the same workplace.
   - ☐ c. Participation by those who belong to the same profession.

10.5 Select QC Circle leaders; roles of leaders and members

9. During the inauguration phase of QC Circle activities the most suitable leaders are:
   - ☐ a. Middle managers.
   - ☐ b. Foremen of workplaces.
   - ☐ c. Persons with leadership abilities.
10. The five primary functions of QC Circle leaders include:
   - ☐ a. Train successors.
   - ☐ b. Instruct the participants on how best to meet the expectations of superiors.
   - ☐ c. Educate QC Circle members.
11. QC Circle members are expected to:
   - ☐ a. Follow the leader's instructions.
   - ☐ b. Study engineering technology and quality control.
   - ☐ c. Carry out the roles assigned to them.

10.6 The QC Story

12. The five priorities in the workplace include:
   - ☐ a. Quality.
   - ☐ b. Costs.
   - ☐ c. Production.

10.7 QC Circle Meetings

13. To conduct QC Circle meetings effectively:
   - ☐ a. All members should attend.
   - ☐ b. A manager should always be present.
   - ☐ c. Brainstorming sessions should be held to generate ideas.
14. An average meeting will last:
   - ☐ a. 20 to 30 minutes.
   - ☐ b. 30 to 60 minutes.
   - ☐ c. 60 to 90 minutes.

10.8 QC Circle Assemblies

15. Which of the following components of a QC Story are in the correct sequence?
   - ☐ a. Reasons for selecting a theme, action plans, establishing targets.
   - ☐ b. Introducing the company, understanding the present situation, action plans.
   - ☐ c. Action plans, examining recurrence prevention measures, analysing key factors.
16. Presenters must:
   - ☐ a. Rehearse their presentations.
   - ☐ b. Avoid pauses.
   - ☐ c. Keep their listeners engaged.

17. Advisors should keep their comments on presentations to about:
    - ☐ a. 1 minute.
    - ☐ b. 2 minutes.
    - ☐ c. 3 minutes.
18. Following a presentation managers, facilitators etc, should pay attention to:
    - ☐ a. The potential profits that the company could achieve from the new ideas.
    - ☐ b. Whether all circle members participated with a sense of awareness.
    - ☐ c. How presentations relate to higher policies.

10.9 Evaluation of QC Circle activities

19. Which of the following are used to evaluate QC Circle activities?
    - ☐ a. Evaluation by CEOs.
    - ☐ b. Self-evaluation by members.
    - ☐ c. Evaluation by managers.
20. Evaluation by managers includes evaluation of:
    - ☐ a. Problem-resolution procedures.
    - ☐ b. QC Circle presentations.
    - ☐ c. Activities carried out by the promotional secretariat.

10.10 The basic procedures for QC Circle activities

21. The basic requirements for keeping QC Circle activities going include:
    - ☐ a. Meetings are always finished at the same time.
    - ☐ b. Leaders and members keep the objectives of activities in mind as they carry them out.
    - ☐ c. Members are willing to work.

10.11 QC Circle training

22. The Seven QC Tools listed in this text include:
    - ☐ a. Pareto diagram.
    - ☐ b. Control chart.
    - ☐ c. Graphic chart.
23. The study methods presented in this text for advancing and managing QC Circle activities include:
    - ☐ a. Read books.
    - ☐ b. Learn from experience.
    - ☐ c. Learn from practice.

10.12 Planning future QC Circle activities

24. The procedure for drafting plans for future QC Circle activities includes:
    - ☐ a. Clearly define the type of QC Circle to be developed.
    - ☐ b. Consider the problems that exist within the company, department or section.
    - ☐ c. Decide the target level of QC Circle activities over a given period.

10.13 Create the right environment for QC Circle activities: the role of the CEO

25. CEOs should:
    - ☐ a. Take an interest in the introduction of QC Circle activities:
    - ☐ b. Clarify the company's policy for the introduction of QC Circles.
    - ☐ c. Try to grasp the detailed problems posed by the introduction of QC Circles.
26. CEOs should:
    - ☐ a. Position QC Circle activities clearly within the company.
    - ☐ b. Pro-actively provide instructions and assistance to QC Circle activities.
    - ☐ c. Manage the promotional systems for QC Circle activities.

10.14 The role of middle management

27. The functions of middle managers in QC Circle activities include:
    - ☐ a. Keep CEOs informed of the status of QC Circle activities.
    - ☐ b. Allow as much time as is needed for giving instruction and assistance.
    - ☐ c. Generate opportunities for members to work together to achieve development.
28. Middle managers take the initiative in:
    - ☐ a. The introductory period.
    - ☐ b. The development period.
    - ☐ c. The period in which spontaneity is established.

10.15 Set up a company-wide organisation to promote QC Circle activities

29. Setting up a company-wide organisation to promote QC Circle activities includes establishing:
    - ☐ a. A QC Circle promotional committee chaired by a department manager.
    - ☐ b. A QC Circle promotional secretariat within the TQM promotional secretariat.
    - ☐ c. In-house registration and reporting systems.
30. The functions of the QC Circle promotional secretariat include:
    - ☐ a. Preparing an environment conducive to QC Circle development.
    - ☐ b. Selecting the QC Circle leader.
    - ☐ c. Publishing QC Circle news and other public relations materials.

10.16 Hold QC Circle exchanges with other companies

31. The preferable number of members to visit another company is:
    - ☐ a. 4 to 6.
    - ☐ b. 5 to 8.
    - ☐ c. 5 to 10.
32. The date, time, place and agenda of the meeting should be arranged by:
    - ☐ a. The members.
    - ☐ b. The group leader.
    - ☐ c. The secretariat.

Unit 11

Statistical Methods

Contents

Unit summary

There are many problems that cannot be solved simply by examining equipment and machinery. Data has to be collected, usually over a period of time, and then analysed and interpreted. Data is numeric information that represents objective facts. When data has been collected the statistical methods and tools presented in Unit 11 will help you to analyse and interpret it.

11.1 Understanding data characteristics

11.1.1 Data for quality characteristics and process conditions
11.1.2 Data for process conditions
11.1.3 Approval of data by managers
11.1.4 Training in statistical techniques

11.2 Understanding data diversity

11.2.1 Criteria for collecting data
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11.1 Understanding data characteristics

This text presents:

11.1.1 Data for quality characteristics and process conditions.
11.1.2 Data for process conditions.
11.1.3 Approval of data by managers.
11.1.4 Training in statistical techniques.

11.1.1 Data for quality characteristics and process conditions

Quality control in manufacturing deals with two categories of data:

a. Data that shows the quality conditions of a product: This data is drawn from the quality characteristics of the product, and is used to check that these characteristics conform to the standards or specifications, or how far they deviate or are dispersed from these targets.
b. Data that shows the conditions of the process that produces this product: This data indicates which factors in the process are effecting the quality characteristics. It indicates both the present conditions of the processes and the conditions in which the processes have been set and maintained.

Getting data for quality characteristics from inspection records

Data for quality characteristics includes data from inspection records and reliability test data. Inspection records include records of acceptance inspections, in-process quality inspections (self-inspections), between-process inspections, finished goods inspections, and delivery inspections. All these contain records of quality characteristics. In-process quality records also contain data for process conditions.

a. Acceptance inspection record: The acceptance inspection confirms that delivered inspection lots can be accepted and that delivered products conform to purchase specifications. During this inspection, acceptance inspection data and the status of acceptance (yes or no) are recorded. The test report and packing list attached to the delivered product are also checked, and then filed as attachments to the acceptance inspection data.
b. In-process quality record (self-inspection): The in-process quality record contains time series quality control conditions and the resulting quality characteristics that help to ensure product quality. It contains data for quality characteristics and process conditions, which is used to verify smooth process functioning, maintaining the process under controlled condition to judge whether the process is actually under controlled condition or not.
c. Between-process inspection record: The between-process inspection determines whether partially-completed products are ready to be sent to the next process. This inspection is carried out at predetermined points. Unacceptable items will not be sent on. The records of this inspection are used to improve process control and reduce variance of quality in the manufacturing of products. These records are particularly important in evaluating quality characteristics that cannot be studied once the product has been passed to the following process.

d. Finished goods inspection record: The finished goods inspection verifies the quality of finished goods. It contains data for quality characteristics examined according to the company inspection standards and forms the basis of test reports submitted to the customer whenever required. Products are inspected according to the company standards in order to verify that they meet the conditions contracted with the particular customer and the quality requirements specified in the product specification.
e. Delivery inspection record: The delivery inspection record is a quality record checked immediately before shipping to make sure that packing conditions, markings, and attached documents meet the specifications.
f. Reliability test record: Destructive tests, accelerated tests, environment tests, and durability tests are used to evaluate the stability over time of those product traits that tend to deteriorate over time. Such tests play a vital role in the product development and design stages. Even with products in mass production, routine reliability tests with accurate data are crucial.

Data for quality characteristics may be replaced by data for alternative characteristics for technical or economic reasons.

Remarks

a. Record of abnormalities, defects and claims: An abnormality report is issued when defects are found in any of these inspections.
b. Record of disposal of in-company defects: A nonconformity (defect) report is issued, together with data for quality characteristics, when a product is found to be defective in relation to the specifications or the company standards in the inspections.
c. Record of reworked or repaired products: Reworking is the term for the actions taken to make defective products meet the specifications. Records for reworking and repair also provide data for product quality characteristics.
d. Record of complaint handling: Keep a record of quality problems that customers have complained about, the conditions in which the product was used, the causes that were investigated, the measures adopted, the preventive measures taken, and the results of surveys on other products in the same lot, as well as the actions taken based on these results.

Note: Although data is usually expressed as numeric values, it can also be expressed in ordinary language. This is referred to as language data. (See Text 11.2.1.)

11.1.2 Data for process conditions

To obtain accurate data for tracking processes, record the process conditions according to the company standards. Keep a record of all data for process conditions in the different steps of the process in the hope of improving the analysis of the process by clarifying the relationship of this data to quality characteristics:

a. In-process quality record: The in-process quality record records data for process conditions when quality measures are incorporated into products.
b. Process control: We cannot manufacture products or provide services at the quality levels required by our customers without rigorous oversight of processes thus the importance of in-process quality records in implementing quality in processes.

c. The next process: In order to provide quality products or services, we must incorporate a concern for quality into each of a product's processes. Think of the next process as your customer.

Figure 11.1.2a Check sheet for investigating defects in copying machines

Table X Check sheet for investigating defects in copying machines

	Product	XX copying machine		Period of investigation		June 1 to 6			
	Product number	FX-124		Section		General Affairs Section			
Determine methods used examine items →	Date of purchase	April		Recorder		Bodhidharma circle members			
	Month/date (day of the week) / Defective item	6/1 Mon	6/2 Tue	6/3 Wed	6/4 Thu	6/5 Fri	6/6 Sat	Total	Total check result
Check items separately	Too dark	𝍸	𝍸 I	𝍸 II	𝍸 I	𝍸 III	𝍸	37	
	Too thin	𝍸 𝍸	𝍸	𝍸	𝍸 II	𝍸 𝍸 I	𝍸 I	44	
	Dirt	III	III	𝍸	𝍸	𝍸 II	𝍸	27	
	Displacement	II	I	𝍸	II	III	III	16	
	Wrong size	I	I	III	II	II	III	12	
	Paper jamming	II	I	I	II	II	I	9	
	Other	I	II	I	I	II	II	9	
Total check result →	Total	24	19	26	25	35	25	154	
	Number of copied sheets	1,808	1,615	1,720	1,900	2,010	1,345	10,398	

Remarks

a. It is crucial to base management on indisputable facts, rather than to rely solely on concepts, experience, or intuition. This requires accurate data for process and quality conditions.
b. Before being filed as quality records, data should be recorded in a specified format on specified media (whether paper, computer etc.) and checked and approved by a proper authority.
c. Quality records should include data for each product or manufacturing lot in the form of processes. These include graphs, control charts, histograms, or check sheets generated by statistical techniques.

11.1.3 Approval of data by managers

Managers should confirm that process data is reliable and correct and has been recorded accurately in line with company standards. They should ensure that work is carried out consistently and that control and improvement activities are promoted effectively. A key task in achieving this is to inspect and verify daily data, and maintain daily management records.

This will demonstrate to workers that using correct data is the basis of quality control.
To maintain daily management work records:

a. Record all necessary data in the standard recording sheets.
b. Avoid inaccurate descriptions, omissions, illegible writing, improper descriptions, or improper corrections.
c. Submit record sheets to the manager responsible for the test without delay, according to the prescribed procedures.
d. Record sheets should provide spaces for the employee responsible for the test to confirm the results, insert comments or instructions, and enter the date of the record.
e. In the event of improper, incorrect, or ambiguous descriptions or of work records that do not meet corporate standards, the manager responsible for the test must obtain an explanation from the employee responsible for the record, confirm the contents, and issue written instructions for corrective actions to be taken.
f. After confirming that the record is correct, the manager responsible for the test must sign it or mark it with a seal in the specified column.

Examples

Check sheet for recording each defective item

Items that tend to have defects are entered in advance in the recording sheet, and this is checked whenever a defect occurs. This check sheet shows the frequency of defects in each item and identifies the most problematic items. Expressing the record as a Pareto diagram makes it easy to see trends in defects. (See Figure 11.1.3a on page 8.)

Check sheet for recording the cause of each defect

This check sheet compiles data for different machines, work categories, and work times, and is useful in finding the cause of a problem. Record different defect categories using such symbols as: ○ , X, ● , △ and □ . (See Figure 11.1.3b on page 8.)

Check sheet for recording the distribution of data characteristics

This check sheet records measurements for dimension, mass, and other characteristics and sorts them into relevant data segments to clarify the profile, centre, and dispersion of distributed data. It makes it easier to record individual values and to process data because it arranges the data in frequency charts and removes the need to do any writing. (See Figure 11.1.3c on page 9.)

Check sheet for recording defect positions

This check sheet marks defect locations on a product sketch, using marks such as ○ , X, ● and △. It is useful in determining defect positioning, clustering, defect categories, and reasons for their concentration. (See Figure 11.1.3d on page 9.)

Figure 11.1.3a Check list for defective items

Defective item check list for the paint process

Line Number: A Period: April 1 to 7

Product: B Inspector: Toda

Item		Total
Dust	III	3
Improper gloss	IIII	4
Uneven painting	I	1
Insufficient painting	𝍸 I	6
Paint runs	II	2
Others		0
	Grand total	16

Method for recording defects: Enter a slash "𝍸" for each defect, as shown in the above illustration

Figure 11.1.3b Check Sheet for recording each defect

Check Sheet for Defects in the Grinding Process

Product: A

Period: April 1 to 7

Date of the week		Mon		Tue		Wed		Thu		Fri		Total
	Machine	AM	PM	AM	PM	AM	PM	AM	PM	AM	PM	
A	Machine Number 1		○					△				2
	Machine Number 2	●		X								2
	Machine Number 3											0
B	Machine Number 4					●				□		2
	Machine Number 5						X					1
	Machine Number 6											0
Total		1	1	1	0	1	1	1	0	1	0	7
		2		1		2		1		1		

(Symbols) ○ Scratch X Improper gloss ● Wrong size △ Improper profile □ Other

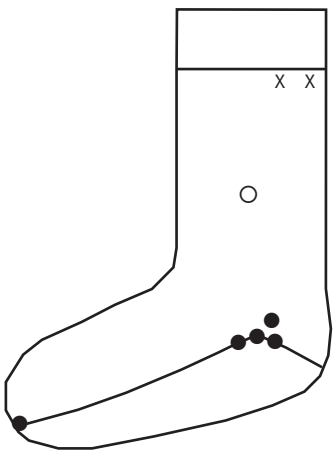
Figure 11.1.3c Check sheet for recording the distribution of data characteristics

Check sheet for outer diameter		Product	Shaft	Date of measurement	April 1
		Standard	8.0±1.5	Instrument	Micrometer
		Unit	mm	Measurer	Suzuki

No.	Section	Median	10	20	30	40	50	60	Frequency
1	7.775-7.825	7.80							0
2	7.825-7.875	7.85	𝍸						5
3	7.875-7.925	7.90	𝍸 𝍸	//					12
4	7.925-7.975	7.95	𝍸 𝍸	𝍸 ///					18
5	7.975-8.025	8.00	𝍸 𝍸	𝍸 𝍸	𝍸 𝍸	/			31
6	8.025-8.075	8.05	𝍸 𝍸	𝍸 𝍸	//				22
7	8.075-8.125	8.10	𝍸 𝍸						10
8	8.125-8.175	8.15	//						2
9	8.175-8.225	8.20							0
10	8.225-8.275	8.25							0
								Total	100

Remarks

Figure 11.1.3d Check list for recording defect positions



Check sheet for defect positions

Product	A	Date of inspection	April 1
Process	B	Inspector	Yoshida
Line Number	C	Number of inspected products	1,000

Use the following symbols to mark defect positions

○ Defective A　　X Defective C
● Defective B　　△ Defective D

Remarks: Enter your observations

Remarks

Be sure to record the following data items for process conditions and quality characteristics:

a. Title, number and version number of the applied standard.
b. Title and model number of the product.
c. Date and time.
d. Title of process.
e. Title of equipment.
f. Title of work.
g. Name of worker.
h. Name of recorder.
i. Lot number in the previous process.
j. Lot number of material.
k. Data for process conditions (temperature, speed, pressure, concentration, contents, time, and other information).
l. Title and number of jig or tool.
m. Title and number of measuring instrument.
n. Conditions of the sampling test and frequency of checks.
o. Data for quality characteristics, whether accepted or rejected.
p. Defects, detailed descriptions, report and actions taken for defects.

Record data for different work categories, machines, and work times, with the correct descriptions of the measuring instruments, testers, inspection equipment, and test methods used in the test. These measuring instruments must be checked and properly calibrated. Data should be precise and accurate, and reliably expressed in significant digits, to allow proper tests.

11.1.4 Training in statistical techniques

Employees may be sent to external seminars to learn statistical techniques and how to apply them in their production processes. These techniques will enable them to increase their control over these processes and make improvements to them. However, such seminars will be useless unless full TQM training is scheduled and performed continuously for workers at each organizational level.

The purpose of in-company training in statistical techniques is to provide all employees with a working knowledge of quality control (QC) and other statistical techniques and how to apply these effectively. Separate training should be provided for each organizational level.

In Unit 12, Education and Training, Text 12.3 gives detailed guidelines on providing training in statistical techniques in the context of TQM training.

11.2 Understanding data diversity

This text presents:

11.2.1 Criteria for collecting data.
11.2.2 Analysing data with a characteristic diagram.
11.2.3 Expressing mean values and dispersion.
11.2.4 Analysing data with a scatter diagram.
11.2.5 Using graphs to analyse data.

11.2.1 Criteria for collecting data

You should standardize methods for collecting data so that you can make judgements based on it quickly and accurately and carry out appropriate improvements. The key terms in collecting data are:

Population: A group of entities whose characteristics are to be investigated or studied or a group of entities from which samples are to be taken.

Sample: Part of a population selected to find out its characteristics.

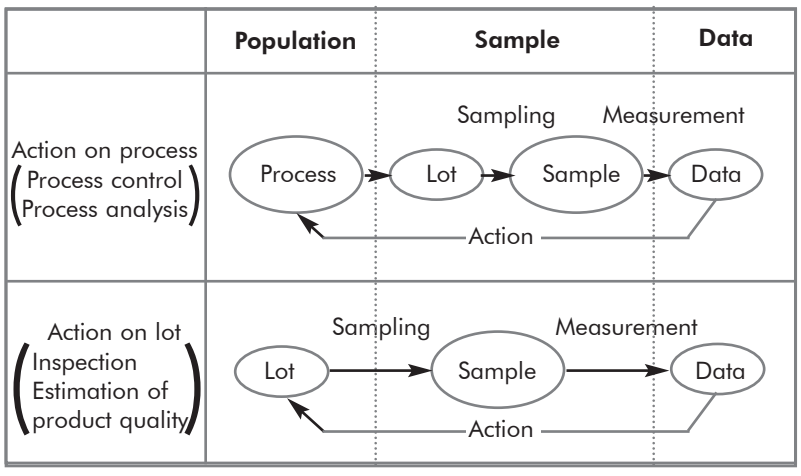
Variable: A quality characteristic value that can be measured as a continuous quantity, but not counted as separate items, e.g. length, colour. Data derived from such values is referred to as variable data.

Discrete value: A quality characteristic value that can be counted, e.g. the number of defects or defective products. Data derived from such values is also referred to as discontinuous data.

Population and sample

The purpose of data collection is to gain an understanding of user needs, the quality characteristics of a product, the quality conditions of a process, and the quality of raw materials. When we have collected data we are able to investigate or inspect a population.

Figure 11.2.1a Population, sample and data



The principle of sampling

Data to which statistical techniques are to be applied is obtained by measuring items sampled from processes, lots, or populations. The data thus obtained has sampling and measuring errors in addition to the dispersion that results from changes in production elements. To give an accurate estimate of a population's characteristics by applying statistical techniques to the data, the unit entities and unit measurement values that compose the population should be sampled at the same probability and a correct measuring method used to obtain the data. Sampling at the same probability is called random sampling. At first glance, random sampling may seem to provide a result governed only by chance but in fact repeated random sampling results in increasing degrees of statistical regularity.

The four principles of random sampling

Principle 1: Products should not be sampled by the workers responsible for manufacturing them (prevention of purposive selection).
Principle 2: Sampling should be witnessed by a person with authority (sampling cannot be checked retrospectively).
Principle 3: Those taking the population sample should be well informed of the significance and purpose of sampling.
Principle 4: Random sampling is based on a table of random numbers.

Remarks

Ideally, we would like to have all the information that applies to a population, but in practice it is not possible to conduct such a thorough survey, so we sample part of the population and extrapolate from this data. The following are important points in collecting data:

a. Data collection must have a purpose. Clarify the purpose of collecting data, and be sure that the data collected is valid for this purpose and expresses objective facts.
b. Before you use data recorded in the past, confirm the purpose for which the data was collected, and examine the context, history, and constraints in its collection. Do not use data collected for different purposes, from different populations, or in different measuring conditions. Do not use improperly sampled data or data measured using different machines.
c. Use stratification. Record data for process conditions in a form that allows stratification for different cause elements. This will allow analysis of the cause and effect relation between process conditions and quality characteristics.
d. The information obtained from data will be used in actions on the population from which the data was taken. Bear in mind that what we learn from the data is limited to this population.
e. The sampling method used must be appropriate to the purpose of sampling. Sampling methods include simple random sampling, two stage sampling, and stratified sampling.
f. In using data, be attentive to objectivity and reliability. Train the workers who collect data in the precautions necessary for using the measuring instruments, and in ways of maintaining instrument precision, measuring methods, and methods of rounding and recording values. Check the conditions in which instruments are calibrated and kept precise.
g. Confirm that correct data has been obtained. Be careful to avoid errors in recording and calculating data. Be careful not to omit all or part of the data required.

11.2.2 Analysing data with a characteristic diagram

Before you begin to analyse the data, identify the cause and effect relations. Characteristic diagrams are useful for doing this. A characteristic diagram is a diagram like a fish bone used to systematically identify the characteristics (the effects) and the factors (the causes) that appear to effect the characteristics.

Characteristics

Characteristics are effects that result from work and processes. They include:

a. Quality (Q): Appearance, dimension, weight, purity, strength, flatness, number of defective products, number of claims, ratio of defective products.
b. Cost (C): Cost of material cost, machining, labour, advertising, overtime, sales, loss due to claims.
c. Quantity/delivery (D): man-hour, availability ratio, turnout, quantity of shipped products, days of delayed delivery, ratio of products delivered on schedule.
d. Safety (S): Disaster ratio, number of accidents, number of near miss incidents, operation time without accidents.
e. Morale (M): Ratio of absenteeism, ratio of participation, number of proposals and improvements made by employees.

In resolving problems at the workplace or in QC circles, when you wish to express poor quality or conditions use expressions such as "Poor appearance of ..." "High material cost of..." "Too many man-hours for..." in order to assess the factors involved.

Factors

Factors are causes identified as affecting results (characteristics). The large, medium, small, and granddaughter bones in a characteristic diagram represent factors.

When the characteristic to be investigated is the quality of the product in production departments, it is normally caused by dispersion in the 4M below. The 4M are normally represented as large bones. Sometimes we speak of 5M to include measurement, but this is not crucial. The 5M are:

a. Man: workers.
b. Material: materials and parts.
c. Machine: machines, facilities (equipment).
d. Method: method of work.
e. Measurement: measurement and sampling.

Key Points in using a characteristic diagram

To get the most out of a characteristic diagram, extract what seem to be the important factors (causes). To do this consider the opinions of your boss, staff members and experts. To determine whether the extracted factors are real causes, study them at the production site or collect data to evaluate their effects. This is called verification (or reconfirmation). Use the following procedures to extract and verify factors:

Extract factors

a. Examine products at the production site and study them.
b. Get the opinions of as many people as you can and extract as many potential factors as possible.
c. Express factors in clear and concrete expressions in single words or short sentences.
d. Pursue factors with the question "why" until the proper actions to take are clear.

Verify factors

a. When you have completed a characteristic diagram, follow the relations between factors, going from large, through medium and small to granddaughter bones, and then do it again in reverse order.
b. Always ask the question "why" of an item, or "and so?" of a factor. If factors cannot be linked, you may have erred in assigning bones, or you may have missed bones or cited items that are not factors. Correct the diagram.

Figure 11.2.2a Example of characteristic diagram

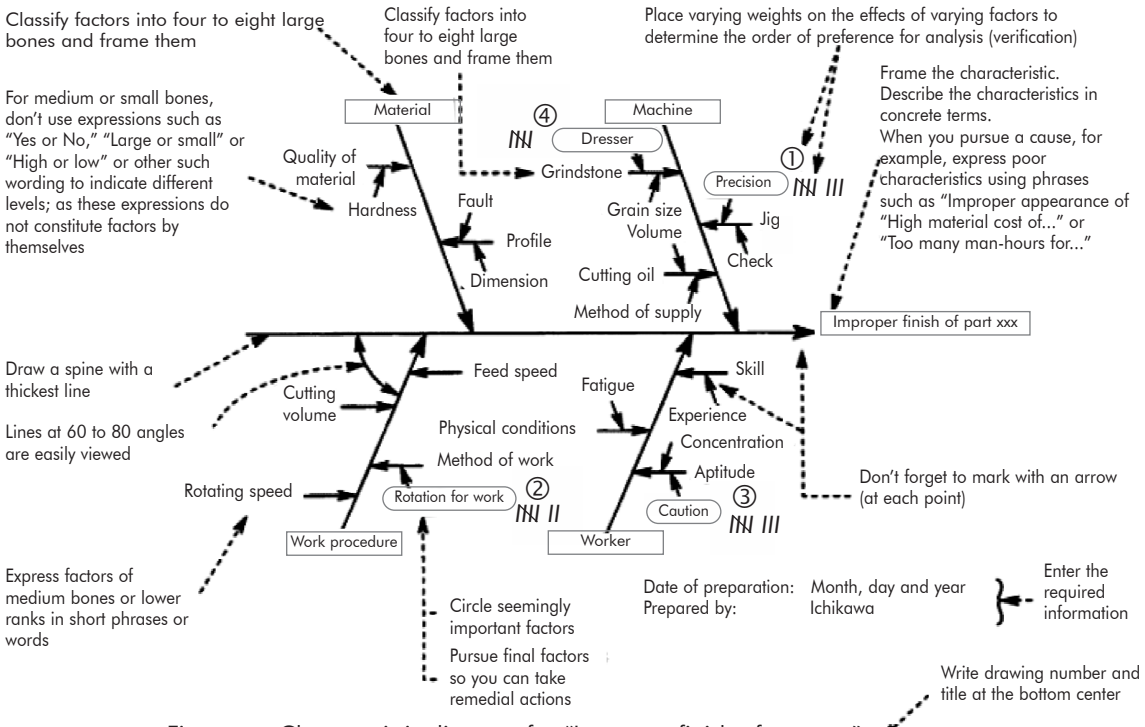


Figure xxx Characteristic diagram for "Improper finish of part xxx"

11.2.3 Expressing mean values and dispersion

We can use statistical techniques on collected data to estimate the mean and dispersion of the population.

Parameters

The following values expressing features of a population are all regarded as parameters:

a. Population mean = μ = E (X)
b. Population standard deviation = σ
c. Population covariance = Cov (X, Y) = E [(X - μx) (Y - μy)]
   (μx = E (X), μy = E (Y))
d. Population coefficient of correlation = p = Cov (X, Y) / $[V(X)\ V(Y)]^{1/2}$

Statistics

Functions and values calculated from data samples express their features. Statistics are employed to estimate population parameters and to verify hypotheses.

Fundamental Statistics:

a. Mean value.
b. Standard deviation.
c. Range.

From these values we can estimate the features of a population distribution.

Random variables:

These are variables that take values according to the rules of probability. Random variables are either discrete or continuous, depending on the nature of their values. The distribution of the former is called a discrete distribution, and that of the latter is called a continuous distribution.

Expected value:

When values of a random variable x are observed repeatedly, the ultimate mean value is called the expected value of x.

Examples

Expression of Central Points

Mean Value ($\bar{x}$)

The sum of n measurements divided by n is called the mean value (arithmetic mean value) and is denoted by ($\bar{x}$) where x_1, x_2, ..., x_n are measurements and n is the number of measurements.

$$\bar{x} = \frac{x_1 + x_2 + \ldots + x_n}{n} = \frac{\sum_{i=1}^{n} x_i}{n}$$

Example 1: Find the mean value of the length of a product from the five measurements 6.2, 5.7, 6.1, 6.3, and 6.0

$\bar{x}$ = (6.2+5.7+6.1+6.3+6.0)/5 = 30.3/5 = 6.06 (mm)

Median ($\tilde{x}$)

When measurements are arranged in size, the value at the centre of the sequence is called the median and is denoted by $\tilde{x}$.

a. Use the measurement at the centre for an odd number of measurements.
   Example 2: 5.7, 6.0, 6.1, 6.2 and 6.3 $\rightarrow \tilde{x} = 6.1$ (mm)
b. Use the mean value of the two measurements at the centre for an even number of measurements.
   Example 3: 5.7, 6.0, 6.1, 6.2 $\rightarrow \tilde{x} = (6.0+6.1)/2 = 6.05$ (mm)

Although a median value is less precise than the mean value, you can obtain it directly without performing a calculation for an odd number of measurements.

Expression of Dispersion

Range (R)

The difference between the maximum value (L) and the minimum value (S) of a data set is called the range and is denoted by R.

$R = L - S$

The range cannot be a negative value.

$R \geq 0$

The range is used for ten measurements or less, ideally for five or six measurements.

Example 4: Find the range of measurements 6.2, 5.7, 6.1, 6.3 and 6.0.

$R = 6.3 - 5.7 = 0.6$ (mm)

Sum of the Squares (S)

The sum of the squared differences between individual measurements and the mean value is called the sum of the squares and is denoted by S.

$S = (x_1 - \bar{x})^2 + (x_2 - \bar{x})^2 + \ldots + (x_n - \bar{x})^2$
$= \Sigma(x_i - \bar{x})^2$ ... Formula for definition
$= \Sigma x_i^2 - (\Sigma x_i)^2/n$ ... Formula for calculation

where the term $(\Sigma x_i)^2/n$ is called a correction term (CT).

Example 5: Calculate the sum of the squares of the data in example 1.

$S = (6.2-6.06)^2 + (5.7-6.06)^2 + (6.1-6.06)^2 + (6.3-6.06)^2 + (6.0-6.06)^2$
$= (6.2^2 + 5.7^2 + 6.1^2 + 6.3^2 + 6.0^2) - (6.2+5.7+6.1+6.3+6.0)^2/5 = 0.212$

Variance (V)

The sum of the squares divided by (n-1) is called the variance or (unbiased variance) and is denoted by V.

$V = S/(n-1)$

The sum of the squares is larger when the number of measurements is larger. However, the variance gives a dispersion unrelated to the number of measurements.

The value (n-1) is called the degree of freedom.

Example 6: Calculate the variance (V) of the data in example 5.

$V = 0.212/(5-1) = 0.0530$ (mm)

Standard Deviation (s)

The square root of the variance is called the standard deviation and is denoted by s.

$s = (\sqrt{V})$

Since the sum of the squares and variance are related to squared measurements, you cannot compare values based on the measurement unit. The standard deviation doesn't have this drawback, and allows us to use the measurement unit.

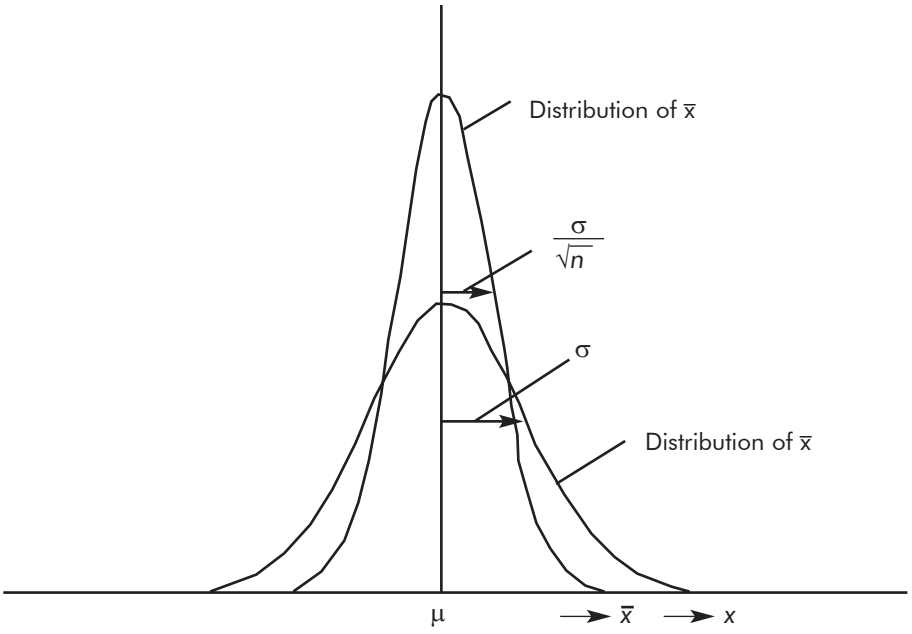
Example 7: Calculate the standard deviation (s) of the data in example 6.

$s = (\sqrt{0.0530}) = 0.230$ (mm)

Distribution of Mean Value ($\bar{x}$)

When measurements of a population are normally distributed with a population mean value μ and a standard deviation σ, the mean value $\bar{x}$ of n measurements sampled at random from this population is also normally distributed, with a mean value μ and a standard deviation $\sigma/(\sqrt{n})$.

Figure 11.2.3a Distribution of mean value



Remarks

Statistics that indicate the centre of distribution

1. Mean ($\bar{x}$)
2. Median ($\tilde{x}$)

Statistics that indicate the degree of dispersion

Sum of the squares

$S = \Sigma_{i=1}^{n}(x_i - \bar{x})^2$

The sum of the squares (S) is a sum of the squared differences between individual measurements and the mean value ($\bar{x}$).

Variance (V)

$V = S/(n-1)$

Standard Deviation (s)

The standard deviation (s) is the square root of variance (V).

$s = (\sqrt{V})$

Range (R)

The range (R) is the difference between the maximum (x_{max}) and minimum (x_{min}) values of the data.

$R = x_{max} - x_{min}$

Expected value and variance of sample mean values

An important rule in the application of statistics to quality control gives the variance of the mean value $\bar{x}$ of n measurements as σ^2/n. The distribution of mean value $\bar{x}$ of n samples has the following traits:

The expected value of the sample mean value $\bar{x}$ is equal to the population mean value μ.

$E(\bar{x}) = \mu$

The variance of the sample mean value $\bar{x}$ is equal to the population variance σ^2 multiplied by 1/n.

$V(\bar{x}) = \sigma^2/n$

11.2.4 Analysing data with a scatter diagram

Scatter diagrams: Relations between characteristics

Scatter diagrams are used to determine whether a relation exists between two characteristics by plotting pairs of data on an X-Y coordinate, or by plotting one characteristic on the Y-axis and another on the X-axis. When a relation exists between the two characteristics, they are said to be correlated. Where one characteristic increases as the other also increases, they are said to be positively correlated (positive correlation). When one becomes smaller as another becomes larger, they are said to be negatively correlated (negative correlation). When two characteristics are positively correlated, data points scatter within an ellipse tilted to its right. When they are negatively correlated, data points scatter within an ellipse tilted to the left. When no relation exists between the two characteristics, they are said to be not correlated, and their data points are found to be scattered within a circle.

Coefficient of correlation

A coefficient of correlation represents the degree of correlation between two characteristics and takes a value in the range from - 1 to + 1. A value close to - 1 indicates a strong negative correlation. A value close to + 1 indicates a strong positive correlation. A value close to 0 indicates that the correlation between the two characteristic is weak.

Figure 11.2.4a Coefficient of correlation

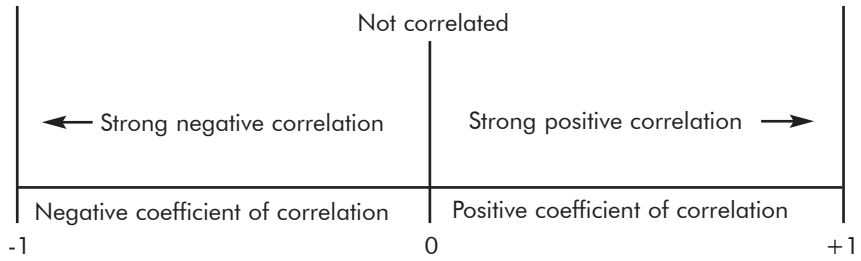
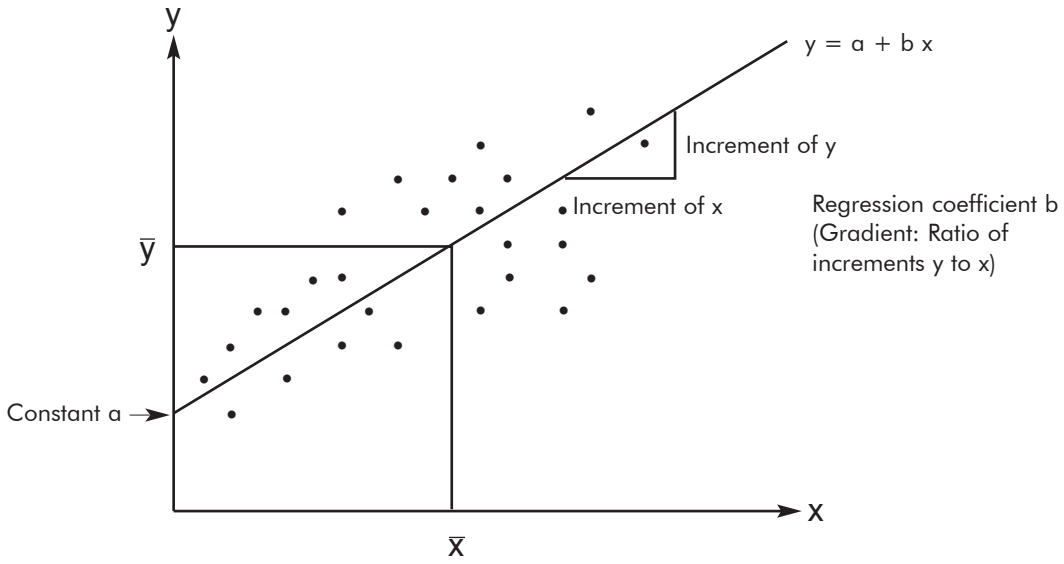


Figure 11.2.4b Conceptual diagram of equation for regression



Example

Procedure 1: Prepare a table to calculate the coefficient of correlation.

Procedure 2: Calculate the sum of the squares of the characteristic x, S(xx).

$S(xx) = \Sigma x_i^2 - (\Sigma x_i)^2/n$

Procedure 3: Calculate the sum of the squares of the characteristic y, S(yy).

$S(yy) = \Sigma y_i^2 - (\Sigma y_i)^2/n$

Procedure 4: Calculate the deviation of the sum of the product of characteristics x and y, S(xy).

$S(xy) = \Sigma x_i y_i - (\Sigma x_i)(\Sigma y_i)/n$

Procedure 5: Calculate the coefficient of correlation (r).

$r^2 = (S(xy))^2/(S(xx).S(yy))$

a. Coefficients of correlation are normally rounded to three significant digits.
b. The value b in the equation for regression indicates the gradient of the regression line rather than the degree of correlation.
c. To calculate the coefficient of correlation, be sure to assign the variable that results in an effect upon x and another on y. This principle also holds in determining the equation for the regression. Caution is called for here, as exchanging x and y will result in an entirely different equation for regression.

Equation for regression

An equation for regression represents the relation between two characteristics y and x, where y is called an objective variable and x an explanatory variable. The equation for regression takes different forms depending on which variables are used, and the numbers of variables. Here, we discuss a case where y is expressed by a linear equation of x, as shown by the following generalized form:

$$y = a + bx$$

where a is a constant or intercept and b is called a regression coefficient.

11.2.5 Using graphs to analyse data

It is important to know how to apply graphs to process control and improvement. This involves creating well defined data by expressing raw data as numeric values and then plotting these numeric values on a graph. What will appear on the graph is a figure rather than simply numbers. This figure will show at once the relations of measurements with lengths, areas and angles. You can use different types of graph to compare the magnitudes of different measurements and see at a glance the measurement changes over time. This allows you to quickly grasp the conditions of process control and the effects of improvement and to communicate this information to others.

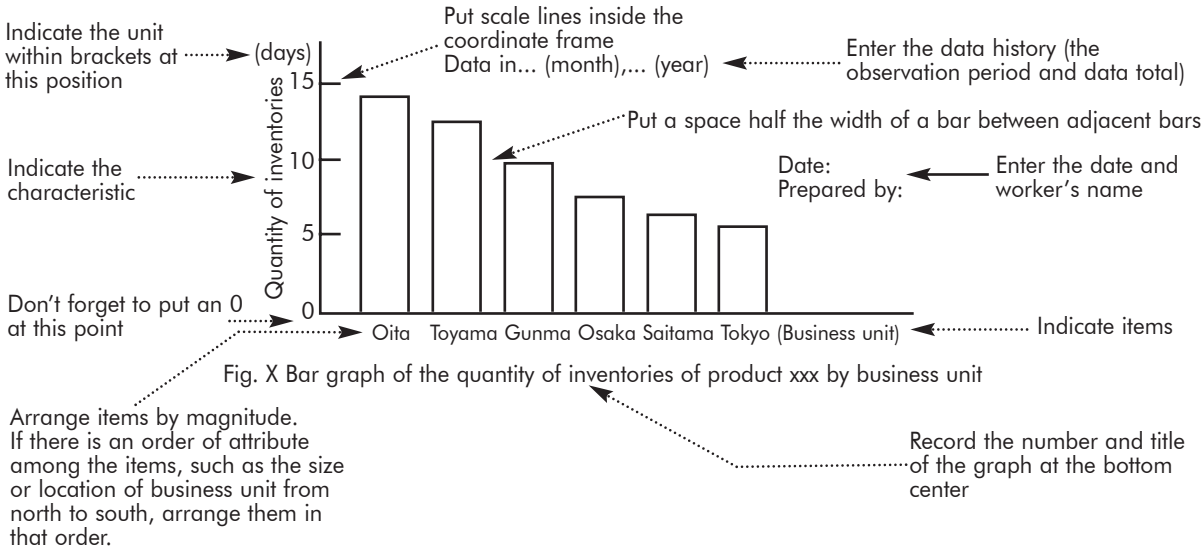
The advantages of using graphs are that:
a. Anyone can draw them quite easily.
b. They allow you to understand and judge the status and conditions of a process at a glance.
c. They can present a great deal of information.

There are different types of graph: bar, polygonal line, circular, band, radar chart, Z, map, triangular and picture graphs. Select the one that is best suited to your purpose. Design expressions that are easy to understand.

Bar graphs

Bar graphs express data using the length of a bar to facilitate comparison between the magnitudes of different data, such as inventories by product or plant, and sales in different business units.

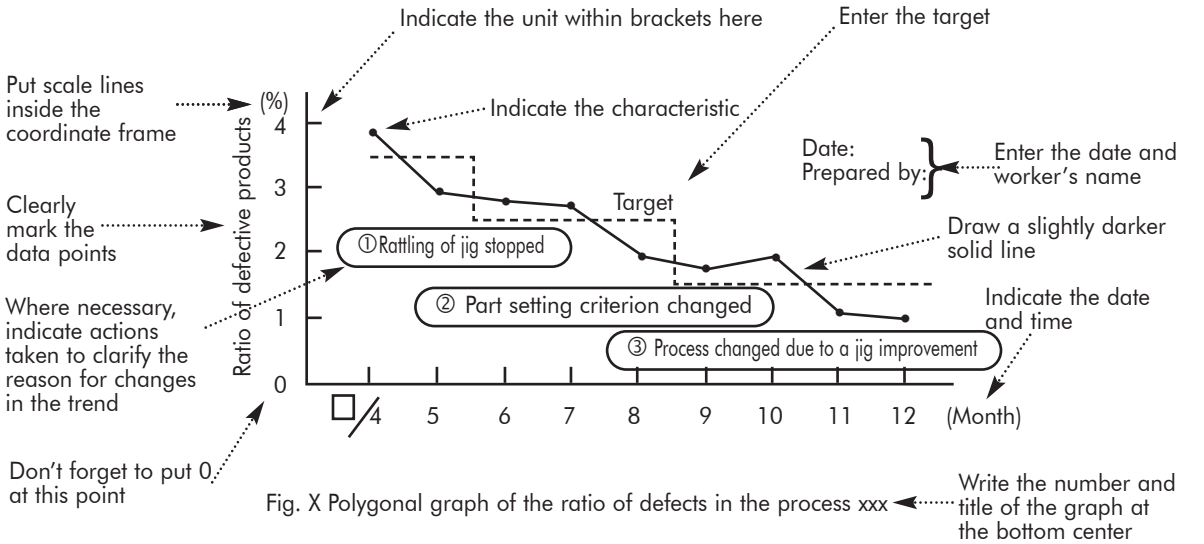
Figure 11.2.5a Example of bar graph



Polygonal line graphs

Polygonal line graphs plot time on the X-axis against a characteristic on the Y-axis. Adjacent data points are connected by line segments to indicate trends or changes in the characteristic over time, such as the quantity of manufactured products, sales, number of defective products, or number of re-workings per month.

Figure 11.2.5b Example of polygonal graph



Circular graphs

In circular graphs, a circle is sectioned along the circumference in proportion to the ratio of each component. Expressing component magnitudes by the central angle and radially spread sections makes it possible to view at a glance the relative sizes of the components.

Figure 11.2.5c Example of circular graph

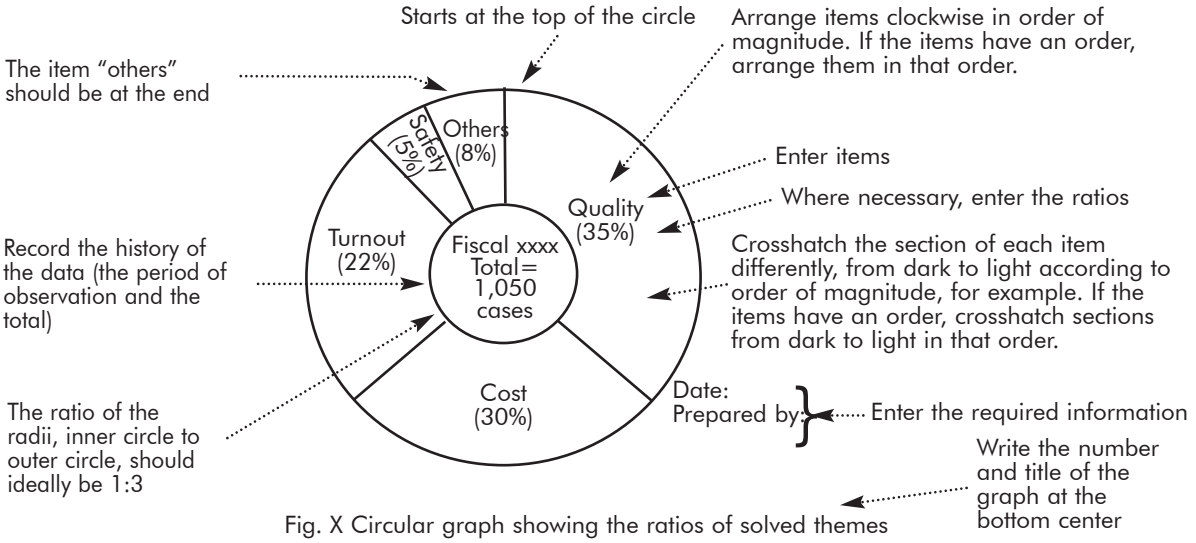


Fig. X Circular graph showing the ratios of solved themes

Band graphs

Band graphs appear rectangular, with the longer side sectioned according to the ratio of the components. Band graphs are used to compare or note changes in the ratios of components over time.

Figure 11.2.5d Example of band graph

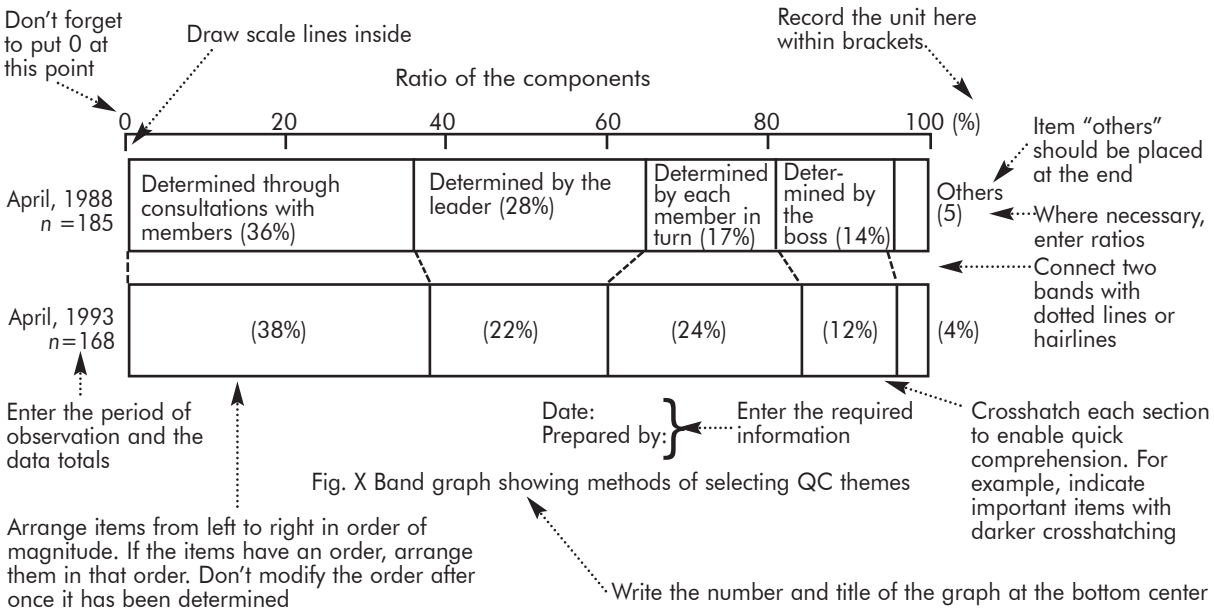
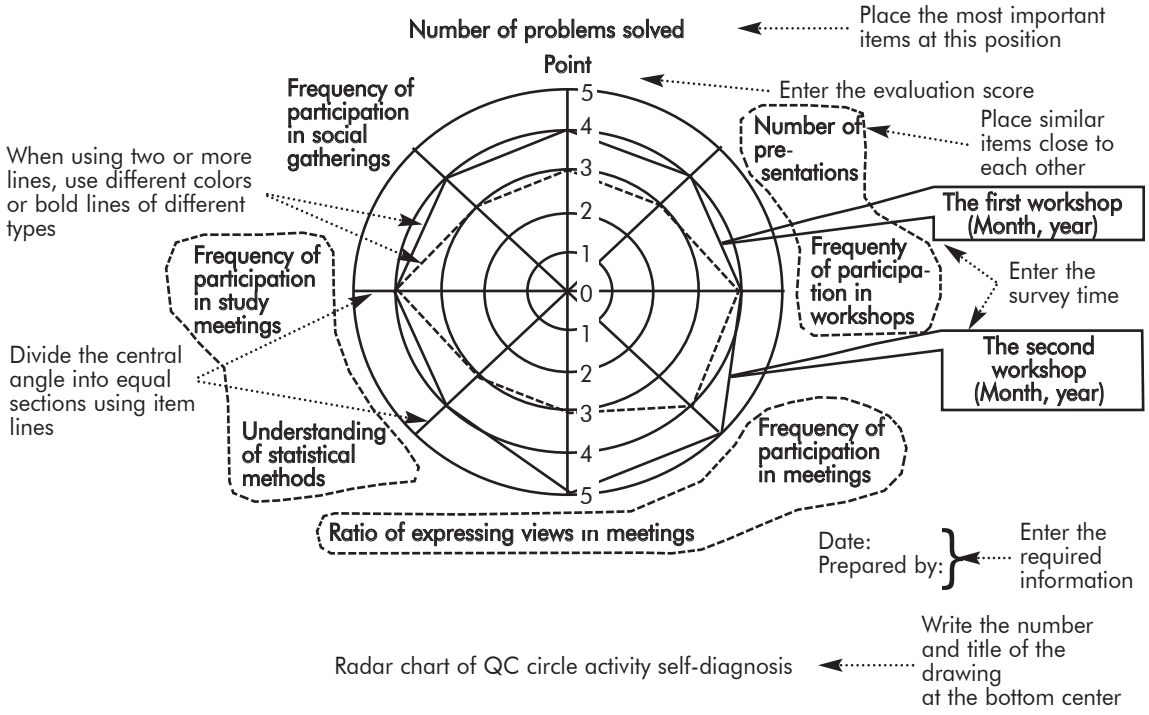


Fig. X Band graph showing methods of selecting QC themes

Radar charts

Radar charts feature lines radiating from the centre of a circle that section the circle into portions of the same size according to the number of items. These lines are scaled. An item value is plotted on each line, and data points on adjacent lines are connected with line segments. Radar charts are useful in representing and comparing a large number of items, and in tracking progress towards targets.

Figure 11.2.5e Example of radar chart



11.3 The seven QC tools

This text presents:

11.3.1 Pareto Charts.
11.3.2 Histograms.
11.3.3 Process Capability.
11.3.4 Stratifying Data.
11.3.5 The QC Story.

11.3.1 Pareto Charts

Pareto charts use bars to express phenomena and causes, grouped by item, such as defective parts, reworked parts, repaired parts, claims, accidents and failures. Polygonal lines are added to show cumulative frequencies.

When we look at a Pareto chart with defect items on the X-axis by frequency and the number of defects or amount of losses and their cumulative amounts on the Y-axis, we can see that it is more effective to pick out a small number of vital items (vital few) than a large number of trivial items (trivial many). This is called Pareto's law. The Pareto chart is widely used to choose problems and subjects for study and discussion at the planning stage for QC circles and to confirm the results of an action once the action is performed.

Key points in drawing a Pareto chart

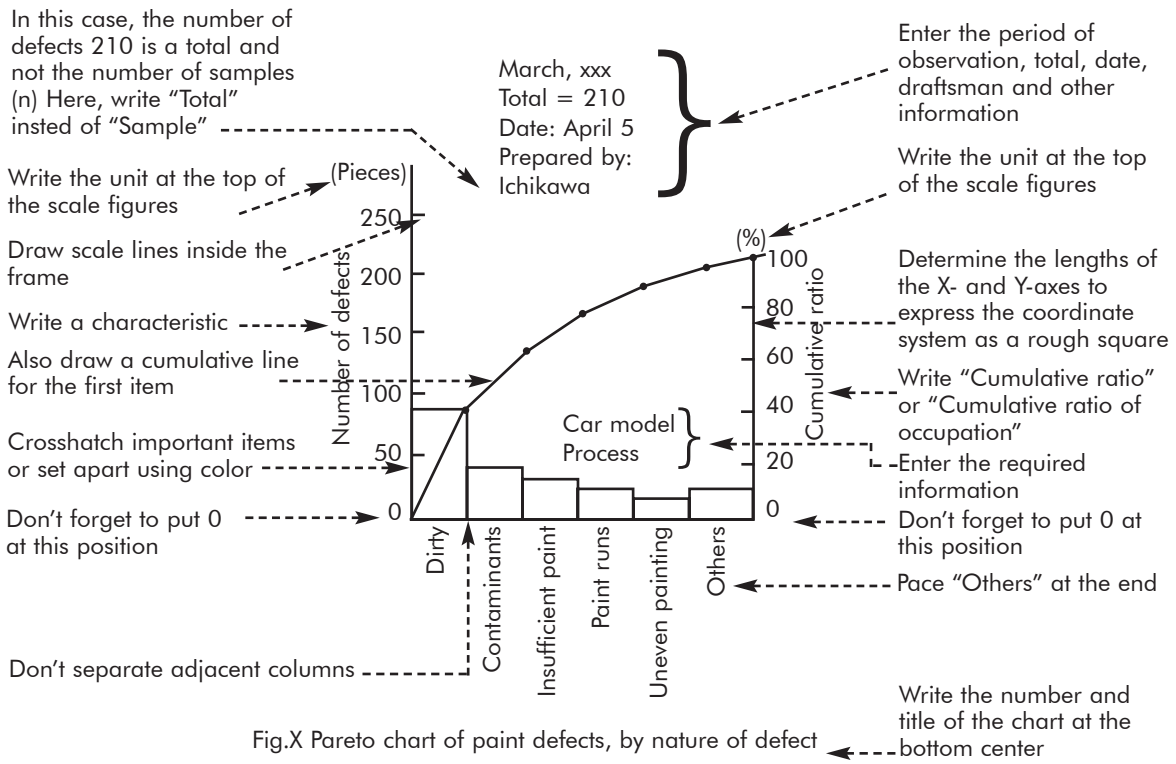
To draw a Pareto chart collect data stratified by cause (factor) or effect (characteristic, phenomenon). Do not use data for items from different classifications, levels, or causes (factors). Be sure to enter totals for cases, amounts and times, and the period of observation.

Key points in using a Pareto chart

a. Adopt the amount of loss along with the number of defects, defect ratios, and the number of claims on the Y axis.
b. Determine a period of observation appropriate to the purpose.
c. When a Pareto chart indicates little difference between different items (strata), change the method of classification or the characteristic on the Y-axis to bring out the important items.
d. After determining the most significant item, draw a secondary Pareto chart for that item alone.

In 1897, the Italian economist V. Pareto established that income distribution is biased toward low-income workers and proved the law that governs this distribution. Applying this law, J.M. Juran, an American management consultant, devised a diagram arranging defective items on an X-axis by frequency, and the number of defects or the amount of losses and their cumulative numbers on the two Y-axes respectively. Juran called this a Pareto chart. The Pareto chart is most widely used as one of the Seven QC Tools, along with characteristic diagrams.

Figure 11.3.1a Example of Pareto chart



11.3.2 Histograms

A histogram for the distribution of numeric statistics is used to enable users to grasp data at a glance. It uses columns to express frequencies of data from different categories. The range of distribution is divided into several sections. Histograms deal with variables such as length, weight, temperature, and hardness, all of which can be obtained by measurement. They clarify the following data features:

a. The profile of distribution of data.
b. The centre of distribution of data.
c. The dispersion of data.
d. The relation of data to standards.

Drawing a histogram

a. You should have at least 50 data (n) points; 100 or more is even better. A small number of data points produces a sketchy distribution profile.
b. Figure 11.3.2a below suggests an appropriate number of sections (k). As a general rule, the square root of the number of data points gives the appropriate number of sections.
c. Determine the scales of the Y and X axes so that the diagram is roughly square.
d. Enter the data history (names of product, process, standards, period of observation and date) and the number of data points (n) in the margin of the diagram.

Figure 11.3.2a Appropriate number of sections (k) according to the number of data (n)

Number of data (n)	Number of sections (k)
50 - 100	6 - 10
100 - 250	7 - 12
250 -	10 - 20

(The equation $k = \sqrt{n}$ provides a rule of thumb for determining the number of sections.)

Using a histogram

Check the following:

a. The profile of distribution. Is it deformed? Does it have isolated islands or a double peak?
b. Position of the distribution centre.
c. Dispersion or bias from the relevant standard.
d. Does the data satisfy relevant standards? Is the process capability adequate?

Figure 11.3.2b Histogram of the outer diameter of the part X at the axis Y

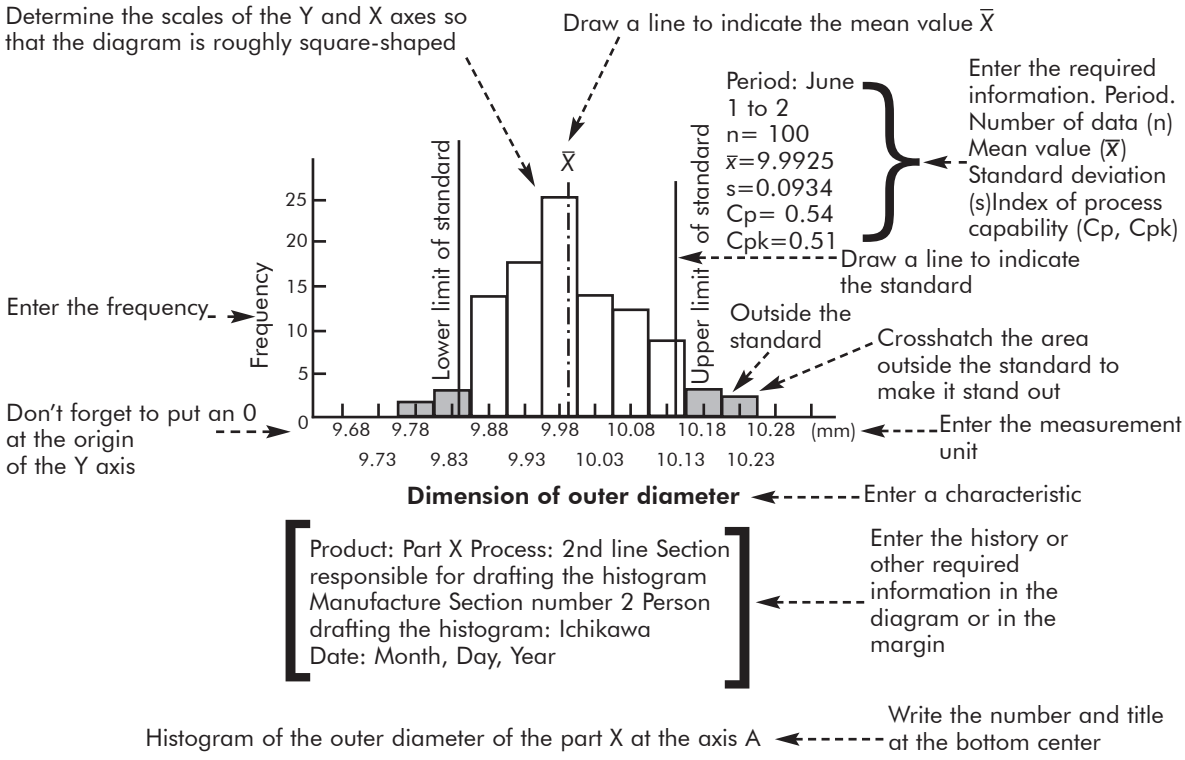
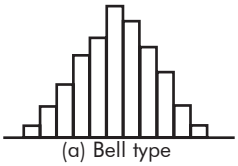
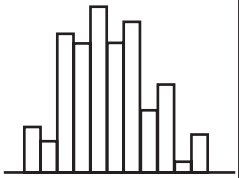
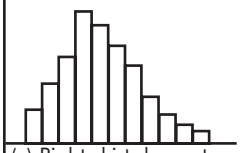
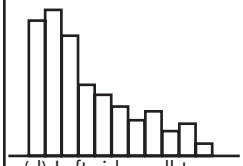
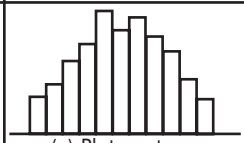
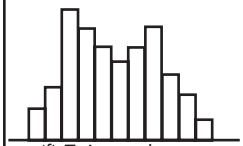
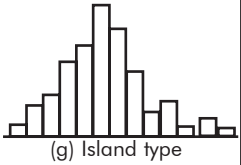


Figure 11.3.2c Interpretation of histogram distribution

Type	Profile	Description	General remarks
Bell or hanging bell	 (a) Bell type	The frequency is highest at the center, decreasing toward both ends of the range. The profile is symmetrical.	Appears when the process is stable.
Toothless or comb	 (b) Toothless type	The frequency is low at every other section, producing a toothless profile, or a comb.	Appears when the section width is not an integral multiple of the measuring unit, or if the person taking the data measurements has a consistent tendency toward skewing when reading instrument indications.
Right skirt drawn type (left skirt drawn type)	 (c) Right skirt drawn type	The mean value of the histogram is biased to the left, with the slope of the profile somewhat steep on the left side and sloping gently on the right. The profile is asymmetric.	Appears when occurrence of data on the lower side is limited by theory or by a standard, or with certain data ranges, including those without negative values.
Left side wall type (right side wall type)	 (d) Left side wall type	The mean value of the histiogram is biased sharply to the left, with a steep profile on the left and sloping gently on the right. The profile is asymmetric.	Appears when non-standard data is excluded, or when measurements are obscured or incorrect.
Plateau type	 (e) Plateau type	Frequencies in different sections are almost the same, producing a plateau pattern.	Appears when several distributions with slightly different mean values are mixed.
Twin-peak type	 (f) Twin-peak type	Frequencies at and around the center are lower than at other parts, producing two peaks.	Appears when two distributions with different mean values are mixed, as when the data pertains to two different machines or materials.
Island type	 (g) Island type	An island appears at the right or left end of the distribution.	When the distribution contains a small quantity of data from a different distribution, or abnormal data.

Comparing a histogram with standard values

We can confirm that the capability of the existing manufacturing process satisfies technological requirements by comparing a histogram and standard values. Figure 11.3.2b shows the relationship between histogram and standard values.

11.3.3 Process capability

This text presents the methods of calculating the process capability indices Cp and Cpk, using the frequency table of a histogram and effective use of the indices.

Process capability is a qualitative capability for a process, a scale used to evaluate the distribution of important product characteristics obtained through the process by comparison with specifications or standard values.

Process capability is determined by the relationship between the dispersion of product characteristics and standard values. It is usually expressed by the process capability index (below). The process capability should be evaluated when the process is stable.

Calculating the process capability index (Cp or Cpk)

The process capability index (Cp or Cpk), compares a histogram with the standards to evaluate whether a process has a capability that satisfies the standards. The methods below are used to calculate the process capability index for two-sided standards with upper and lower limits, and one-sided standards.

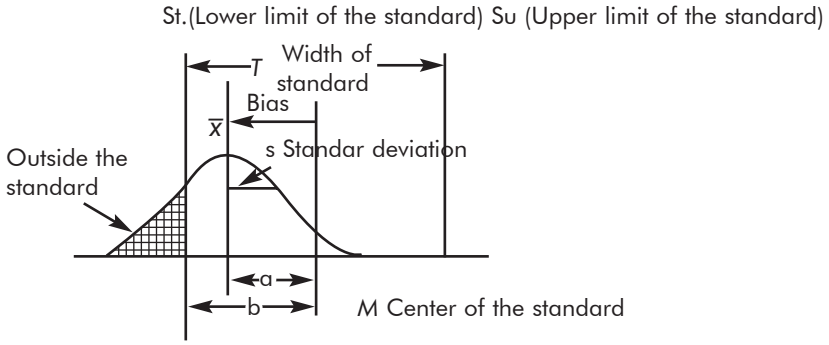
Two-sided standards with upper and lower limits

These standards set both the upper and lower limits of standard values. Process capability is calculated with the following formula.

Cp = (SU-SL)/6s = (Upper limit - lower limit)/(6×Standard deviation)

Even when the process capability index Cp is sufficiently large, characteristics do not satisfy a standard if the difference between the centre (M) of the standard and the mean value $\bar{x}$ of the characteristic is too large, or if the distribution of the characteristic is biased from the standard.

Figure 11.3.3a When the mean value is biased



To account for the biased mean value $\bar{x}$ while evaluating characteristics, use a process capability index (Cpk) to evaluate the bias. When the mean value is biased, Cp > Cpk. Otherwise, Cp = Cpk.

Cpk of a normal distribution is obtained by the following formula:

$Cpk = (1-k)Cp = (1-k)(S_U-S_L)/6s$

= (1 - degree of bias)×(Upper limit - lower limit)/(6×Standard deviation)

where K is the degree of bias.

The degree of bias (K) is obtained by the following formula, in which M is the centre of the standard value:

$K = b/a = (|M-\bar{x}|)/(T/2) = (|(S_U+S_L)/2 - \bar{x}|)/((S_U-S_L)/2)$

= |(Upper limit + lower limit)/2 - Mean value|/((Upper limit-lower limit)/2)

After drafting a histogram, you can obtain the same result by using the standard value on the biased side alone for calculation, as for a one-sided standard.

One-sided standards

One-sided standards prescribe only one limit (upper or lower). When the standard has only an upper limit (S_U), the process capability index (Cp) is obtained by the following formula.

$Cp = (S_U - \bar{x})/3s$ = (Upper limit - Mean value)/(3×Standard deviation)

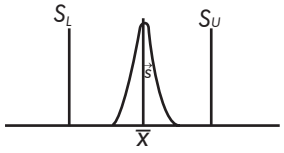
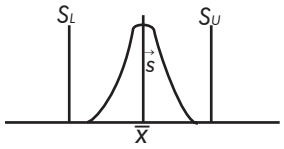
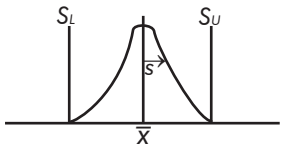
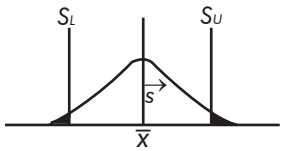
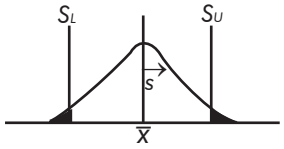
When the standard has only the lower limit (S_L), the process capability index (Cp) is obtained by the following formula.

$Cp = (\bar{x} - S_L)/3s$ = (Mean value - lower limit)/(3×Standard deviation)

Example

Use the table in Figure 11.3.3b to determine the degree of process capability.

Figure 11.3.3b Judgement criteria for process capability

No.	Value of Cp (or Cpk)	Relationship between the distribution and the standard	Judgement eciterion on process capability
1.	Cp≥1.67		Process capability is adequate, with room to spare.
2.	1.67>Cp≥1.33		Process capability is adequate.
3.	1.33>Cp≥1.00		Process capability is marginally adequate
4.	1.00>Cp≥0.67		Process capability is inadequate.
5.	0.67>Cp		Process capabilitys is markedly inadequate.

The standard value of the data for the product mass in Figure 11.3.3c is 80.0 ± 1.5kg; the mean value $\bar{x}$ = 80.182kg, and the standard deviation (s) = 0.756kg. In this case, the process capability index (Cp) is:

Cp = (SU - SL)/6s = (81.5 - 78.5)/(6×0.756) = 3.0/4.536 = 0.66

The process capability is markedly inadequate.

Figure 11.3.3c Data for product mass

Standard value 80.0±1.5									Unit kg n=100
Data									
80.0	X 78.4	79.7	O 81.6	X 79.0	79.4	80.5	81.0	X 79.1	79.6
80.5	80.0	X 79.3	81.0	80.2	80.7	78.9	79.9	80.7	80.1
O 81.4	81.0	79.7	80.6	80.0	O 81.3	80.0	80.9	O 81.2	80.2
X 78.8	80.6	80.0	80.2	79.5	79.2	79.7	O 81.5	80.2	79.9
80.5	81.1	O 81.5	80.5	80.2	80.4	X 78.6	X 79.0	79.8	81.5
80.3	79.4	79.9	X 78.8	80.1	79.4	80.2	79.4	80.3	O 82.0
80.7	80.5	80.0	79.8	O 80.8	80.0	80.5	79.1	79.7	80.5
80.6	80.3	80.5	80.8	80.5	X 78.9	80.3	80.0	80.5	X 79.4
81.2	79.4	81.1	80.1	80.3	79.8	O 81.7	79.5	80.0	80.4
81.0	O 81.2	80.1	80.7	O 80.8	79.7	80.4	79.2	79.8	79.5

Figure 11.3.3d shows the relationship between the process capability index (Cp) and the mean process defect ratio of normal distribution with a mean value not biased to either of two standards.

Figure 11.3.3d Relationship between the process capability index and the mean process defect ratio

Cp (Process capability index)	P (Mean process defect ratio)
0.67	4.55%
1	0.3%
1.33	0.006%
1.67	0.00006%
2	0.0000002%

(Note) Percentages (%) are calculated from a normal distribution

11.3.4 Stratifying data

This text describes the methods of applying stratification to process control and improvement. Stratification refers to the division of a population into different strata (groups). This should be done when individuals composing sub-populations are similar to others within the same sub-population, but differ markedly from individuals in other sub-populations.

Dividing is understanding

By stratification, items in the data that has been collected or the objects of a survey are divided into groups according to either cause or effect. Elements of a group will therefore share characteristics that differ significantly from the characteristics of a different group. Data for defective products can be divided into groups (strata) by, for example, worker, machine, equipment, method of work. Each group will have a distinctive common feature.

Method of stratification

Procedure 1: Clarify the items to be solved or the contents you want to understand.
Procedure 2: Determine the items to be stratified.
Procedure 3: Collect data for stratification.
Procedure 4: Compare stratified items using an appropriate QC method. If a difference is found, investigate the causes. If no difference is found, adopt other items for stratification and start again from procedure 2.

Key Points of Stratification

a. Stratification by result (characteristic): This examines differences between factors by stratifying data by result (characteristic). Example: Classify marketing units into those with large and small sales and compare the difference.
b. Stratification by factor (cause): This examines differences between characteristics by stratifying data by factor (cause). Draw a characteristic diagram to pick out a factor that seems to significantly affect results and stratify data by that factor. If no difference is found, select another factor. For example, if no differences are found between defect ratios classified by treatment temperature, try classifying data by machine.

Example

See the example of stratum items normally used in finding the cause of defect in Figure 11.3.4a.

Remarks

a. Comparison of stratified data is a valuable way of checking data. This will clarify the reasons for defects and the factors that affect characteristics.
b. It is also important to stratify qualitative information, and not just data expressed in numeric values.
c. An effective way to analyze a process is to use QC methods to stratify data according to various factors chosen on the basis of past experience.
d. Present the data stratified for different levels of factors in check sheets, histograms, graphs, characteristic diagrams, scatter diagrams, and control charts to clarify the differences between different strata. Once a difference is found between groups, investigate its cause. This should help to solve the quality problem.

Figure11.3.4a Example of stratum items normally used in finding the cause of defect

Stratum	Example of stratum items
1. Product	Product, name, manufacturer, design, class, size, weight, cost
2. Geography	Town, muncipality, prefecture, city, region, country
3. Marketing unit	Region, number of employee, sales, quantity of products, advertising cost, number of claims
4. Phenomenon (quality)	Appearance, size, condition of defect, weight, purity, durability, strength, content
5. Distribution route	Channel, marketing style, market, customer
6. Organization	Team, group, section, division, operation unit, plant, district, branch office, marketing unit
7. Ledger	Product name, manufacturer, design, size, color, filling, interval of recording
8. Time	Hour, day, week, month, term, season, year, morning, afternoon, day of the week, day-time, night
9. Worker	Sex, job, age, experience, qualification, job rank, character, hobby
10. Customer	Sex, job, age, character, hobby, yearly income
11. Raw material and part	Manufacturer, supplier, place of origin, brand, product number, counting, material, content
12. Machine and equipment	Machine type, model, performance, plant, line, degree of adjustment, before or after repair
13. Method of work and condition	Size, lot, place, purpose, method, speed, temperature, pressure
14. Measurement and inspection	Tester, measuring instrument, measurer, inspector
15. Environment, atmosphere and weather	Noise, ventilation, illumination, wind, atmospheric pressure, atmospheric temperature, humidity, weather

11.3.5 The QC Story

A QC story is used to control and improve processes. It is composed of the following eight steps:

a. Select a theme to work on.
b. Set targets.
c. Assess the present situation - the effects the problem has caused.
d. Analysis: investigate and analyse the causes.
e. Devise and implement recurrence prevention measures.
f. Confirm the effects of these measures.
g. Standardize, maintain and control the new methods.
h. Reflect on any problems left unsolved, and consider future countermeasures.

QC Stories, Seven QC Tools and Seven New QC Tools

Once the QC story procedures have been used to solve a problem, use the Seven QC Tools or Seven New QC Tools to report the results. This allows even those hearing the story for the first time to easily understand the series of activities that were used to solve the problem.

Example

The QC story, with the Seven QC Tools and Seven New QC Tools may be used in a presentation at a QC workshop:

Select a theme

Hold brainstorming, construct the diagrams, use a Pareto chart.

Set targets

Use a Gantt chart.

Assess the present situation

a. What are the problems? – Use Pareto chart.
b. What is the present status? – Use a histogram, check sheet, scatter diagram, graph, control chart.
c. What is the relationship between cause and effect? – Characteristic diagram, correspondence diagram, matrix diagram, PDPC method.

Repeat steps a. to c. above to clarify the current problem.

Analysis: investigate and analyse the causes

a. Does it help to stratify the data? – Use histogram, scatter diagram, graph, control chart.
b. How are the characteristics related? – Use scatter diagram, graph, control chart.
c. Do characteristics change over time? – Use histogram, graph, control chart.

Devise and implement recurrence prevention measures

Use a characteristic diagram, PDPC, arrow diagram.

Confirm the effects of these measures

Use histogram, check sheet, scatter diagram, graph, control chart, Pareto chart.

Standardize, maintain and control the new methods

a. Standardization (brake): Histogram, check sheet, scatter diagram, graph, control chart.
b. Maintenance and horizontal evolution of effects: Histogram, check sheet, scatter diagram, graph, control chart.

Reflect on any problems left unsolved, and consider future countermeasures

Use Histogram, check sheet, scatter diagram, graph, control chart.

(See Unit 9, Texts 9.9, 9.10 and 9.11 for more detailed guidelines on using the QC Story. Note that steps 2 and 3 are arranged a little differently in Unit 9, but the essence is the same.)

Remarks

a. The QC story consists of logically linked steps, without leaps or contradictions between them.
b. The Seven QC Tools and Seven New QC Tools are expressed in graphs and tables, making it easy for workshop participants to quickly and accurately grasp the overall picture of the activities.
c. Reporting the results of activities in QC circle workshops should strictly follow the QC story.
d. Achievement at each step in the QC story and the application of the Seven QC Tools and Seven New QC Tools are important elements in the evaluation score table.
e. The QC story is adopted not only in QC circles and other workplace control and improvement activities, but in group discussions in QC seminars for executives and managers both inside and outside the corporate organization in order to improve training results.

11.4 The concept of dispersion

This text presents:

11.4.1 Control charts for each process.
11.4.2 Control charts for continuous variables.
11.4.3 Control charts for discrete values.
11.4.4 Interpreting control charts.
11.4.5 Methods for using control charts.

11.4.1 Control charts for each process

A control chart is a polygonal diagram for plotting the mean value of a characteristic, the ratio of defects, or the number of defects. It shows changes in characteristics (control characteristics) and can therefore be used to check for process abnormalities. It is used to confirm that a process is stable, and to maintain its stability.

Control lines

A control chart has three lines:

a. A central line (CL) which represents the average value for all data collected.
b. Two lines that indicate control limits, the upper control limit (UCL) line and the lower control limit (LCL) line.

Points representing quality or process conditions are plotted on the chart. When these points fall between the control limit lines and do not show any particular trend, the process is stable. When the plotted points fall outside the control limit lines or show a trend, something unusual is causing this. When this happens find and eliminate the cause.

Control characteristics (values)

Control characteristics represent process results from which we learn the control status of the process. They include quality, turnout, original units, quantity and amount of sold products, rate of attendance, overtime work, number of claims and other quantities representing end results (characteristics) and control status.

Variables or continuous data

Variables or continuous data include figures for length, mass, time, strength, content, yield, and purity, and such data that can be measured in the usual way. Data of this kind can be measured in as small a unit as you wish. A monetary amount is also regarded as a variable.

Discrete values or enumerated data

Discrete values or enumerated data include figures for the number of defective products, the number of defects, the ratio of defective products, the average number of defects, and other such countable values. A percentage indicating a ratio to a total is a variable if the numerator is a variable, and a discrete value if the numerator is a discrete value.

Sub-groups

Sub-groups are sets of measurements divided into sections when differences appear in terms

of time, product, or material while checking whether they are stable. The term used for dividing measurements into groups is called sub-grouping. The number of measurements included in a subgroup is called the group size. Ideally, group size is 2 to 6 for $\bar{x}$-R control charts and 100 to 1,000 for p control charts.

Types of dispersion

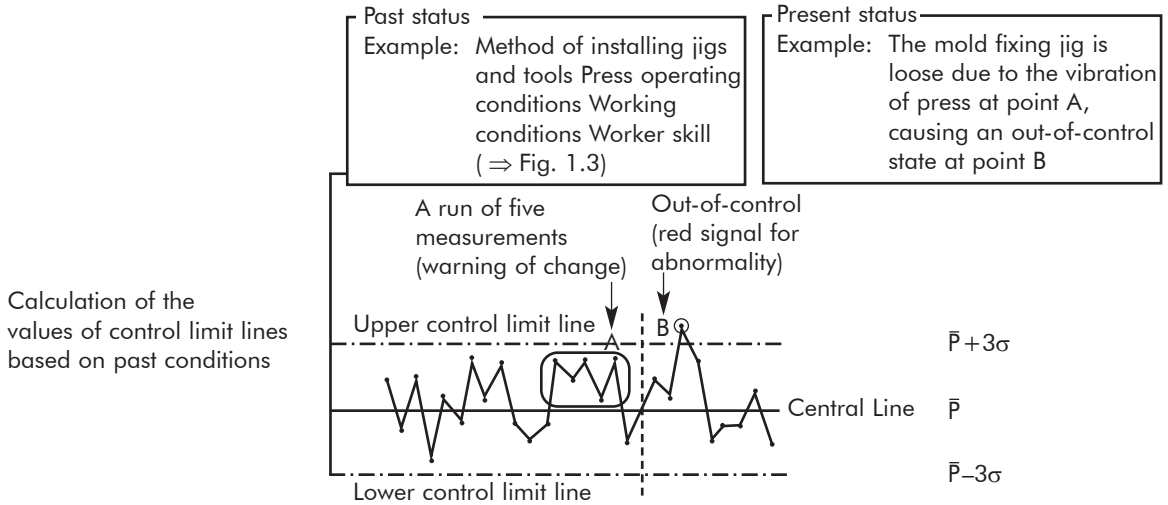
Two types of dispersion are found in data collected from a process. The first, dispersion by chance, is inevitable even in well-controlled processes. The second, dispersion due to abnormal causes, can be avoided through adequate process control. Calculate the standard deviation due to dispersion by chance and set control limit lines at a distance three times the standard deviation from the central line (the mean value of the distribution). If the process is stable, data for the control characteristics will disperse between the two control lines.

If the control lines are drawn in this way, only three out of 1,000 measurements should fall outside these lines, given unchanged process conditions or environmental conditions, machine conditions and material specifications.

This is a concept derived from the probability theory related to normal distributions. Processes are regarded as stable when the data points plotted between the control lines do not exhibit a run, trend or periodicity, because the dispersion is within tolerance or an allowable range under the set conditions. This is called dispersion by chance.

Figure 11.4.1a is a control chart of the daily defect ratio observed in a part manufacturing process by an automatic press. The point B apparently indicates an out-of-control state. In control charts, a run of seven measurements is regarded as an out-of-control state. A run of five measurements is an indication of the likelihood of an abnormal change for which action should be taken before an error actually occurs. In contrast to ordinary graphs, control charts track the trend of data points plotted in the chart and produce a clear cut judgement on process normalcy.

Figure 11.4.1a Control chart for defect ratio



Using a control chart

Controlling a process with a control chart calls for periodic observations. In order to confirm that the process is normal, you must plot data on the chart and check that data points do not fall outside the control limit lines or mark a trend (a special feature).

Types of control chart

There are two types of control charts. One is used for process analysis, and the other is used for process control.

Control chart for process analysis

This chart is formed by drawing control lines based on the data already recorded, provided that process conditions at the time of data collection are clear. If no data is recorded, record the process conditions precisely and collect data for the control chart. (Initially a control chart can be used to identify specific assignable causes of variation. These assignable causes must then be eliminated to achieve a state of control).

Control chart for process control

This chart is used to determine the presence of abnormalities in a process. It is formed by the daily plotting of data and makes use of the control lines of a control chart for process analysis. (Once you have confirmed that the process is under control with the control chart for process analysis, you can extend the chart's control lines and use them for a control chart for process control.) The control lines of a control chart for process analysis are drawn as broken lines (----), and those for process control as lines composed of dashes and dots (- . -). The central line is a solid line in both charts. (After using the control chart for process analysis, it can be used to maintain processes in a stable condition).

Categories of control chart

$\bar{x}$-R Control Chart (Variables)

The $\bar{x}$ -R control chart consists of an $\bar{x}$ control chart used to check changes in the mean value, and an R control chart used to check changes in dispersion. The $\bar{x}$-R control chart represents the largest quantity of information among the different control chart categories.

$\tilde{x}$-R Control Chart (Variables)

This control chart uses the median $\tilde{x}$ of X in place of $\bar{x}$ in the $\bar{x}$-R control chart to eliminate the calculation of $\bar{x}$. However, compared to the $\bar{x}$ control chart, the $\tilde{x}$ control chart is somewhat less efficient in detecting abnormalities.

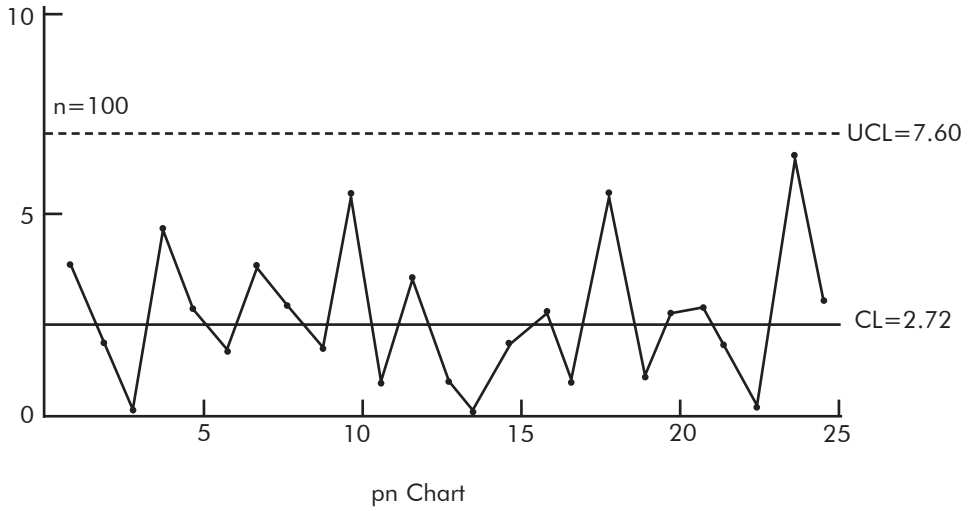
X Control Chart

This control chart uses individual measurements (X) without dividing them into subgroups.

pn Control Chart (Discrete Values)

pn control charts are used to control a process with the number of defective products (pn) in the total samples by judging the quality of each product, whether it is accepted or rejected. The sample size (quantity of products) should be the same for different groups. Since the pn control chart is a particular case of a p control chart in which n is constant, the two control chart types are fundamentally the same.

Figure 11.4.1b pn chart



p Control Chart (discrete values)
p control charts are used to control a process with the defect ratio (p). Sample size (n) does not have to be equal for different groups.

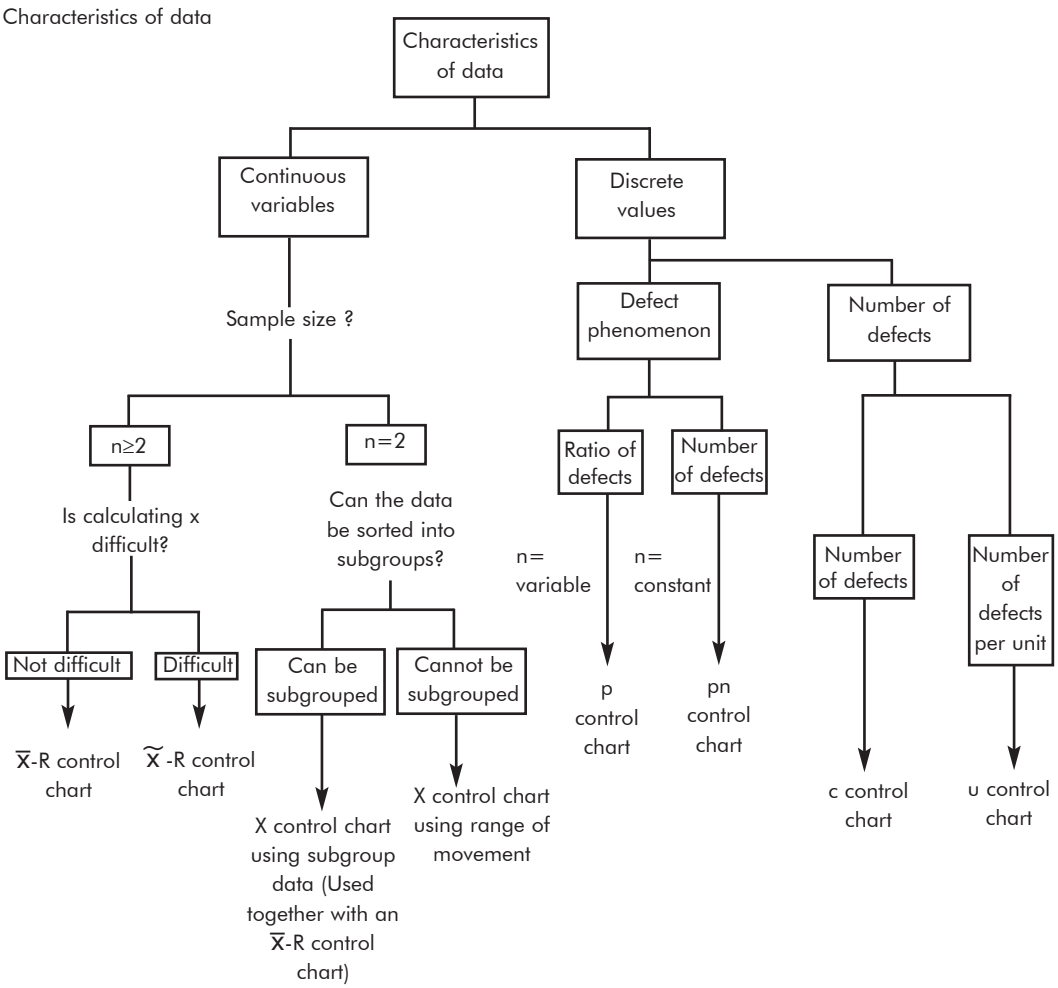
c Control Chart (discrete values)
c control charts are used to control a process with the number of defects, accidents, or failures in a certain unit or during a certain period of time, when the range of possible defects is constant.

u Control Chart (discrete values)
u control charts are used to control a process with the number of defects in a certain unit of products when the range of possible defects changes.

Selecting a control chart

Select one of these control charts according to the object or data to be controlled. Follow the steps in Figure 11.4.1c on the next page.

Figure 11.4.1c Steps in selecting a control chart



11.4.2 Control charts for continuous variables

This text describes how to draft a control chart for continuous variables and to apply it to control and improve processes. These charts are used to assess quality conditions with a small number of samples. There are three subtypes of control charts for continuous variables:

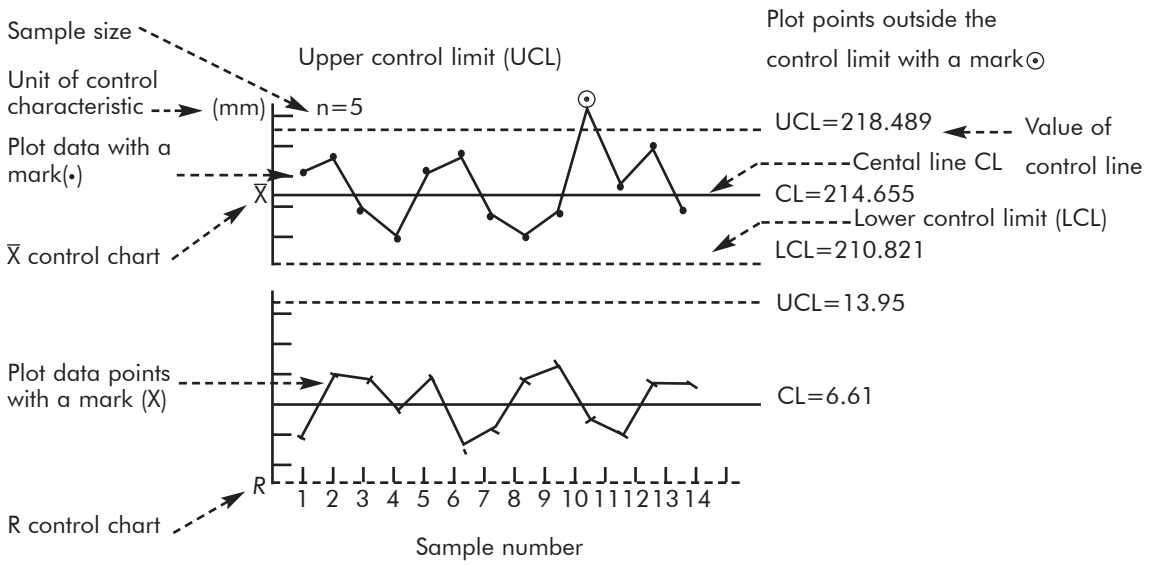
- $\bar{x}$-R control chart
- $\tilde{x}$-R control chart
- X control chart (X-Rs control chart)

The $\bar{x}$-R control chart is the one that is most widely used. If you have mastered drawing and using a $\bar{x}$-R control chart, you will find it relatively easy to understand the other control charts.

$\bar{x}$-R Control Chart

The $\bar{x}$-R control chart is composed of an $\bar{x}$ control chart, used to check changes in the mean value, and an R control chart, used to cheek changes in dispersion. It represents the largest volume of information among the different control charts.

Figure 11.4.2a Concept of $\bar{x}$-R control chart



$\bar{x}$ control chart:

Central line: CL = $\bar{x}$

Upper control limit: UCL = $\bar{x}$-$A_2\bar{R}$

Lower control limit: LCL = $\bar{x}$-$A_2\bar{R}$

R control chart:

Central line: CL = $\bar{R}$

Upper control limit: UCL =$D_4\bar{R}$

Lower control limit: LCL = $D_3\bar{R}$

A_2, D_4 and D_3 are coefficients determined by subgroup size (n). (See Figure 11.4.2b.)

$\tilde{x}$-R Control Chart

The $\tilde{x}$-R control chart uses the median $\tilde{x}$ in place of $\bar{x}$ for the groups in $\bar{x}$-R control charts, eliminating the calculation of $\bar{x}$. Although not as efficient in detecting abnormalities as control charts, its applications and method of use are the same as those for control charts.

X Control Chart (X-Rs Control Chart)

The X control chart uses individual measurements (X) in the following cases:

a. When only one measurement is available (e.g., power consumption per day).
b. When the process is almost the same, and a single data point is sufficient for representing the process (e.g., the concentration of alcohol).
c. When obtaining certain measurements is time consuming and costly (e.g., some chemical analyses).

Control limit lines for X control charts:

- UCL = $\bar{x}$+$E_2\bar{R}$s
- LCL = $\bar{x}$-$E_2\bar{R}$s, where E_2= $\sqrt{n}$ A_2

Control limit lines for Rs control charts.

- UCL = $D_4\bar{R}$s, LCL is not applicable:
- (When n = 2, E_2 = 2.659 and D_4 = 3.267)

Figure 11.4.2b Control chart coefficients

Sample size	x control chart	R control chart				x control chart	x control chart
n	A_2	d_2	$1/d_2$	D_3	D_4	$m_3 A_2$	E_2
2	1.880	1.128	0.8862	–	3.267	1.880	2.659
3	1.023	1.693	0.5908	–	2.575	1.187	1.772
4	0.729	2.059	0.4857	–	2.282	0.796	1.457
5	0.577	2.326	0.4299	–	2.115	0.691	1.290
6	0.483	2.534	0.3946	–	2.004	0.549	1.184
7	0.419	2.704	0.3698	0.076	1.924	0.509	1.109
8	0.373	2.847	0.3512	0.136	1.864	0.432	1.054
9	0.337	2.970	0.3367	0.184	1.816	0.412	1.010
10	0.308	3.078	0.3249	0.223	1.777	0.363	0.975

Note:

d_2: A coefficient indicating the relation of $\bar{R}$ to the standard deviation s for a specific value of n. When the estimated s is denoted by $\hat{\sigma}$: $\sigma\bar{R}/d_2$. Using this coefficient, s can be estimated.

A_2: A coefficient indicating the relationship between $\bar{R}$ and the distance $3\sigma/\sqrt{n}$ between CL of the $\bar{x}$ control chart and the control limit.

D_3: A coefficient indicating the relationship between $\bar{R}$ and LCL of the R control chart (CL – three times the standard deviation of R). The line "-" in the column D_3 indicates that LCL is not applicable.

D_4: A coefficient indicating the relationship between $\bar{x}$ and UCL of the R control chart (CL + three times the standard deviation of R).

11.4.3 Control charts for discrete values

This text describes how to draft a control chart for discrete values and to apply it to process control. This chart allows control of statistics that are difficult to quantify.

Categories of control chart for discrete values

Control charts for discrete values are:

a. pn control chart
b. p control chart
c. c control chart
d. u control chart

pn control charts are a special case of p control charts in which n is constant. There are no fundamental differences between these two control chart types. If you already understand pn

and n control charts, you should have few problems understanding the other control charts. Unlike the $\bar{x}$-R control chart which combines two kinds of control charts, control charts for discrete values use only one chart. The method of determining control lines differs from that for continuous variables, but the basic concept is the same. Control charts for discrete values are classified as shown in Figure 11.4.3a by characteristic.

Figure 11.4.3a Categories of control chart for discrete values

Discrete values	pn control chart	Control chart for the number of defective products	Group size is constant, so processes are controlled by the number of defective products
	pn control chart	Control chart of defect ratio	The group size is not constant – processes can be controlled by the defect ratio, rather than number of defective products
	pn control chart	Control chart for the number of defects	The group size is constant, so processes are controlled with the number of defects
	pn control chart	Contol chart of the number of defects per unit	Since group size is not constant, processes can be controlled by the number of defects per unit, rather than number of defect

How to draw a control chart for discrete values

p Control Chart (Discrete Values)

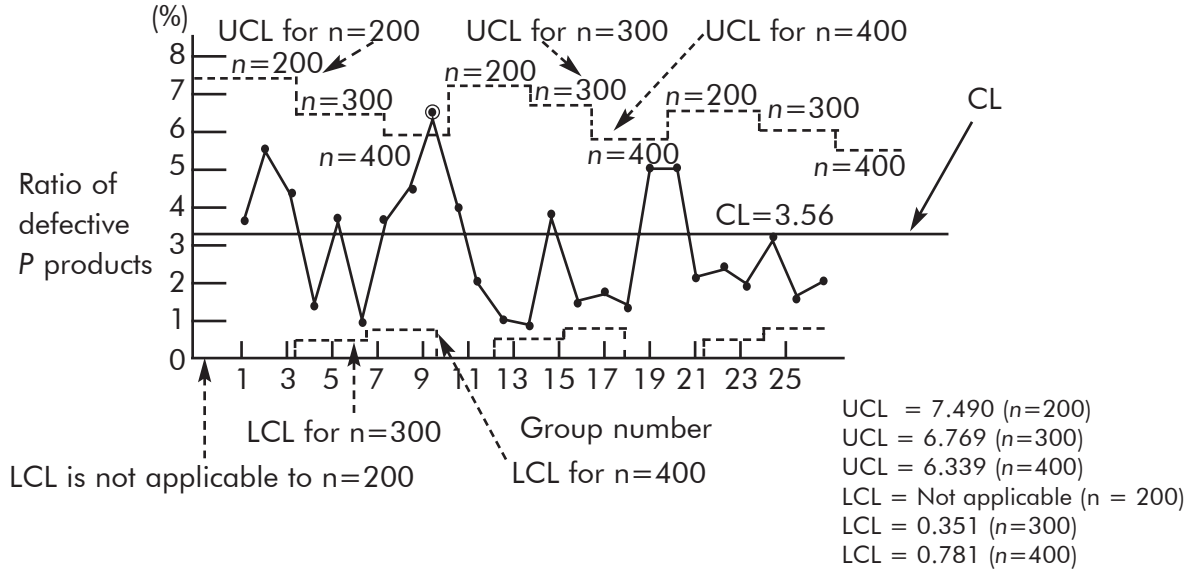
Values of p control chart:

Central line: CL = $\bar{P}$

Upper control limit line: UCL = $\bar{P}+3\sqrt{\bar{P}(1-\bar{P})/\bar{n}}$

Lower control limit line: LCL = $\bar{P}-3\sqrt{\bar{P}(1-\bar{P})/\bar{n}}$

Figure 11.4.3b Control chart for discrete values (p control chart)



Key points in drawing a control chart

To use a control chart for discrete values to analyze and evaluate a process effectively, you must collect data for at least twenty groups. The average ratio of defective products ($\underline{P}$) used for p control charts is not the average ratio of defective products in each group, but is calculated using the following formula:

$\overline{P}$ = Total number of defective products/Total number of inspected products.

This provides an average weighted by sample size (n), which differs from group to group. Although the values of control limits differ for different sample sizes (n) in p control charts, they can be made constant in simplified p control charts that use the average of n which differs from group to group. The average of n ($\overline{n}$) is obtained using the following formula:

$\overline{n}$ = Total of the values of n/Number of groups (k)

When this method is used, the values of n should not differ significantly from group to group, but should fall in the following range:

$\overline{n}/2$ to 2n

The charts are relatively easy to use, since control limit lines do not fluctuate. However, to evaluate data points close to a control line, you must determine control limit lines exactly, using the correct value of n for the group in question.

Determining control limit lines for discrete values

Figure 11.4.3c Method of determining control limit lines for discrete values

Category of control chart	CL	UCL, LCL
pn control chart	$\overline{P}n$	$\overline{P}n \pm 3x \sqrt{\overline{P}n(1-\overline{P})}$
p control chart	$\overline{P}$	$\overline{P}n \pm 3x \sqrt{\overline{P}n(1-\overline{P})/n}$
c control chart	$\overline{c}$	$\overline{c} \pm 3 \sqrt{\overline{c}}$
u control chart	$\overline{u}$	$\overline{u} \pm 3 \sqrt{\overline{u}}$

pn Control Chart (Discrete Values)

pn Control charts are used to control a process with the number of defective products (pn) in the total sample, by judging the quality of each product, whether accepted or rejected. In this case, the sample size n (quantity of products) should be the same for different groups. The pn control chart is a special case of the p control chart when n is constant. There are no fundamental differences between these two control chart types.

c Control Chart

c Control charts are used to control a process using the number of defects in a certain unit or number of accidents or failures during a certain period of time when the range of possible defects is constant.

u Control Chart

As with c control charts, u control charts are used to control a process using the number of defects in a certain unit or number of products when the range of possible defects changes.

Examples

pn Control Chart

pn control charts are used to control a process with a constant sample size, using the number of defective products (pn). For the pn value, you can use the number of normal products in selected defective products, the number of second class products, or the number of specific products with some other characteristic.

Procedure 1: Collecting data

a. Select 20 to 25 groups of data of the same sample size and count the number pn of defective products in each group.
b. Estimate the ratio of defective products in the process being examined and determine a sample size so that a group contains one to five defective products.

Namely:

As pn = 1 to 5, n =$1/\bar{P}$ to $5/\bar{P}$

If the estimate is that $\bar{P}$ = 5%, for example, n = 1/0.05 to 5/0.05 = 20 to 100

Caution:

From $\bar{P}$ = 5%, take care not to assume that n = 1/5 to 5/5 = 0.2 to 1

Calculate n from $\bar{P}$ = 5% = 0.05.

Procedure 2: Determination of control limit lines

Central line

$$\overline{pn} = \frac{\Sigma^{k}_{i=1} pn}{k} = \frac{(pn)_1 + (pn)_2 + \ldots + (pn)_k}{k}$$

Where:

pn: Number of defective products in a group

$\Sigma^{k}_{i=1} pn$: Total of the number of defective products in k groups

k: Number of groups

The values of control limits are calculated using the following formulae:

Upper control limit UCL=$(\overline{pn} + 3\sqrt{\overline{pn}(1-\bar{p})})$

Lower control limit LCL=$(\overline{pn} - 3\sqrt{\overline{pn}(1-\bar{p})})$

Determine the values of control limits to one less significant digit than for measurements. The average process defect ratio (*P*) is obtained using the following formula and the formula for the central line *pn*.

$$\bar{p}n = \frac{\Sigma^{k}_{i=1} pn}{kn} = \frac{(pn)_1 + (pn)_2 + \ldots + (pn)_k}{kn}$$

When the calculated value is negative, LCL is not applicable.

Procedure 3: Drawing a control chart

a. Scale the Y axis for the number of defective parts (pn), and the X axis for the number of groups (k).
b. Plot the number of defective parts for each group.
c. Draw control lines.
   i. Draw a solid line with scale marks for 15n at the centre.
   ii. Draw broken lines for UCL and LCL with scale marks.
   iii. Enter the value of n.

Procedure 4: Confirmation of stability

Example 1

Assume that a process performs surface treatment for lots consisting of 200 parts. Figure 11.4.3d shows the number of parts with defective surface treatment in each lot, as observed by inspection. Check whether the process is stable.

Figure 11.4.3d

No.	pn	No.	pn	No.	pn	No.	pn
1	4	6	3	11	1	16	0
2	5	7	5	12	2	17	0
3	0	8	5	13	2	18	1
4	1	9	6	14	3	19	2
5	2	10	1	15	5	20	4
						Total	52

$n = 200$

$\sum^{h}_{1=1} pn = 52$

$\bar{p}n = \frac{\sum pn}{k} = \frac{52}{20} = 2.6$

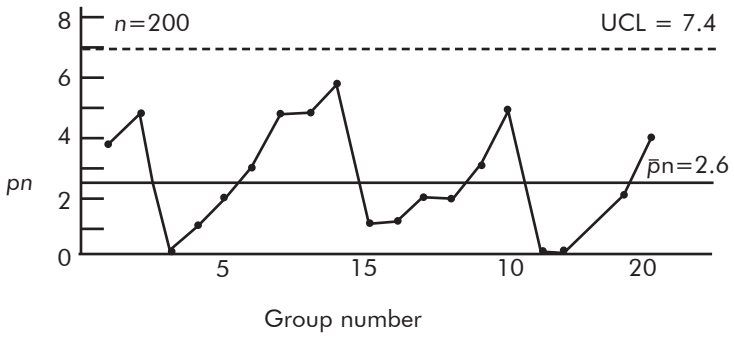
$\bar{p} = \frac{\sum pn}{\sum n} = \frac{52}{20 \times 200} = 0.013$

$3\sqrt{\bar{p}n\,(1-\bar{p})} = 4.8$

$UCL = \bar{p}n + 3\sqrt{\bar{p}n\,(1-\bar{p})} = 2.6 + 4.8 = 7.4$

$UCL = \bar{p}n - 3\sqrt{\bar{p}n\,(1-\bar{p})} = 2.6 - 4.8 = \text{Not applicable}$

Figure 11.4.3e



The data does not fall outside the control limits, but has a periodicity leading to increases at pitches of 6 to 7 groups, before suddenly dropping, indicating instability. Investigate the cause.

p Control Chart

p control charts are used to control a process. The sample size need not be equal for different groups. Drawing a p control chart is the same as drawing a pn control chart, except for the formulae needed to calculate control limits. Ranges differ for different sample sizes (n).

Procedure 1: Data collection

Estimate the defect ratio for the process and determine a sample size so that a sample includes 1 to 5 defective parts. Count the number of defective parts in approximately 20 to 25 samples.

Procedure 2: Calculating the value of p

Calculate the ratio p of defective parts in each group.

$$p = pn/n$$

where

pn: Number of defective parts in a sample,

n: Sample size for each group.

Procedure 3: Calculation of the values of control limits

Central line

$$\bar{p} = \frac{\Sigma^{k}_{i=1} pn}{\Sigma^{n}} = \frac{(pn)_1 + (pn)_2 + \ldots + (pn)_k}{n_1 + n_2 + \ldots + n_k}$$

where

$\Sigma^{k}_{i=1} pn$: Total number of defective parts

$\Sigma^{k}_{i=1} n$: Total number of inspected parts

k: Number of groups

Caution: The value of $\bar{p}$ is not the arithmetic mean of the ratios of defective parts in all groups.

The control limits are calculated using the following formulae:

Upper control limit UCL = $\bar{p}+3\sqrt{\bar{p}\,(1-\bar{p})/n}$

Lower control limit LCL = $\bar{p}-3\sqrt{\bar{p}\,(1-\bar{p})/n}$

Calculate the values to one less significant digit than for $\bar{p}$.

Remark 1: When the sample size differs from group to group, calculate the control limits for each group and apply the results to each data point, with the central line unchanged. When drawn in the control chart, the control limit lines exhibits a wave pattern; and the larger the value of n, the smaller the range.

Remark 2: Even when the sample size differs from group to group, you can approximate the control limits by using n, or the mean value of n, and applying the following method, if the sample sizes n of different groups are within ±50% of the mean value n.

For data close to a control line, do not use the above simplified method. Instead, evaluate by calculating the control limit.

Example 2

Figure 11.4.3f shows the number of defective parts obtained by a complete inspection of lots in a part machining process. Draw a control chart and determine whether the process is stable.

Figure 11.4.3f

No.	n	pn	No.	n	pn	No.	n	pn	No.	n	pn
1	100	0	6	100	3	11	100	3	16	72	4
2	90	1	7	100	2	12	64	2	17	90	0
3	81	0	8	81	1	13	90	5	18	81	3
4	100	4	9	90	4	14	64	2	19	81	2
5	90	2	10	72	0	15	100	3	20	100	6
									Total	**1746**	**47**

$$\bar{p}=\frac{\sum_{1=1}^{k} pn}{\sum_{1=1}^{k} n}=\frac{47}{1746}=0.0269\ (2.69\%)$$

$\sqrt{\bar{p}\,(1-\bar{p})}=16.18\%$

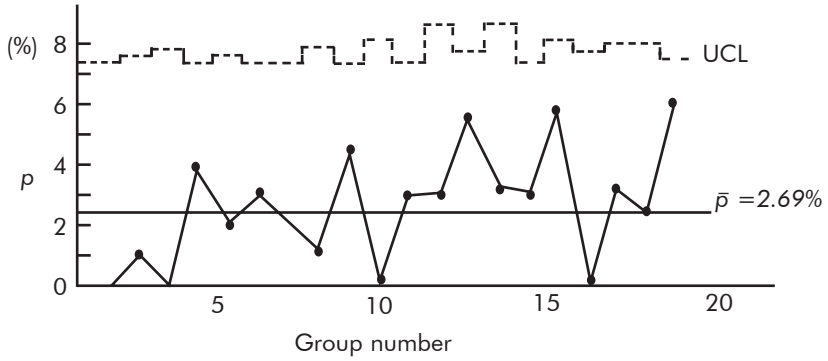
Calculation of the values of control limit lines

For the first group: as n=100 $\frac{3}{\sqrt{n}}=\frac{3}{\sqrt{100}}=0.30$

$\frac{3}{\sqrt{n}}\times\sqrt{\bar{p}(1-\bar{p})}=0.30\times 16.18=4.85\%$

UCL 2.69 + 4.85 = 7.54%
LCL 2.69 - 4.85 = -2.16% (Not applicable)
Repeat the above calculations for other groups.

Figure 11.4.3g



The figure shows that data does not fall outside the control limits.
[Using the simplified method.]

$$\bar{n} = \frac{\Sigma^{k}_{i=1} n}{k} = \frac{1746}{20} = 87.3$$

Since the maximum sample size is 100 and the minimum is 64, the sample sizes are within 50% of the mean value n therefore the simplified method can be used.

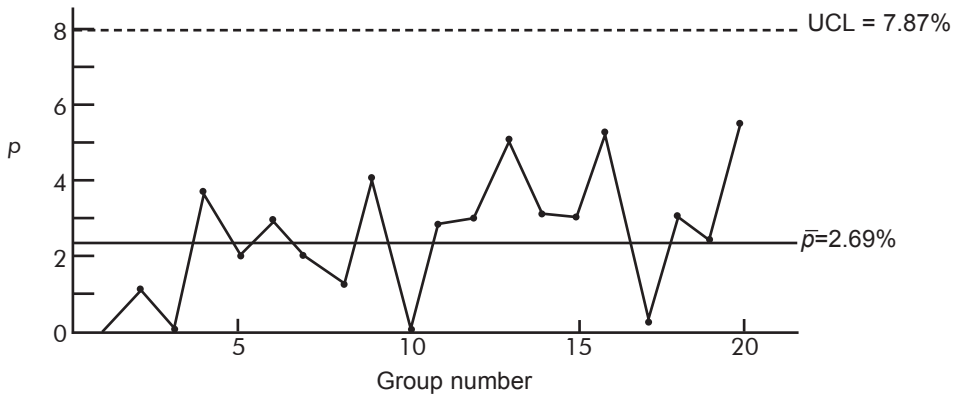
As n= 87, $3/\sqrt{n}$ = 0.3. As p= 0.0269%, $\sqrt{p(1-p)}$= 0.1618=16.18%

$3/\sqrt{n} \times \sqrt{p(1-p)}$= 0.32 × 16.18 = 5.18%

UCL = 2.69+5.18=7.87%

LCL = 2.69-5.18=-2.49%

Figure 11.4.3h



Remarks: to obtain the value of $3/\sqrt{n}$, calculate $\sqrt{n} \times 3/n$ using a hand-held calculator.

Figure 11.4.3i Example of p control data sheet

Group number	Sample size n	Number of defective parts pn	Ratio of defective parts p	$\frac{3}{\sqrt{n}}$	$\frac{3}{\sqrt{n}}x\sqrt{\bar{p}\ (1-\bar{p})}$	UCL $\bar{p}+\frac{3}{\sqrt{n}}\sqrt{\bar{p}(1-\bar{p})}$	LCL $\bar{p}-\frac{3}{\sqrt{n}}\sqrt{\bar{p}(1-\bar{p})}$
1	100	0	0%	0.30	4.85%	7.54%	–
2	90	1	1.1	0.32	5.18	7.87	–
3	81	0	0	0.33	5.34	8.03	
4	100	4	4.0	0.30	4.85	7.54	–
5	90	2	2.2	0.32	5.18	7.87	–
6	100	3	3.0	0.30	4.85	7.54	–
7	100	2	2.0	0.30	4.85	7.54	–
8	81	1	12	0.33	5.34	8.03	–
9	90	4	4.4	0.32	5.18	7.87	–
10	72	0	0	0.35	5.67	8.36	–
11	100	3	3.0	0.30	4.85	7.54	–
12	64	2	3.1	0.38	6.15	8.84	–
13	90	5	5.6	0.32	5.18	7.87	–
14	64	2	3.1	0.38	6.15	8.84	–
15	100	3	3.0	0.30	4.85	7.54	–
16	72	4	5.6	0.35	5.67	8.36	–
17	90	0	0	0.32	5.18	7.87	–
18	81	3	3.7	0.33	5.34	8.03	–
19	81	2	2.5	0.33	5.34	8.03	–
20	100	6	6.0	0.30	4.85	7.54	–
	$\sum_{1=1}^{k} n$	$\sum_{1=1}^{k} pn$					
Total	1746	47					

$\bar{p}=\sum_{1=1}^{k} pn / \sum_{1=1}^{k} n = 47/1746 = 0.0269\ (2.69\%)$

$\sqrt{\bar{p}\ (1-\bar{p})} = 16.18\%$

c Control Chart

c control charts are used to control a process having a constant range in which defects may appear. For example, design mistakes or drawing mistakes within a design department, pinholes in the gold plating of wristwatch cases of a specific size, or the number of accidents in a specific plant can be controlled by using c control charts.

Procedure 1: Collecting data

a. Select 20 to 25 groups of data of the same sample size and count the number c of defects in each group.
b. Estimate the number of process defects and set the sample size so that a sample has 1 to 5 defects. For example, when the estimated number of defects = 1 for products with the same dimension, select a sample size (number of products in this case) n = 1 to 5.

Procedure 2: Calculation of the values of control limit lines

Central line:

$$\bar{c} = \frac{\Sigma_{i=1}^{k} c}{k} = \frac{c_1 + c_2 + \ldots + c_k}{k}$$

where:

c : Number of defects in a group
$\Sigma_{i=1}^{k} c$: Total number of defects
k : Number of groups

Calculate the value to one less significant digit than for the measurements. c is the average number of process defects. Calculate the control limits using the following formulae:

Upper control limit UCL = $\bar{c} + 3\sqrt{\bar{c}}$
Lower control limit LCL = $\bar{c} + 3\sqrt{\bar{c}}$

Calculate the values to one less significant digit than for measurements.
Remark: If the calculated value is negative, the LCL is not applicable.

Procedure 3: Drawing a control chart.

a. Scale the Y axis for the number of defects (c), and the X axis for the number of groups (k).
b. Plot the number of defects for each group.
c. Draw control lines.
    i. Draw a solid line with scale marks for c at the centre.
    ii. Draw broken lines for UCL and LCL with scale marks.

Procedure 4: Confirmation of stability

Example 3

A c control chart is used to confirm the stability of a machining process of glass substrates (of the same dimension) for liquid crystal displays. Figure 11.4.3j shows the number of faults and bubbles found by inspection for each glass substrate.

Figure 11.4.3j Confirming the stability of a process

Group	Number of defects	Group	Number of defects	Group	Number of defects
1	4	11	7	21	1
2	6	12	0	22	3
3	1	13	1	23	5
4	4	14	5	24	4
5	4	15	6	25	6
6	1	16	4	26	4
7	4	17	2	27	4
8	2	18	1	28	2
9	5	19	2	29	2
10	2	20	3	30	4
				Total	**99**

$\sum_{1=1}^{k} c = 99$

$\bar{c} = \sum c/k = 99/30 = 3.3$

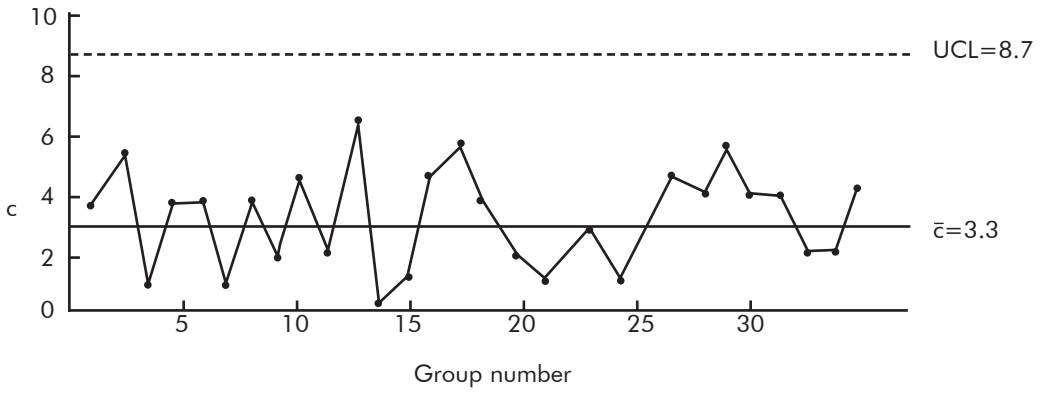
$3\sqrt{\bar{c}} = 5.4$

$\sqrt{\bar{c}} = 5.4$

$UCL = \bar{c} + 3\sqrt{\bar{c}} = 3.3 + 5.4 = 8.7$

$UCL = \bar{c} - 3\sqrt{\bar{c}} = 3.3 - 5.4 =$ Not applicable

Figure 11.4.3k indicates the process is stable



u Control Chart

u control charts are used to control processes in which defects appear in different ranges, such as a process where liquid crystal panels having different dimensions are manufactured following the same steps. The process is controlled based on the number of defects. Note that u control charts use the number of defects per unit.

Procedure 1: Collecting data

a. Count the sample size (e.g., dimension, length or time) and the number of defects c in approximately 20 to 25 samples.
b. Estimate the number of defects in the process and set a sample size so that a sample has an average of 1 to 5 defects.

Procedure 2: Calculation of the values of control limit lines

The sample size differs from group to group, so determine the sample size n by unit.
The sample size n is the number of units included in a group. When the unit is $1m^2$, for example, n=5 for a dimension of $5m^2$.

Central line:

$$\bar{u} = \frac{\Sigma^{k}_{i=1} c}{\Sigma^{k}_{i=1} n}$$

where

$\Sigma^{k}_{i=1} c$: Total number of defects

$\Sigma^{k}_{i=1} n$: Total number of sample sizes n

Control limits are calculated using the following formulae:

$$\text{Upper control limit UCL} = \bar{u} + 3\sqrt{u/n}$$
$$\text{Lower control limit LCL} = \bar{u} - 3\sqrt{u/n}$$

Calculate the values to one less significant digit than for measurements. Calculate the number of defects u per unit using the following formula.

$$u = c/n$$

where

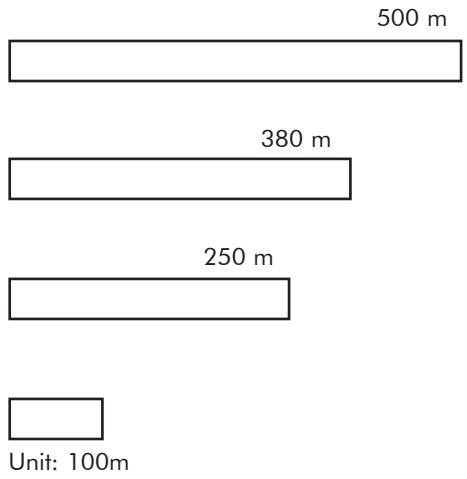
c: number of defects in a sample.

n: Sample size.

Example 4

Assume a copper plate roll process that has a recorded productivity of 500, 380,and 250m, and 20, 19 and 20 defects, respectively, over one day. When the unit is set to a length of 100m, the sample size and number of defects per unit are calculated as shown in Figure 11.4.3l.

Figure 11.4.3l Explanatory illustration



Number of defects	Sample size n	Number of defects per unit u
20	5.0	4
19	3.8	5
20	2.5	8

$n = 500 \div 100 = 5$ $\quad u = 20 \div 5 = 4$

$n = 380 \div 100 = 3.8$ $\quad u = 19 \div 3.8 = 5$

$n = 25 \div 100 = 2.5$ $\quad u = 20 \div 2.5 = 8$

$$\bar{u} = \frac{59}{11.3} = 5.2$$

When the sample size differs from group to group, calculate the control limits for each group and apply the results to each data point. When drawn in the control chart, the control limit lines exhibit a wave pattern; and the larger the value of n, the smaller the range.
Even when the sample size differs from group to group, you can approximate the control limits by using $\underline{n}$ and applying it to all data points, if the sample sizes n of different groups are within $\pm 50\%$ of the mean value $\bar{n}$. This is shown by:

$$\bar{u} + 3\sqrt{u/n}$$

For data close to a control line, do not use the above simplified method. Instead evaluate by calculating the control limit with the correct value of n.

Procedure 3: Drawing a control chart

a. Scale the Y axis for the number of defects per unit (u), and the X axis for the number of groups (k).
b. Plot the number of defects for each group.
c. Draw control lines.
   i. Draw a solid line with scale marks for U at the centre.
   ii. Draw broken lines for UCL and LCL with scale marks.

Procedure 4: Confirmation of stability

Example 5

Figure 11.4.3m shows the number of defects in liquid crystal glass panels of varying sizes manufactured for hand held calculator. Draw a control chart to confirm the stability of the process. The value u in the table is the number of defects per unit dimension of a glass panel.

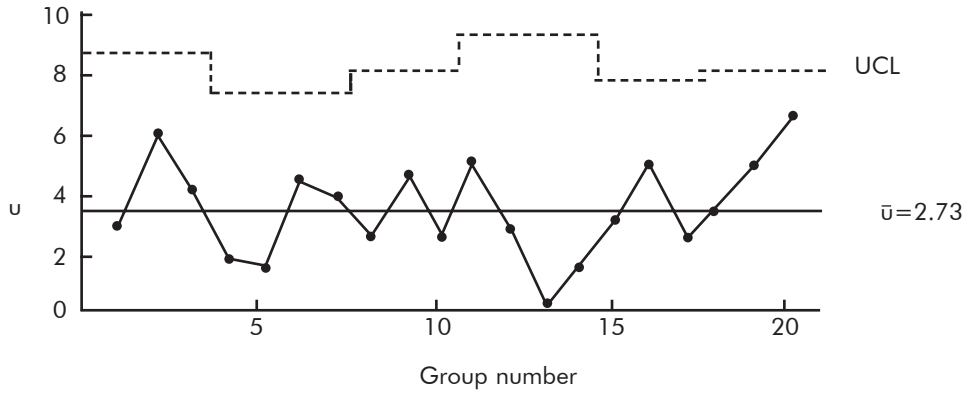
$$\bar{u} = \frac{\Sigma^{k}_{i=1} c}{\Sigma^{k}_{i=1} n} = 2.73$$

$$3\sqrt{u} = 4.96$$

Figure 11.4.3m

Sample number	Sample size n	Number of defects	Number of defects per unit	$\frac{1}{\sqrt{n}}$	UCL	LCL
1	1.2	3	2.50	0.913	7.26	–
2	1.2	6	5.00	0.913	7.26	–
3	1.2	4	3.33	0.913	7.26	–
4	2.0	3	1.50	0.707	6.23	–
5	2.0	2	1.00	0.707	6.23	–
6	2.0	7	3.50	0.707	6.23	–
7	2.0	6	3.00	0.707	6.23	–
8	1.5	3	2.00	0.816	6.77	–
9	1.5	5	3.33	0.816	6.77	–
10	1.5	3	2.00	0.816	6.77	–
11	1.0	4	4.00	1.0	7.69	–
12	1.0	2	2.00	1.0	7.69	–
13	1.0	0	0	1.0	7.69	–
14	1.0	1	1.00	1.0	7.69	–
15	1.7	4	2.35	0.767	6.53	–
16	1.7	7	4.12	0.767	6.53	–
17	1.7	3	1.76	0.767	6.53	–
18	1.5	4	2.67	0.816	6.77	–
19	1.5	6	4.00	0.816	6.77	–
20	1.5	8	5.33	0.816	6.77	–
Total	29.7	81	–	–	–	

Figure 11.4.3n



11.4.4 Interpreting control charts

As we have seen, control charts are characterized by a central line, and upper and lower control limit lines that are used as a scale to check data dispersion around the central line. Circumstances for which a data point falls outside the control limit lines are referred to as "out-of-control" states. Data points fall outside limit lines:

a. By chance, or
b. Due to a process abnormality.

Falling outside by chance has a probability of about 0.27% in the Shewhart chart (three sigma chart), or three times per 1,000 plots. Because of this low probability, the fundamental principle of using a control chart is to interpret an out of control incident as being due to a process abnormality and to find the cause of the abnormality.

The criteria that are used to judge whether a process is controlled or stable are presented below. Ideally, the status of a process should be evaluated with 25 or more measurements.

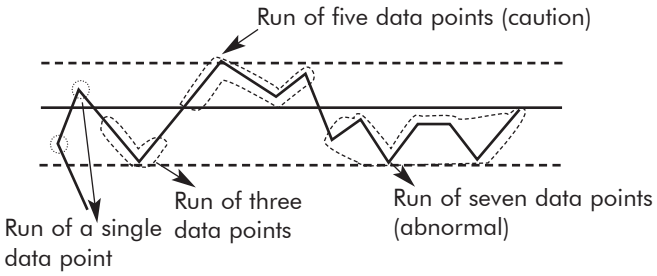
A process can be considered to be controlled in the following cases:

a. Data points do not fall on or outside the control limit lines, nor do they mark a trend.
b. 25 or more successive data points fall within the control limit lines.
c. Among 35 successive data points, only one data point for which an abnormality is not detected falls outside the control limit lines.
d. Among 100 successive data points, only one or two data points for which an abnormality is not detected fall outside the control limit lines.

A process is considered abnormal in the following cases:

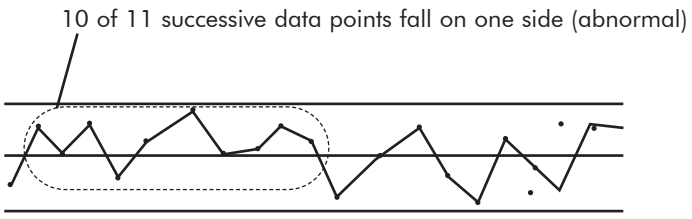
a. Data points are on and outside the control limit lines.
b. Though all data points fall within the control lines, a run of seven data points falls on one side of the central line (the median line). Pay close attention to the process if you observe a run of five to six such data points.

Figure 11.4.4a Runs



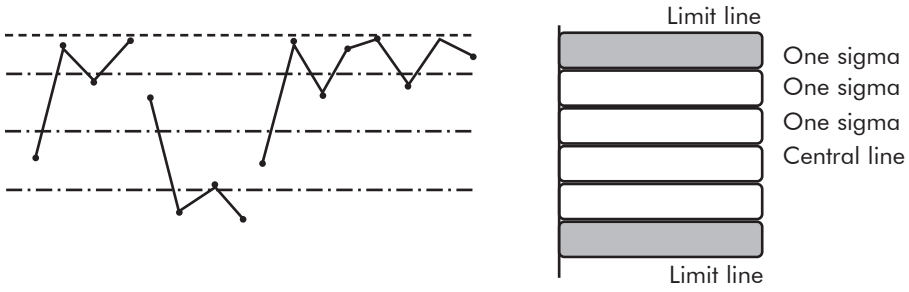
c. Even for a run on one side of the central line of fewer than seven data points, the process is abnormal if any of the following is true:
   i. 10 of 11 successive data points fall on one side.
   ii. At least 12 of 14 successive data points fall on one side.
   iii. At least 14 of 17 successive data points fall on one side.
   iv. At least 16 of 20 successive data points fall on one side.

Figure 11.4.4b Run of data points on one side of the central line



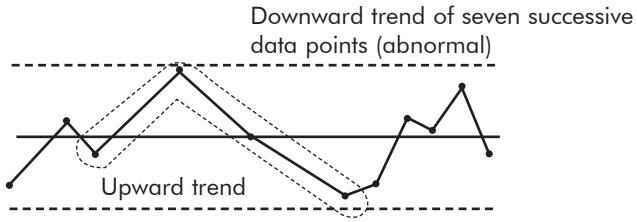
d. The process can be deemed abnormal when data points frequently appear close to the control limit lines. On either side of the central line, divide the range between the central line and the control limit line with another new line at a position two thirds of the way from the central line. If data points fall between the new lines and the control limit line on either side in the following manner, the process is abnormal:
   i. 2 of 3 successive data points fall in the range.
   ii. 3 of 7 successive data points fall in the range.
   iii. 4 of 10 successive data points fall in the range.
   In the above cases, the process can safely be considered abnormal, since only about 5% of data points fall outside the ±2s range from the central line in normal processes.

Figure 11.4.4c Data points close to control limit lines



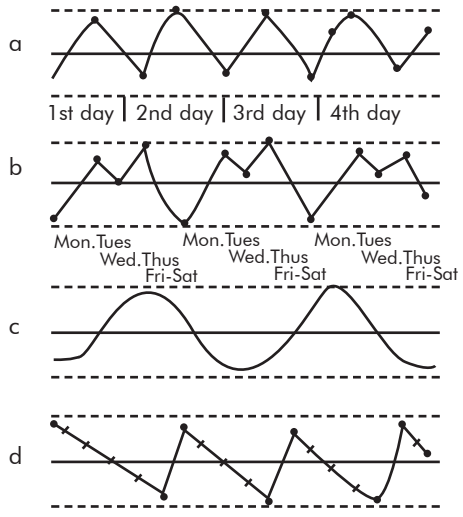
e. The process can be deemed abnormal when at least seven successive points form an upward or downward trend.

Figure 11.4.4d Trends



f. If data points exhibit periodicity, the process is abnormal.

Figure 11.4.4e Periodicity



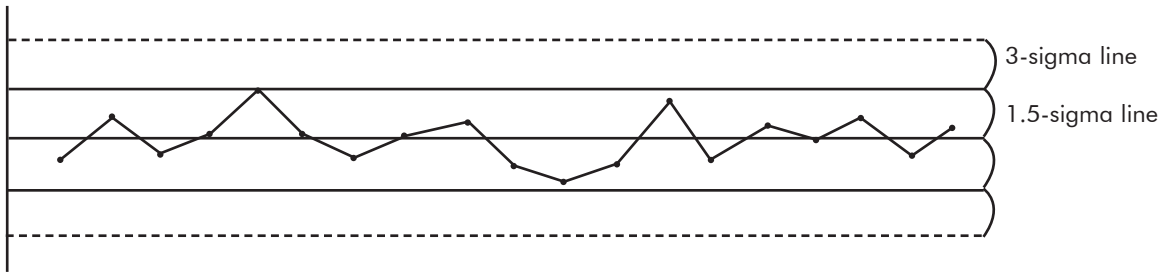
A daily periodicity is often seen with furnaces for which the temperature is not controlled or automatic lathes for special purposes

A weekly periodicity is seen in the ratios for attendance, defects, and yields

A sine wave periodicity does not necessarily indicate an abnormal process. If a cause can be located and the phenomenon is found to recur, the process may be normal

A saw-tooth wave periodicity is often seen with automatic machining processes when tools are repeatedly adjusted. If a cause can be located and the phenomenon is found to recur, the process may be normal by same judgement as (c)

Figure 11.4.4f Concentration toward the central line



g. If data points suddenly begin to concentrate around the central line within the range or from the central line – in a process that has been stable up to that point, the process is abnormal. This phenomenon is seen when heterogeneous data is contained in a group.

Remarks

It is important to train all workers involved so they can perceive abnormal values. When abnormal data is reported, take immediate action.

11.4.5 Methods for using control charts

This text describes how to use control charts to control and analyse processes.

Process control

Control charts for process control

Control charts are particularly effective in controlling processes. Draw a control chart for process analysis for the characteristic to be controlled. When a process has been judged as stable, extend the control lines and use it as a process control chart.

Revision of control lines

Control lines should be revised in the following cases:

a. When workers, methods of work, materials, or machines change.
b. When a control chart indicates a change in the process.
c. Even for a stable process, when a certain length of time (e.g. three months) has passed.

Abnormalities in a process

When an abnormality is seen in a process, find the cause immediately and correct it. Systematise procedures for this purpose so that quick action can be taken when an abnormality is confirmed. Use an Abnormality Report to report abnormalities promptly to the authorities responsible for taking the first course of action.

Process analysis

Process analysis determines the factors that affect the characteristics of a process, and how they affect it, and sets out the actions needed to improve the process. You should therefore use process analysis when you want to find problems in the process. Set work standards and decide on the process control method.

To use control charts effectively:

a. Draw stratified control charts.
b. Devise an efficient method for sub-grouping.
c. Devise an efficient sampling method.

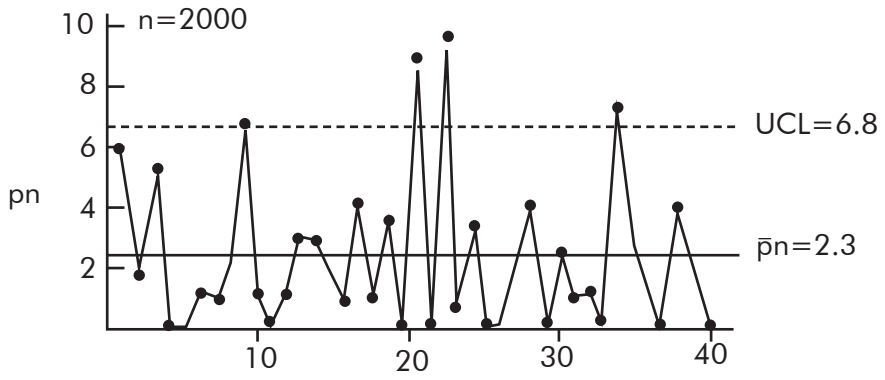
Draw stratified control charts

You can often locate the cause of a problem by drawing control charts stratified by time, worker, or machine, comparing mean values and dispersions, and looking for differences in defect ratios. (See Text 11.5.4 on stratification of data.) This requires data for each lot, classified by raw material, machine, worker, day and time of work, working condition, and other causal factors. Figure 11.4.5a is a control chart of defect ratio for entire production lots. When stratified by machine, as shown in Figure 11.4.5b, it clearly shows that machine number 1 is under control, while machine number 2 is problematic.

Devise an efficient sampling method

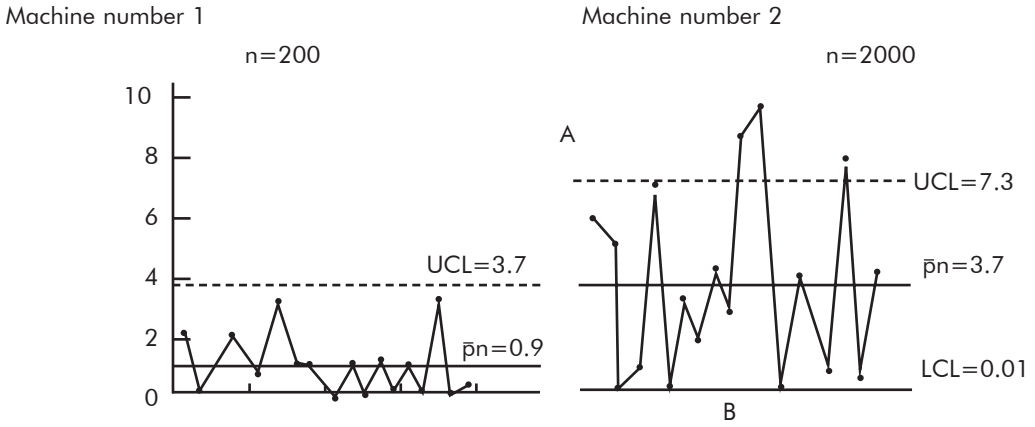
The method of sampling determines whether process conditions are reflected in $\bar{x}$ control charts. Select a sampling method that gathers data points in the $\bar{x}$ chart representative of each group. Clarify changes in process conditions from a technological viewpoint. Clarify what you want to control. Determine a sampling interval and a sampling method.

Figure 11.4.5a



	Machine number 1	Machine number 2	Total
Above the central line	2	12	14
Below the central line	18	8	26

Figure 11.4.5b



11.5 Applying various statistical techniques

This text presents:

11.5.1 Applying statistical techniques: the QC Tools.
11.5.2 Appropriate applications for the QC tools.
11.5.3 Applying control charts to process control.
11.5.4 Applying statistical techniques to defect ratio control.
11.5.5 The process abnormality report sheet.

11.5.1 Applying statistical techniques: the QC Tools

Modern quality control makes wide use of statistical techniques. It is essential to recognise the value of these techniques in controlling and improving processes in a variety of company activities, to be able to select those that are appropriate, and to apply them effectively. Key statistical techniques required to promote TQM are found in the Seven QC Tools and the New Seven Tools for QC. In addition to these, the following are also effective:

a. Test and estimation.
b. Correlation and regression analysis.
c. Design of experiments.
d. Multivariate analysis.
e. Statistical sampling.
f. Sensory test.
g. Reliability test.

Statistical techniques can be applied to:

a. Market analysis and product design.
b. Dependability specification and estimation of life and durability.
c. Process control and research of process capability.
d. Determination of quality level in planning sampling tests.
e. Data analysis, performance evaluation, and nonconformity analysis.
f. Process improvement.
g. Safety evaluation and risk analysis.
h. Claim analysis for shipped products.

These techniques are widely used to make improvements in quality and in costs, quantities, and corporate structures closely related to product quality, and in other activities related to TQM throughout the company.

Introducing and using statistical techniques

Statistical techniques should be introduced step by step for the following purposes:

To reduce product defects:

a. Instruct workers to become conscious of problems and be willing to make improvements. Eliminate customer claims.
b. Study and introduce the Seven QC Tools and master the methods used to apply them.

To eliminate product defects:

a. Apply the Seven QC Tools consistently to stabilize processes and keep them under control.
b. Master statistical techniques such as test and estimation.

To improve quality and achieve zero defects:

a. Pursue optimum conditions to attain the highest quality characteristics through experiment design and multivariate analysis.

In developing new products and new technologies:

a. Apply statistical techniques to develop and introduce new technologies and to raise product quality.

Applying statistical techniques

Base application on facts

Quality control expresses facts in the form of data, it processes dispersed phenomena using statistical techniques, and it yields objective judgments of the results. Given accurate data expressed in numeric values, we can use statistical techniques to implement control and improvement measures.

Support statistical techniques with engineering technologies

Statistical techniques are incapable of solving problems without the aid of engineering technologies. They provide clues to the essence of a problem while engineering technologies provide actual problem-solving methods. Engineering technologies will be developed in this process. Statistical techniques demonstrate their power only when backed up by excellent engineering technologies.

Notice dispersions

When we apply statistical techniques to express quality characteristics we consider dispersion as well as mean value.

Identify the causes

A control chart is a powerful statistical technique in determining whether dispersion of quality characteristics results from chance or is due to an abnormality.

Analyse the relation between quality characteristics and process conditions

In seeking to raise product quality, we can use statistical techniques as an effective means of examining the dispersion of a product's quality characteristics and analyzing their relation to process conditions.

Improve quality

In seeking optimized process conditions for quality improvement, we can draw scatter diagrams and perform correlation and regression analyses of quality characteristic data for different process conditions. Multivariate analysis (including multiple regression analysis and principal component analysis) and experiment design are especially useful when investigating several process conditions simultaneously.

Perform actions on a population

To perform appropriate actions on a population, we estimate the conditions of the population, based on data. This data must first be sampled and collected, and then analyzed statistically.

Remarks

a. Keep in mind that statistical techniques are a means to an end.
b. Be familiar with the history of the data to which statistical techniques are applied. Use accurate and appropriate data.
c. Make effective use of simple methods. Apply the Seven QC Tools first. Newer and more sophisticated statistical methods do not necessarily provide better (or even adequate) results.
d. Make sure you understand the characteristics of statistical techniques and methods before using them. Avoid errors in applying them.
e. Use plain, everyday language to report the results obtained by using statistical techniques.

11.5.2 Appropriate applications for the QC tools

This text shows how various TQM methods can be applied to a wide range of business activities.

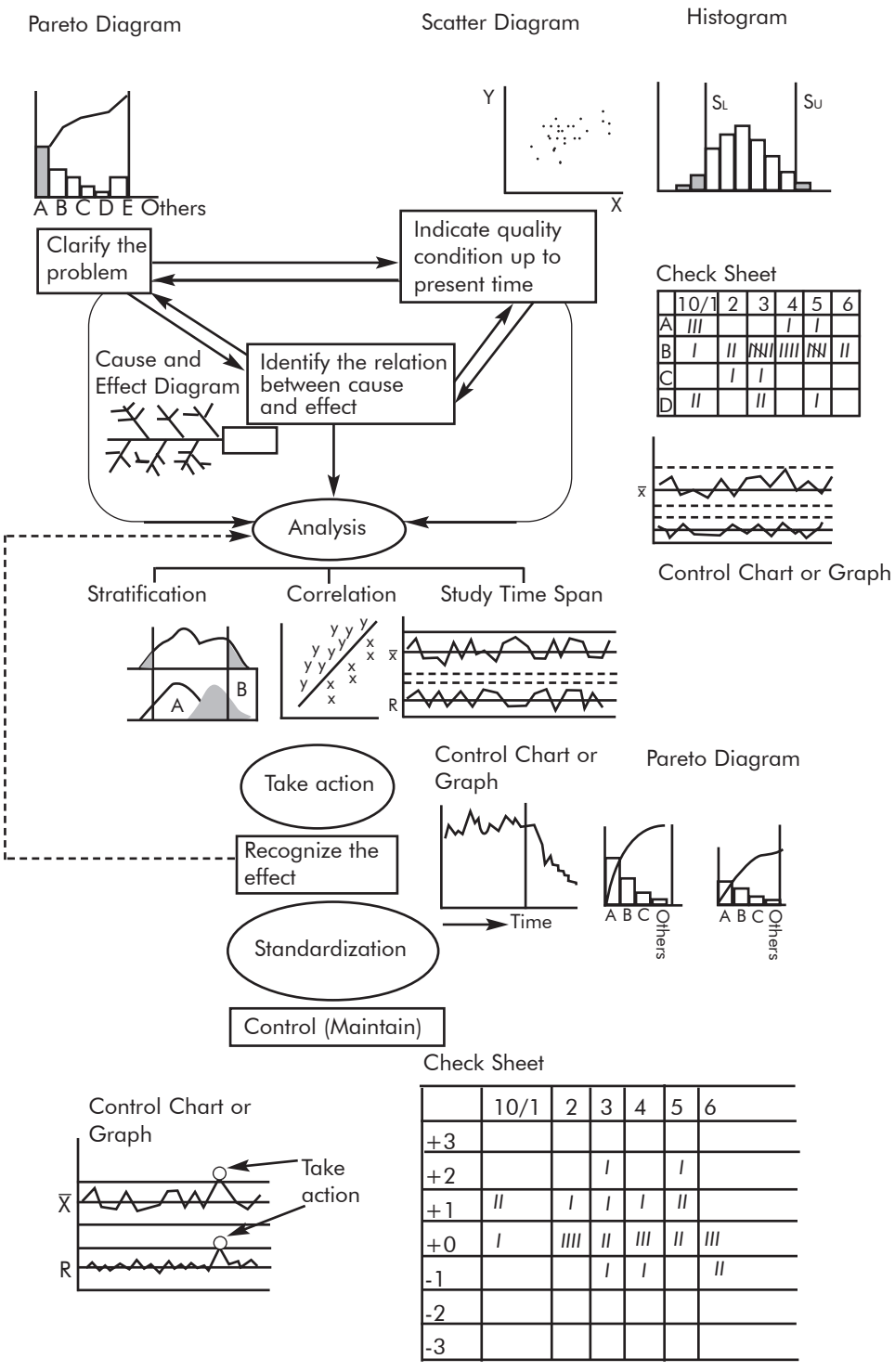
TQM is widely used in Japan and has produced successful results not only in the manufacturing industry but also in the construction and service industries. Modern QC techniques, including the Seven QC Tools and New Seven Tools for QC, have been widely promulgated through QC education, and there is widespread familiarity with improvement activities based on the QC story. The QC story, a positive data-based method, is regarded as being the most reliable of the different problem-solving methods in quality control and the one with the widest range of applications. The participation of employees in the development of TQM can be strengthened by giving them the opportunity to give presentations in QC workshops.

To use the Seven QC Tools and New Seven Tools for QC effectively in corporate problem solving, one must understand the specific purposes and results of the various methods they include. The problem-solving process in the QC Story should proceed through the following activities, always keeping in mind their interdependence:

a. Select a theme.
b. Set targets.
c. Assess the present situation.
d. Analysis: Investigate and analyse the causes
e. Devise and implement recurrence prevention measures
f. Confirm the effects of these measures
g. Standardize, maintain and control the new methods.
h. Reflect on any problems left unsolved, and consider future countermeasures.

Choose a suitable method from among the Seven QC Tools, New Seven Tools for QC, and other statistical methods to objectively assess a specific situation and to find the most effective means of solving a problem. Figure 11.5.2a shows the procedures and appropriate statistical techniques that can be used.

Figure 11.5.2a Using the Seven QC Tools



By T. Yoneyama: Textbook of QC practice (JUSE)

11.5.3 Applying control charts to process control

This text describes how to use statistical techniques based on facts and data to control processes effectively.

Outline of process

Here we take the example of a metal plate grinding process. This process grinds rectangular metal plates to a standard thickness, using five sets of jigs, each receiving ten plates from the previous process. The process measures the thickness of a plate and halts grinding on attaining the standard value. The difference between the measured and standard thickness of the plate is defined as the control characteristic of the process.

Control characteristic = Measured thickness - Standard thickness

Classification of factors

We classified the following factors:

a. Change of material (change in the group).
b. Change in the previous process (change in the group).
c. Change due to irregularities to do with the jig (change in the group).
d. Change due to differences between jigs (change in the group).
e. Change due to different timings for halting grinding (change in the group).
f. Change over time (change in the group).

Collection of data

We selected five metal plates from a jig at random and measured their thickness.

Process Analysis

Part 1.

To check the present status, we collected data from 40 groups (200 measurements) and drew a control chart (Figure 11.5.3a). The figure shows that the mean value has decreased over time as a result of factor f) (Change over time). In the R control chart, data points have fallen out of control, indicating an unstable process.

Part 2.

By taking into account changes in the conditions of the grinding tool over time, we standardized the frequency of grinding and collected data from 40 groups. Although changes over time are eliminated in the control chart (Figure 11.5.3b), the mean value still exhibits wide fluctuations. The R control chart has stabilized.

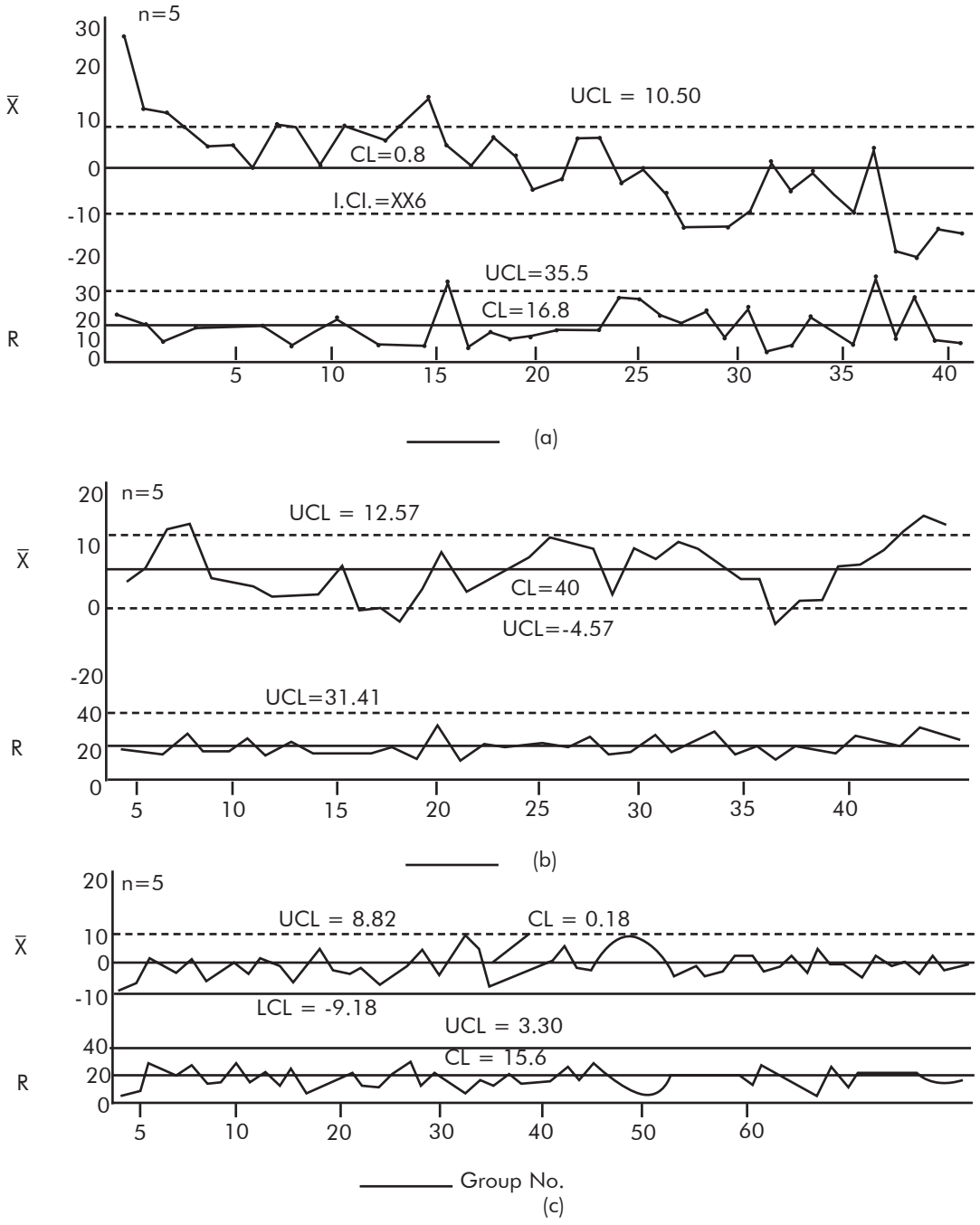
Part 3.

We suspected that the fluctuations of the mean value were due largely to the timing of halting grinding, or by factor e) (Change due to different timings for halting grinding), since the method for measuring thickness was faulty. We improved and standardized the use of the measuring instrument, collected data from 60 groups, and drew a control chart (Figure 11.5.3c). These steps resulted in a significant reduction in change between groups, but within-group changes remained unchanged.

Conclusion

By analyzing the process using control charts, we were able to reduce between-group changes. Next, we adopted a theme to reduce the changes remaining within each group.

Figure 11.5.3a,b,c $\bar{x}$-R control chart for plate thickness in a grinding process



11.5.4 Applying statistical techniques to defect ratio control

This text describes how to use stratification of data to gain a significant lowering of defect ratios.

Status of overall defect ratios

A pottery using four furnaces produces defective products of different types. On average, a particular furnace bakes 2,214 products. Figure 11.5.4a shows a control chart for all defect ratios. The figure indicates that the process is markedly out of control.

Stratification by furnace and work team

Of the four furnaces, numbers 1, 2, 5, and 6, No. 1 and No. 2 are attended by team A and No. 5 and No. 6 are attended by team B. Figure 11.5.4b shows a control chart for defect ratios stratified by furnace. The defect ratio appears higher for furnaces 5 and 6, but data points fall in the out-of-control region for all furnaces, suggesting that the cause of the problem lies elsewhere, and not in the furnaces.

Stratification by defect phenomena

To investigate the problem from a different perspective, we stratified the data by defect phenomena into data groups for four different recorded defect items. Look at Figure 11.5.4c for the following phenomena:

a. Defect phenomenon A. The successive data points 14, 15, and 16 are out of control. After examining the product types for these data points, we successfully located the cause of this phenomenon.
b. Defect phenomenon B. Since we were unable to obtain useful information from this defect phenomenon, which has a number of unknown causes, we stratified the data by worker and date.
c. Defect phenomenon C. The process rapidly returns to normal after data point 7, due to technological improvements (changes in glazing method and the addition of temperature sensors). Since some data points still fell out-of-control after these improvements, we stratified the data by another factor, as we did for defect phenomenon B.
d. Defect phenomenon D. This phenomenon was extremely unstable. Plots divided by team A and team B indicated a difference between the two teams. Since the skill of workers in team B was in doubt, it was decided that they should receive training.

Conclusion

In the case described above, we stratified the data by equipment, worker and defect phenomenon. We may also profit from stratifying data by other factors such as cause of defect and date.

Figure 11.5.4a Total defect ratio control chart (sanitary earthenware)

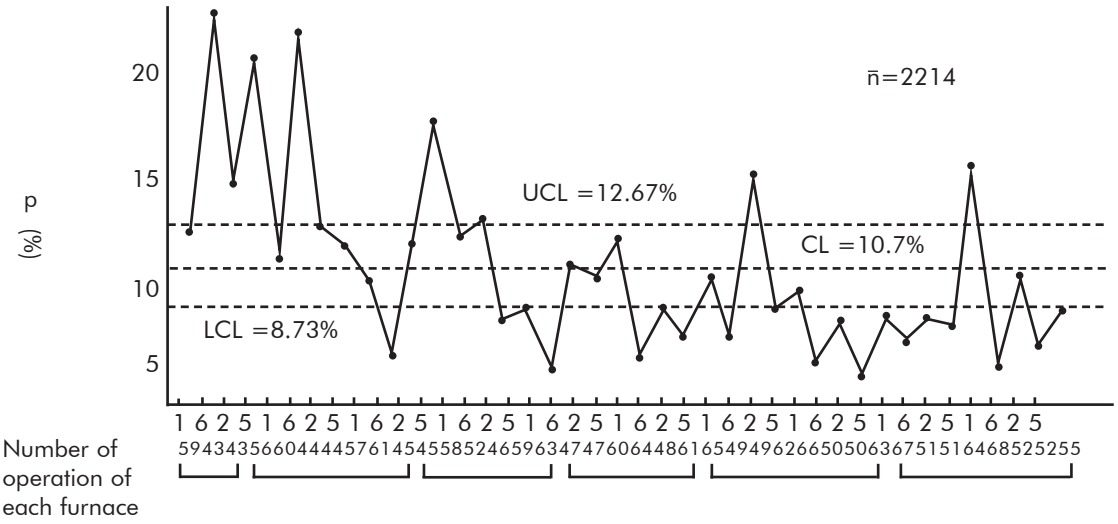


Figure 11.5.4b A control chart of total defect ratios stratified by furnaces

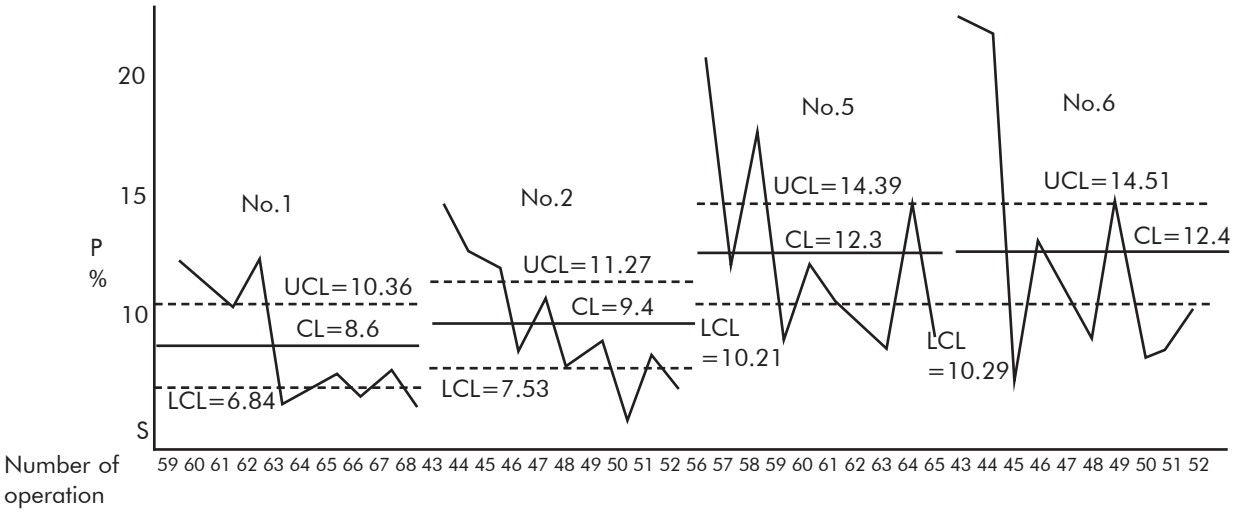
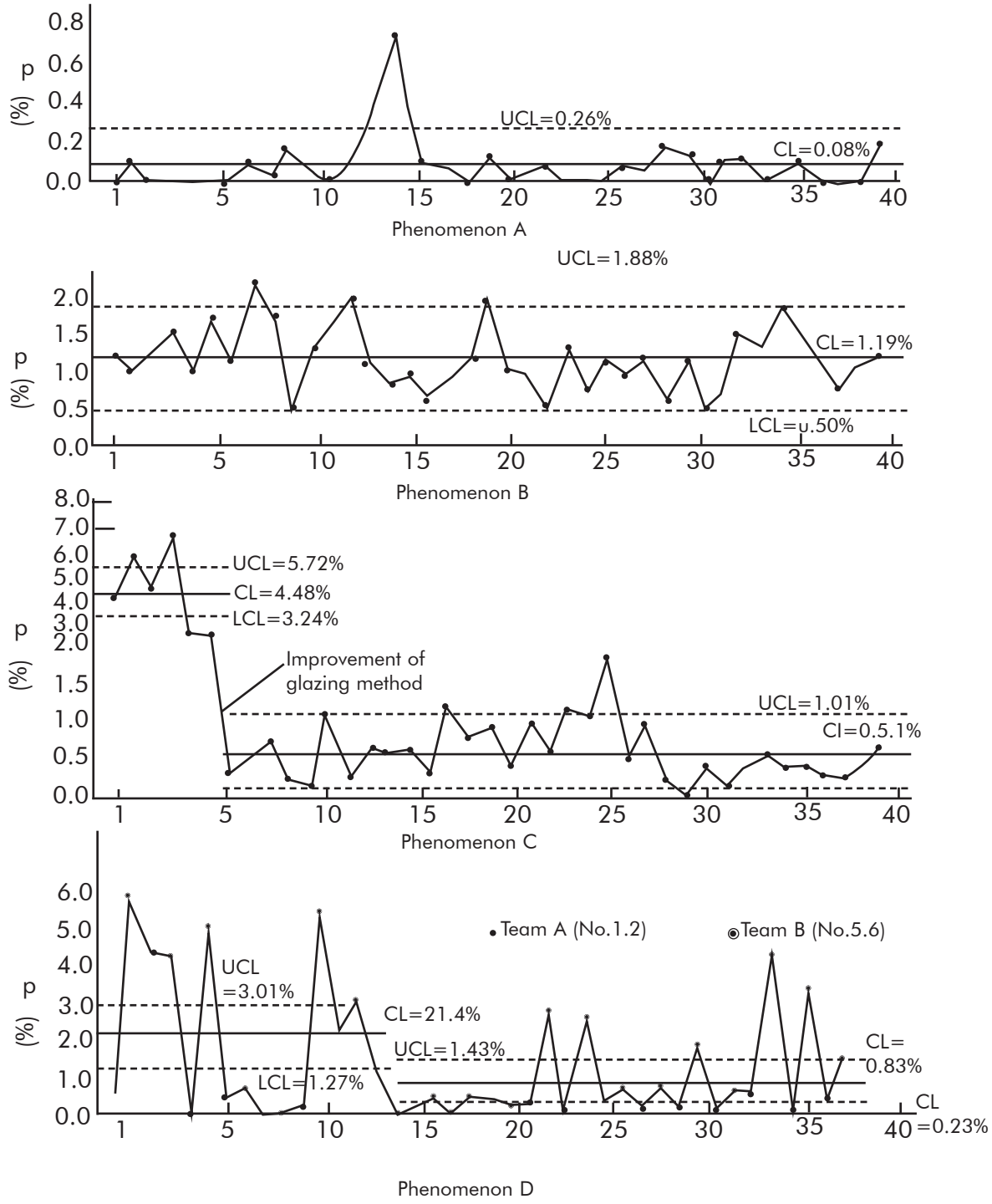


Figure 11.5.4c A control chart for defect ratios stratified by defect phenomena



11.5.5 The process abnormality report sheet

This text describes how to improve quality and productivity by establishing a system that enables managers to recognize process abnormalities when they occur and to ensure and verify that action is taken.

Use a process abnormality report sheet to:
a. Report process abnormalities promptly.
b. Verify that proper actions are taken.
c. Analyse and correct abnormalities to prevent their repeated occurrence.
d. File abnormalities, organise research on countermeasures, and provide a reference to determine investment priorities for plants and facilities.

The report should contain:
a. Serial number.
b. Process conditions: Control chart number, name of process, product, control characteristics, lot number, lot conditions, worker, and other information.
c. Contents of abnormality: Date of occurrence, time, conditions of abnormality, person detecting abnormality.
d. Cause: The cause, if identified, and the views of the person in charge.
e. Actions: Temporary measures, immediate actions taken against cause and process, date of correction and adjustment, notification of other departments, and related information.
f. Survey: Survey of measures to prevent repeated occurrence.
g. Measures to prevent repeated occurrence: Countermeasures to prevent repeated occurrence, future outlook, date that countermeasures are fully implemented, and results.
h. Confirmation of countermeasures and future control methods.
i. Others: Person responsible, person reporting, those receiving the circulated report, filing departments, and related information.

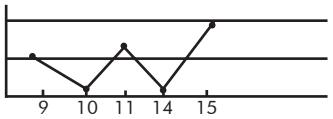
Adopt a standard for the report, including the following:
a. What data should be entered? Who completes the report and when? How many copies should be issued?
b. Method of circulation.
c. Determine the system to be maintained until the final solution of the abnormality, especially before implementing measures to prevent repeated occurrence and confirming the results.

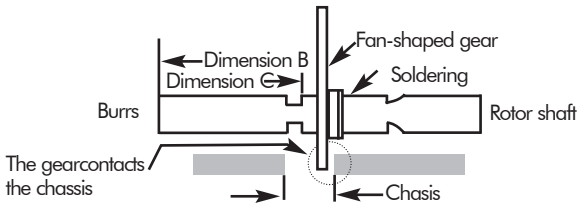
Notes for Figure 11.5.5a
a. Date and time are clarified for each step, from detection of the abnormality to the implementation of steps to prevent reoccurrence and to the confirmation of results.
b. Confirmation of the results of action taken.
c. The form has columns for notification of relevant departments and sections.

Remarks
Establish a corporate system to notify other departments as soon as possible, providing drawings and pictures, if available.

Figure 11.5.5a Example of a process abnormality report sheet.

Serial No. UA-009 **Process abnormality report sheet**

<table>
<tr><td rowspan="4">Occurrence of abnormality</td><td>Machine</td><td>ENT-86814</td><td>Control chart registration number</td><td>20-2-Tuu-A3-2</td><td>Date and time of occurrence</td></tr>
<tr><td>Process</td><td>PRE.TEST</td><td>Lot number</td><td></td><td rowspan="2">February 15
AM..hours
PM 5 hours</td></tr>
<tr><td>Quality characterstic</td><td>Electrical performance (waveform)</td><td>Worker (Inspector)</td><td></td></tr>
<tr><td colspan="5">Three percent, according to a control chart that stratifies changes in the waveform
 

UCL=1.12
CL=0.3</td><td>Detector</td></tr>
<tr><td>Investigation of cause</td><td colspan="5">The position of fan-shaped gear (dimension C) was determined in the past using the rotor shaft groove as a reference. To improve efficiency, the fan-shaped gear reference. As a result, the dispersion of dimension C has increased, due to burrs on the rotor shaft and other factors, which cause the gear to contact the chassis and change the waveform.
 

For future increases in output, we would like to continue using the current jig, which has proven its efficiency.</td><td>Investigation of cause
1 When February 16
Who
2 When Month, Day
Who
3 When Month, Day
Who</td></tr>
<tr><td>First Line of Action</td><td colspan="3">•Confirm that the fan-shaped gear does not contact the chassis when the ground spring is soldered.
•Modify the rotor shaft fan-shaped gear soldering jig in the rotor assembling process.</td><td>Arrangement to notify other divisons
February 17 Sent a study request sheet to the Engineering Divison (UTU-014)</td><td>1 First Line of Action
Who
2 When February 17
Con firmed</td></tr>
<tr><td>Measures to prevent reoccurence</td><td colspan="4">•Control rotor shaft and fan-shaped gear soldering dimensions (dimension B) using an X-R control chart for the rotor assembling process (from February 17)
• Change the dimensions where the chassis contacts the fan-shaped gear (dimension A), from 5.5 to 6.5 mm.</td><td>Prevention of reoccurence
When February 28
Who
Confirm-ation of actions</td></tr>
<tr><td>Confirmation of the effects of actions to prevent repetition</td><td colspan="4">•The waveform does not change after dimension A is altered, a result confirmed by the p control chart for changes or waveform. Continue controlling the process with the X-R control chart.
•Control the dimension of the rotor shaft and the fan shaped gear soldering with the X-R control chart</td><td>Confirmation
When March 8
Who</td></tr>
<tr><td colspan="2">File retaining period Three years
From Number TG-Q-001</td><td colspan="2">Tuner Marketing Division
Team xxx, UHF Assembly Group, Manufacturing Section, MP Plant</td><td>Section Manager / Foreman / Leader</td></tr>
</table>

Test

Answer these questions using only the information given in the text. For each question one, two or all three answers may be correct. Tick the answer or answers you think are correct for each question. Each question carries 3 points – you get one point for each correct answer that you tick, and one point for each wrong answer that you do not tick.

11.1.1 Data for quality characteristics and process conditions

1. Data for quality characteristics shows:
   - ☐ a. The conditions of the process.
   - ☐ b. The quality conditions of the product.
   - ☐ c. The specifications of the product.
2. Inspection records include records of:
   - ☐ a. Acceptance inspections.
   - ☐ b. Between-process inspections.
   - ☐ c. Delivery inspections.
3. The between-process inspections are used to determine whether:
   - ☐ a. Products are ready to be shipped.
   - ☐ b. Partially completed products are ready to be sent on to the next process.
   - ☐ c. Process conditions are satisfactory.
4. Reliability tests are used to:
   - ☐ a. Evaluate the stability of products over time.
   - ☐ b. Make sure that packing conditions meet the specifications.
   - ☐ c. Ensure products meet the conditions contracted with a particular customer.

11.1.2 Data for process conditions

5. The in-process quality record:
   - ☐ a. Records data on the process conditions.
   - ☐ b. Records data for process conditions when quality measures are incorporated in products.
   - ☐ c. Records the quality of products before they are sent on to the next process.

11.1.3 Approval of data by managers

6. A key management task in ensuring that control and improvement tasks are promoted effectively is to inspect data:
   - ☐ a. Daily.
   - ☐ b. Weekly.
   - ☐ c. Monthly.
7. Maintaining daily management work records includes:
   - ☐ a. Submit record sheets to the manager responsible for the test at the end of each week.

- ☐ b. Record sheets should be marked for confirmation and comments by the supervisor of the employee responsible for the test.
- ☐ c. When records are incorrectly completed the test manager must get an explanation from the employee who completed the record.

8. The check sheet for recording distribution of characteristics makes it easier to process data because it presents the data in:
   - ☐ a. Cause and effect diagrams.
   - ☐ b. Frequency charts.
   - ☐ c. Clear language.

11.1.4 Training in statistical techniques.

9. The purpose of in-company training in statistical techniques is to provide all employees with:
   - ☐ a. An overview of QC and other statistical techniques.
   - ☐ b. A working knowledge of QC and other statistical techniques.
   - ☐ c. An in-depth knowledge of QC and other statistical techniques.

11.2.1 Criteria for collecting data

10. A population is:
    - ☐ a. A group of people who live in the same area.
    - ☐ b. A group of entities whose characteristics are to be studied.
    - ☐ c. A selection of items from a group of items.
11. Variable data is composed of:
    - ☐ a. Discrete values.
    - ☐ b. Discontinuous data.
    - ☐ c. Continuous values.
12. Random sampling gives a result:
    - ☐ a. Governed only by chance.
    - ☐ b. Of statistical regularity.
    - ☐ c. That is error free.
13. Products should be sampled by the workers responsible for manufacturing them:
    - ☐ a. Sometimes.
    - ☐ b. Always.
    - ☐ c. Never.
14. Before data recorded in the past is used:
    - ☐ a. Confirm the purpose for which it was collected.
    - ☐ b. Examine the constraints on its collection.
    - ☐ c. Talk to the employees who collected it.
15. Characteristic diagrams are used to identify:
    - ☐ a. Cause and effect relations.
    - ☐ b. Sampling errors.
    - ☐ c. Defective products.

11.2.2 Analysing data with a characteristic diagram

16. Characteristics that may be included in characteristic diagrams include:
    - ☐ a. Cost.
    - ☐ b. Safety.
    - ☐ c. Morale.
17. The 5M include:
    - ☐ a. Material.
    - ☐ b. Method.
    - ☐ c. Money.
18. The method for extracting factors that effect results includes:
    - ☐ a. Examine products at the work site.
    - ☐ b. Express factors only numerically.
    - ☐ c. Express factors in single words or short sentences.
19. After completing a characteristic diagram follow the relations between factors:
    - ☐ a. Going from small to large bones.
    - ☐ b. Going from large to small bones.
    - ☐ c. Going from large to small bones and then back again.

11.2.3 Expressing mean values and dispersion

20. Random variables are:
    - ☐ a. Discrete.
    - ☐ b. Variable.
    - ☐ c. Discrete or variable.
21. When measurements are arranged in size, the value at the centre of the sequence is called the:
    - ☐ a. Mean.
    - ☐ b. Median.
    - ☐ c. Range.
22. The sum of n measurements divided by n is called the:
    - ☐ a. Mean value.
    - ☐ b. Median value.
    - ☐ c. Range.
23. The difference between the maximum value and the minimum value of a data set is called:
    - ☐ a. The mean.
    - ☐ b. The median.
    - ☐ c. The range.
24. The median value:
    - ☐ a. Is more precise than the mean values.
    - ☐ b. Is less precise than the mean value.
    - ☐ c. Has the same precision as the mean value.

11.2.4 Analysing data with a scatter diagram

25. When a relation exists between two variables they are said to be:
    - ☐ a. Positively correlated.
    - ☐ b. Negatively correlated.
    - ☐ c. Correlated.

26. The coefficient of correlation takes a value in the range from:
    - ☐ a. -2 to +2
    - ☐ b. -1 to +1
    - ☐ c. -0.5 to +0.5

11.2.5 Using graphs to analyse data

27. The advantages of graphs are that:
    - ☐ a. Anyone can draw them quite easily.
    - ☐ b. They allow us to judge the process status and conditions at a glance.
    - ☐ c. They can present a great amount of information clearly.
28. The most suitable graphs for comparing the magnitudes of inventories by product or plant are:
    - ☐ a. Circular graphs.
    - ☐ b. Bar graphs.
    - ☐ c. Polygonal line graphs.
29. To compare or note changes in the ratios of components over time use:
    - ☐ a. A radar chart.
    - ☐ b. A bar graph.
    - ☐ c. A band graph.

11.3.1 Pareto Charts

30. The value of Pareto charts is that they help us to:
    - ☐ a. Recognise phenomena and causes.
    - ☐ b. Recognise the important problems to deal with.
    - ☐ c. Recognise the full range of problems to deal with.
31. The key points in using a pareto chart include:
    - ☐ a. Determine a period of observation appropriate to the purpose.
    - ☐ b. When a Pareto chart indicates little difference between different items (strata), change the method of classification.
    - ☐ c. After determining the most significant item, draw a Pareto chart for the secondary items.

11.3.2 Histograms

32. A histogram uses columns to express frequencies of data:
    - ☐ a. From similar categories.
    - ☐ b. From different categories.
    - ☐ c. With similar dispersion.
33. To draw a histogram you should have at least:
    - ☐ a. 30 data points.
    - ☐ b. 50 data points.
    - ☐ c. 100 data points.

11.3.3 Process Capability

34. Process capability is determined by the relationship between:
    - ☐ a. Different characteristics in the same product.
    - ☐ b. The dispersion of product characteristics and standard values.
    - ☐ c. Characteristics in different products.

11.3.4 Stratifying Data

35. Stratification should be used when individuals within a sub-population:
    - ☐ a. Are similar to others in the same subpopulation, but are different from those in other sub-populations.
    - ☐ b. Are different to each other, but similar to those in other sub-populations.
    - ☐ c. Are similar to others in the same sub-population, and similar to those in other sub-populations.
36. The procedures for stratifiying data include:
    - ☐ a. Clarify the purpose of stratifying the data.
    - ☐ b. Decide which items are to be stratified.
    - ☐ c. Use an appropriate QC method to compare the stratified data.

11.3.5 The QC Story

37. In the QC story use brainstorming to:
    - ☐ a. Select a theme.
    - ☐ b. Set a target.
    - ☐ c. Assess the present situation.
38. Use a gantt chart to:
    - ☐ a. Confirm causes.
    - ☐ b. Assess the present situation.
    - ☐ c. Set a target.
39. A control chart shows that a process is stable when points representing quality:
    - ☐ a. Fall outside the control lines.
    - ☐ b. Fall inside the control lines.
    - ☐ c. Fall inside the control lines and do not show a trend.

11.4.1 Control charts for each process

40. Sets of measurements divided into sections when differences appear in terms of time, product or material are called:
    - ☐ a. Subsections.
    - ☐ b. Subgroups.
    - ☐ c. Subsets.
41. When control lines are properly drawn and process, environmental and machine conditions and material specifications are unchanged, the number of measurements that fall outside these lines should only be:
    - ☐ a. 3 out of 100.
    - ☐ b. 3 out of 1000.
    - ☐ c. 5 out of 1000.
42. In control charts a run of ..... is regarded as an out-of-control state.
    - ☐ a. Five.
    - ☐ b. Seven.
    - ☐ c. Nine.
43. Controlling a process with a control chart requires ..... observations.
    - ☐ a. Daily.
    - ☐ b. Weekly.
    - ☐ c. Periodic.

44. The chart used to determine the presence of abnormalities in a process is:
    - ☐ a. A control chart for process analysis.
    - ☐ b. A control chart for process control.
    - ☐ c. A control chart for abnormality control.
45. The control chart used to control a process with the number of defects, accidents, or failures in a certain unit or during a certain period is a:
    - ☐ a. p Control chart.
    - ☐ b. c Control chart.
    - ☐ c. u Control chart.

11.4.3 Control charts for discrete values

46. pn control charts are ..... p control charts.
    - ☐ a. identical to.
    - ☐ b. not very different from.
    - ☐ c. very different from.
47. To use a control for discrete values to analyze and evaluate a process effectively, you must collect data for at least:
    - ☐ a. 10 groups.
    - ☐ b. 20 groups.
    - ☐ c. 30 groups.
48. The pn control chart is a special case of the p control chart when n is:
    - ☐ a. Variable.
    - ☐ b. Constant.
    - ☐ c. Unknown.
49. u control charts are used to control a process using the number of defects in a certain unit or number of products when the range of possible defects:
    - ☐ a. Increases.
    - ☐ b. Decreases.
    - ☐ c. Changes.

11.4.4 Interpreting control charts

50. A process can be considered to be controlled when:
    - ☐ a. 15 or more successive data points fall within the control limit lines.
    - ☐ b. Among 35 successive data points, only one data point for which an abnormality is not detected falls outside the control limit lines.
    - ☐ c. Among 100 successive data points, only one or two data points for which an abnormality is not detected fall outside the control limit lines.
51. For a run on one side of the central line of fewer than seven data points, the process is abnormal if which of the following is true:
    - ☐ a. 2 of 4 successive data points fall in the range.
    - ☐ b. 3 of 7 successive data points fall in the range.
    - ☐ c. 4 of 10 successive data points fall in the range.
52. If data points exhibit periodicity, the process is:
    - ☐ a. Normal.
    - ☐ b. Abnormal.
    - ☐ c. Rational.

11.4.5 Methods for using control charts

53. Control lines should be revised in which of the following cases?
    - ☐ a. When workers, methods of work, materials, or machines change.
    - ☐ b. When a control chart indicates a change in the process.
    - ☐ c. When a certain length of time passes.
54. You can often locate the cause of a problem by drawing control charts stratified by:
    - ☐ a. Time.
    - ☐ b. Cost.
    - ☐ c. Machine.
55. To carry out efficient sampling you need to:
    - ☐ a. Clarify what you want to control.
    - ☐ b. Determine a sampling interval.
    - ☐ c. Determine a sampling method.

11.5.1 Applying statistical techniques: the QC Tools

56. Statistical techniques that are efficient in addition to QC tools include:
    - ☐ a. Correlation and regression analysis.
    - ☐ b. Multivariate analysis.
    - ☐ c. Design of processes.
57. Statistical techniques can be applied to:
    - ☐ a. Market analysis.
    - ☐ b. Safety evaluation and risk analysis.
    - ☐ c. Replying to customer claims.
58. Statistical techniques are incapable of solving problems without the aid of:
    - ☐ a. Design technology.
    - ☐ b. Engineering technology.
    - ☐ c. Computers.

11.5.5 The process abnormality report sheet

59. A process abnormality sheet is used to:
    - ☐ a. Detect abnormalities.
    - ☐ b. Verify that proper actions are taken.
    - ☐ c. Organise research on counermeasures.
60. The abnormality report sheet should include:
    - ☐ a. Process conditions.
    - ☐ b. Survey of measures to prevent repeated occurrence.
    - ☐ c. Methods for detecting abnormalities.

Note: Sections 11.4.2, 11.5.2, 11.5.3 and 11.5.4 are not suitable for multiple choice questions.

Unit 12

Education and Training

Contents

Unit summary

The quality of the education and training that your company provides for its staff will determine the quality of the products and services you offer. Ultimately it will determine the success of your business. You should approach it systematically, implement it thoughtfully, and continuously evaluate and improve it.

12.1 Establish an employee development policy

The first step in training your staff is to have an employee development policy, and to communicate this policy to your staff. The objectives of the policy should be to:

a. Improve employees' competence in their work.
b. Improve their understanding of their responsibilities.
c. Improve their ability to make good judgements.
d. Improve their capacity to solve problems.

12.2 Train employees in using machinery and equipment

In most companies a primary focus of training is on using machinery and other equipment. This training will be both off-the-job-training (OFF-JT) and on-the-job training (OJT), and will deal in particular with:

a. How to handle, operate, and maintain machinery and equipment.
b. How to avoid danger, promote safety, and prevent breakage and damage.

12.3 Provide TQM education and training; set up a TQM education and training office

Education and training is particularly important when you decide to introduce TQM. Set up a well-structured TQM curriculum for each level of management, for each sub-department, and for each job. Typical groupings are top management, middle managers, TQM promotional staff, foremen and group leaders, and general employees. Each of these groups will have different needs, interests and constraints. If you can also set up a TQM education and training office you will find this a valuable resource for improving the quality of both TQM education and training and other training in your company.

12.4 Maintain a resource of good training materials

Good training materials are an essential training resource. They will provide appropriate content, will meet the needs of the participants, will fulfil the purpose of the course and the overall curriculum, and will allow the annual and monthly training plans to be followed. Review them regularly, and file them systematically.

12.5 Evaluate and improve your training

Training should be the focus of continuous improvement. You should:

a. Evaluate what your employees gain from each course.
b. Regularly evaluate your overall training programme, and seek ways to improve it in both content and methodology.

12.6 Encourage employees to pursue self-development

Best results will be achieved by those employees who are motivated to pursue their own development. Your company should encourage and facilitate such employees to undertake training in the skills and knowledge, and for the licences, that each is interested in, and which are necessary both in their own work area and company-wide. This is particularly valuable when employees need to be able to respond effectively to changes in customer needs.

12.7 Set up a system for employees to acquire licenses

Establish a license qualification system that will certify that employees have achieved the level of knowledge and skills required for certain jobs. This system should specify the work that a license is required for, and the method by which qualifications will be awarded.

12.8 Provide training in new products and new technology

Products and technology are always changing. Employees must often be given training that will keep them up to date with these changes. Such training will be required for:

a. Engineers in the R&D department; they will require both training in the new technology, and the basic knowledge that will enable them to develop more advanced technology.
b. Employees in the workplace, who will have to become familiar with new raw materials, and with production and inspection methods for the new components.
c. The sales representatives who will have to sell the new products.

Terminology Note

In employee development one often uses the terms education and training together, education referring to teaching participants an understanding of principles, and training to teaching them practical skills. The terms are sometimes used together in this unit (in 12.1 and 12.3), but for ease of reading and especially of discussion, it has been decided to use only the term 'training', even where it would be more accurate to use both terms. The use of 'training' in a particular context, therefore, does not exclude the meaning of 'education' in that context.

Learning tools

The RADAR questions

As you read each text you will discuss how it could be applied in your company. The RADAR questions will help you to focus this discussion:

R - Are these ideas **relevant** to my company?
A - How would I **apply** each of them in my company?
D - What **difficulties** might I meet and how would I overcome them?
A - Are there any **additional** actions that I might take that are not mentioned in the text?
R - What **resources** would be needed, what would these cost, and how could they be acquired?

There will of course be some discussion points where not all of these questions will be applicable.

The 6-Point Structure

After you have discussed the ideas in the text, you write an action plan in which you present practical proposals for implementing the conclusions you have reached in your discussion. The 6-Point Structure will help you to write your action plan:

1. **Problems:** Problems you have in your company in the area you have just discussed.
2. **Proposals:** Your proposals for improvement.
   a. Be specific and concrete.
   b. Include an implementation plan, with a time schedule and minimum and optimal implementation targets.
   c. Refer to any forms, charts, tables etc. that you would use, and include samples in an appendix.
3. **Obstacles:** Obstacles to implementation in employee attitudes, company organization and culture etc., and how these could be overcome.
4. **Resources:**
   a. The resources required: funds, equipment, materials, man-hours, expertise etc.
   b. The resources available within the company.
   c. Any resources that would have to be found outside the company.
   d. Alternatives that could be used to cover any shortfall in resources.
5. **Assessment:** Ways of assessing the results of implementing these proposals.
6. **Benefits:** The benefits your proposals would bring.

12.1 Establish an employee development policy

1. The success of your company depends on having well-trained staff. The first step in achieving this is to have an employee development policy, and to communicate this policy to staff. The objectives of the policy should be to:
   a. Improve employees' competence in their work.
   b. Improve their understanding of their responsibilities.
   c. Improve their ability to make good judgements.
   d. Improve their capacity to solve problems.

2. To formulate and implement your employee development policy, you will need to establish rules and procedures for education and training. These rules and procedures, or standards as they are also known, should describe how to:
   a. Formulate a basic policy for employee development.
   b. Set up a committee for the promotion of employee development.
   c. Set up a unit to promote education and training.
   d. Set up a schedule for education and training.
   e. Provide internal and external educational guidance.
   f. Evaluate education and training.

3. An example of rules and procedures for education and training:

   Provision No.1: Purpose
   This decree is established to define the basic education and training policy, which has as its goal the development of employees throughout the company.

   Provision No.2: Basic education and training policy
   Education and training has, as its purpose, the development of employees by providing instruction in the basic knowledge and skills needed to conduct day-to-day business.

   Provision No.3: Authority and responsibility
   This rule governs the areas of authority and responsibility for education and training:
   a. The "Education Committee" is the highest authority within the company on matters of company education and training. An executive from the personnel department shall serve as its chairman. The organization and operation of the Committee are defined in the "Rules Governing Education Committee".
   b. The head of each department is responsible for the education and training of his/her department.

Provision No.4: Education and training in each department

The head of each department is responsible for setting up a unit to promote education and training within his department, assigning a person in-charge, coordinating the activities of his unit with those of the Education Committee, and running it effectively with regard to the following provisions as they pertain to operations within his department. The unit should:

a. Be aware of the history of formal education, actual job duties, education and training, and official licenses held by all the members of the department.
b. Create an annual plan for education and training, a plan for the earning of new licenses, and a budget for these activities.
c. Complete a curriculum for education and training for each level in the management by hierarchy, by each sub-department, and by each function.
d. Develop and organize all necessary training materials.
e. Select and register instructors.
f. Be aware of the past education and training programmes and confirm their effectiveness.
g. Maintain records of education and training programmes and all licenses earned.

Discussion

The following questions ask you to think about how the ideas in the text could be applied in your company. Some of the ideas may not be relevant to you. Concentrate on what is relevant. Keep notes of your conclusions – you will need them to prepare your action plan afterwards. Where appropriate ask yourself the RADAR questions.

Note: Always include in your discussion any figures referred to in the text, ***if*** you feel these are relevant to your company.

a. How important is education and training in your company? Do you think it should be given more importance? If so, what changes should be made? How would these benefit your company?
b. Parag. 1 Do you agree that employees should know what the employee development policy is? Why?
c. Parag. 1 suggests four objectives for education and training. Would these also be appropriate objectives for your company? Are there any others you would add?
d. Parag. 2 refers to the importance of establishing rules and procedures for education and training in six areas. After you have read the example, apply the RADAR questions to actually establishing and implementing rules and procedures that would be appropriate for your company.

Action plan

Take the ideas you have found useful in the text, and in your discussion, and present them in a well-structured action plan for introducing improvements in your company. Alternatively you many decide to combine the ideas from several texts in one action plan. You might like to follow the 6-Point structure.

12.2 Train employees in using machinery and equipment

Introduction

1. In most companies a primary focus of training is on using machinery and other equipment. This training will be both off-the-job-training (OFF-JT) and on-the-job training (OJT), and will deal in particular with:
   a. How to handle, operate, and maintain machinery and equipment.
   b. How to avoid danger, promote safety, and prevent breakage and damage.

   Both forms of training must have systems for:
   a. Confirming that employees have reached a verified level of knowledge and skills through the training.
   b. Registering these employees to operate and use specific machinery and equipment.

   There must, of course, be agreement on how the operations should be carried out, and what exactly the procedures are, before any training can be carried out. These agreed ways of carrying out the company's business should be written down in standards. (See Unit 8 Standardization, especially the list of typical manufacturing standards in Text 8.1 – these are the kind of standards you should base your training on.)

Off-the-job training (OFF-JT)

2. In off-the-job training (OFF-JT) use the operation manuals for machinery and equipment as defined in the job standards. Instruction should cover machinery, inspection equipment, measuring devices, constituent components, jigs, tools, and spare parts. It should be given to all the relevant personnel, and should include:
   a. The purpose of the item of machinery or equipment, its range of use, the environment in which it should be used, and the conditions for using it.
   b. An explanation of its basic functions.
   c. Its structure, principles, capabilities, accuracy, and reliability.
   d. Its constituent components (i.e. its permanently assembled parts), attached components, and spare parts.
   e. Warning notices to ensure operator safety and avoid accidents.
   f. How its proper handling will affect product quality.
   g. Actions that are forbidden, either with it or near it, to prevent damage, malfunction or breakage.
   h. Notices about methods of transporting it from storage and handling it.
   i. Notices for checking and handling the constituent components.
   j. All the procedures for handling, operating, inspecting, adjusting and verifying it; for recording any incidents that occur; for processing data related to it; and for the pre-operation, start of operation, mid-operation, and end-of-operation stages.

k. Post-operation actions: inspection of the main unit and the constituent components, verification, cleaning, adjustments, recording; post-operation processing (e.g. repair, oiling, prevention of rusting, ensuring that it remains in good working order, and prevention of scratches); transportation, storage, storage method, replacement of components that deteriorate through use and replacement of maintenance materials, etc.
l. Methods for reporting information on products, and the documents, records, etc that are used.
m. The handling and management of waste materials after cleaning is finished.
n. For all of the above points, a strong emphasis on those factors that must absolutely be followed, checked and confirmed, and those that are forbidden.
o. Points for which a record must be kept, and the format of these records.
p. Issues that have to be reported to a superior, issues to be recorded, and the storage of records.
q. What to do when abnormalities or breakages are discovered, the countermeasures to take, and how to report and record such incidents.
r. What alternative actions to take when operating procedures cannot be followed, what approval is required for making such changes, and how to have them made permanent if they are an improvement.
s. Standards, work procedure manuals, and operation manuals.

On-the-job Training (OJT)

3. On-the-job training (OJT) is provided on the work site. The instructor demonstrates and explains the correct procedure using the actual machinery, measuring devices, raw materials, components, WIP (work-in-progress), and finished products. Observe the following:
   a. Use OJT where there is a special focus on the purpose of the work at hand, on safety, on product quality, on handling things carefully to prevent damage and breakage, on operation procedures and measuring methods, on countermeasures to be taken against abnormalities, and on the reporting of abnormalities.
   b. Provide adequate training in the special care needed to handle measuring devices, and testing and inspection equipment in order to maintain their accuracy.
   c. As teaching materials, use written job standards, work procedure manuals, user manuals, and textbooks; make effective use of related materials such as maintenance standards for equipment, handling standards for measuring devices, samples of actual materials, photographs, boundary samples, and one-point lectures (supplementary standards that make it easier to understand the use of equipment etc.).
   d. Obtain approval in advance to use these teaching materials, register them, and make repeated use of them for training.
   e. In the course of training, do not make any changes to machinery and measuring devices and their specifications unless permission has been obtained from the person in charge, and do so according to the proper, designated procedures.
   f. Emphasize that these items are only to be used for their intended purpose unless permission is given by the person in charge, and make sure that nobody misuses them.

Keep training records

4. It is essential to keep training records:
   a. Keep records of the date of training, the instructor's name, participants' names, and the teaching materials and textbooks.
   b. Have the person in charge, or the supervisor:
      i. Verify and maintain records for each of his subordinates showing the level of learning he/she has achieved in the use, operation, and handling of the machinery or other equipment.
      ii. Verify and record whether or not stable product quality is being efficiently and continuously achieved.
   c. Use these records to plan and carry out future training.
      Have an occasional follow-up for employees to refresh the skills and knowledge they have acquired in their training. This could take the form of competitions or quizzes.

Figure 12.2a Basic procedures for using measuring devices. This is a very useful example, and one that you should look carefully at.

Discussion

The following questions ask you to think about how the ideas in the text could be applied in your company. Some of the ideas may not be relevant to you. Concentrate on what is relevant. Keep notes of your conclusions – you will need them to prepare your action plan afterwards. Where appropriate ask yourself the RADAR questions.

Note: Always include in your discussion any figures referred to in the text, ***if*** you feel these are relevant to your company.

a. Parag.1: To what extent does your company already provide training in the areas described here? In what ways could it be improved? Give some examples of things that have gone wrong because of inadequate training in these areas.
b. Parag. 1: Does your company already have a system for approving employees who have attained a verified level in training? And for registering these employees to operate and use special machinery and measuring devices? If so, how effective is it. If not, do you think it would be a good idea to have such systems? Why?
c. Parag. 2: To what extent does your company already use OFF-JT and OJT in training employees to use your machinery and equipment? How effective are your systems? Where do you feel there is room for improvement? When is one more appropriate than the other? When should both be used?
d. Parag. 2: Apply the RADAR questions to these guidelines for OFF-JT.
e. Parag. 3: Apply the RADAR questions to these guidelines for OJT.
f. Parag. 4: Does your company keep training records? If so, how effective is your system? Where could it be improved? What is the value of keeping training records?
g. Parag. 4: Apply the RADAR questions to these guidelines for keeping training records.
h. Look at Figure 12.6. What operations in your company could this be used as a model for. If appropriate, discuss what you would include in a similar set of procedures for one of your typical operations. If you feel it would be useful draft a similar one.

Action plan

Draw up an action plan for providing training in your company in using machinery and other equipment. You might like to follow the 6-Point Structure. Alternatively you may prefer to combine your discussions of several texts in one action plan.

12.3 Provide TQM education and training; set up a TQM education and training office

Introduction

1. Education and training is particularly important when you decide to introduce TQM. Set up a well-structured TQM curriculum for each level of management, for each section, and for each job. Typical groupings are top management, middle managers, TQM promotional staff, foremen and group leaders, and general employees. Each of these groups will have different needs, interests and constraints. If you can also set up a TQM education and training office you will find this a valuable resource for improving the quality of both TQM education and training and other training in your company.

Provide TQM education and training

2. Top managers should:
   a. Attend TQM seminars held outside the company.
   b. Attend internal TQM lectures held by instructors invited from outside the company.
   c. Determine the company's TQM policy, supervise its implementation, evaluate its results and take whatever decisions are required.

3. Middle managers should:
   a. Attend external and internal TQM seminars.
   b. Acquire the training needed to determine policy and targets for their departments, and to guide their subordinates.
   c. Become familiar with the Seven QC Tools, the basics of statistical methods used for TQM, and techniques for applying TQM to solve problems. They should be able to give their employees an overview of statistical techniques and how they should be applied.
   d. Attend staff and leadership seminars where they can learn to organize and expand TQM and QC Circle activities, and advise and evaluate their subordinates on these activities.
   e. Use employee reports to examine and evaluate the status and effectiveness of QC and statistical techniques as applied to routine activities and tasks.
   f. Make effective use of the knowledge and experience they have gained from seminars: education should not end at the classroom door.

4. TQM promotional staff:
   a. Should attend internal and external TQM seminars in which they learn the basics of TQM, the seven QC tools, the new seven QC tools, the QC story, methods for planning experiments, multivariate analysis, and quality function deployment. (The latter refers to analysing the customer's quality requirements and converting these

requirements into design and production features. See Units 9 and 11 for details of the other tools and methods.) TQM specialists should be invited as instructors, and those employees who have already completed external TQM education and training should be assistant instructors.

b. Before attending these seminars, they should consult superiors and prepare a list of problems related to their work, with the relevant data. This will give a much more clear and concrete focus in the seminars.
c. They should be actively supported and encouraged by their superiors in attending these seminars, especially since this training can be quite lengthy.
d. Assistant instructors should be trained to work as independent instructors for internal training.

5. Foremen and group leaders should:
   a. Attend internal and external TQM seminars and study the implementation of TQM and QC Circle activities. (See Unit 10).
   b. Attend internal seminars that teach statistical methods, the seven QC tools, the new seven QC tools, and the QC story. This knowledge should be repeatedly used within QC circle activities to solve everyday work problems and improve work. Doing this will greatly increase the benefits that education has brought.
      Those who work near production lines should be trained mainly in the more accessible methods of the Seven QC Tools and New Seven QC Tools. They should be able to apply statistical techniques to carry out control and improvements in routine jobs.
   c. Attend external presentations and contests, and do their best to expand their horizons.
   d. Take tours of other companies to get a good idea of how QC Circles operate. These visits will bring a sharing of experience, an exchange of opinions and mutual motivation.

6. Technical staff should be trained for quality function deployment (QFD), experiment design, multivariate analysis, and other statistical techniques useful in research and development, and in the application of statistics to day-to-day tasks.

7. General employees, including new employees, and employees transferred from other companies or departments: Use OJT and/or QC circle activities to educate and train employees with no education in TQM, in:
   a. The QC approach to problem-solving (the QC story).
   b. Using the new seven QC tools as effectively as their understanding and problem-solving skills allow.

8. Your company should also organise training for related companies, including subcontractors and sales distributors, in all the five categories above.

Figure 12.3a Diagram for Education and Training Curriculum
Figure 12.3b Diagram for OJT and OFF-JT
Figure 12.3c Skill Evaluation Sheet
Figure 12.3d Education and Training Record
Figure 12.3e Company Education System

Set up a TQM education and training office

9. A TQM education and training office can be a valuable resource in your company. Its primary function will be to promote TQM on a company-wide basis, and to facilitate an exchange of information on the evaluation and improvement of training. The TQM education and training office should:
   a. Come under the personnel department (or general affairs), although this will vary depending on the organization of the company.
   b. Plan TQM training at each organizational level according to basic corporate policies, including external seminars on QC (quality control), and reliability and statistical techniques.
   c. Obtain management approval for a training budget; select the TQM seminars; obtain management approval to register employees in the seminars; and carry out registration.
   d. Work with those responsible for training in each department, and hold regular meetings with them. Superiors (section managers and department managers) to whom trainees report need to monitor QC, reliability and statistical methods training, until trainees are able to apply these techniques to routine tasks.
   e. Keep minutes of all these meetings and distribute them to those in charge of education, as well as to all participants, and store and maintain the original minutes as well as copies of all the materials used in the regular meetings.
   f. When appropriate arrange to have training conducted by correspondence, TV or radio, provided that trainees are closely supervised by their superiors and back-up support is given by experts both inside and outside the company.
   g. Appoint as QC instructors those who get excellent results in seminars and courses and who successfully apply this training to routine tasks, in line with company procedures.
   h. Verify the status of the TQM education and training promotion schedule, and provide appropriate advice and instructions.
   i. Generate a draft plan for the coming year, based on the results of the current year, as well as mid-term and long-term draft plans, and get internal approval for these.

10. With all the focus on methods and techniques, do not forget that TQM is first and foremost a philosophy of quality first. And remember, too, that TQM will not work if it meets with opposition from management. It is crucial that management shares a common view of TQM.

Discussion

Apply the RADAR questions to these guidelines, first those for introducing a TQM curriculum in your company, and then those for setting up a TQM education and training office. Keep notes of your conclusions – you will need them to prepare your action plan afterwards.

Action plan

Draw up an action plan for setting up a TQM curriculum in your company. You might like to follow the 6-Point Structure. Alternatively you may choose to combine your discussions of several texts in one action plan.

12.4 Maintain a resource of good training materials

1. Good training materials are an essential training resource. These are the course materials, textbooks, audio-visual aids etc that are used in seminars and courses. Good training materials will provide appropriate content, will meet the needs of the participants, will fulfil the purpose of the course and the overall curriculum, and will allow the annual and monthly training plans to be followed. Review them regularly, and file them systematically.

2. To review in-house training materials, examine the education records, get the opinion of the trainer, get direct feedback from the participants, and check how well they have understood them.

3. Keep text materials in a fixed file so that they will not be scattered, put someone in charge of them, and store them in a designated location. They will then be easily available whenever they are needed.

4. With external seminars, make sure that a list of the materials used is attached to the seminar report. The textbooks used should be taken by the training department, stored, with someone given responsibility for them, and then used for internal training.

5. With commercial generic training materials available in book stores, such as books, audio/video recordings and slides, be careful to choose materials that meet the education level and target of course participants, and have these controlled by the education department.

Discussion

The following questions ask you to think about how the ideas in the text could be applied in your company. Some of the ideas may not be relevant to you. Concentrate on what is relevant. Keep notes of your conclusions – you will need them to prepare your action plan afterwards. Where appropriate ask yourself the RADAR questions.

Note: Always include in your discussion any figures referred to in the text, ***if*** you feel these are relevant to your company.

a. What system does your company have for organizing teaching materials, looking after them and keeping them up to date? What are the shortcomings, if any, in your system?
b. How would the guidelines in this text improve the way you do this? Apply the RADAR questions.

Action plan

Write a short action plan for improving the way that teaching materials are organized, looked after and kept up to date. You may like to follow the 6-Point Structure. Alternatively you may choose to combine your discussions of several texts in one action plan.

12.5 Evaluate and improve your training

1. Your training will ultimately determine the success of your company. It should be the focus of continuous improvement. You should:
   a. Evaluate what your employees gain from each course.
   b. Regularly evaluate your overall training programme, and seek ways to improve it in both content and methodology.

Evaluate the effectiveness of each course

2. The value of training is best seen in the results that participants gain from it. There are a number of ways to evaluate this: checklists, job observation, reports that participants submit, and instructor evaluation.
   a. Use a check sheet to verify that each participant understands what they have been taught, and have acquired the skills to put it into practice. Enter on the check sheet in advance what exactly they are expected to learn.
   b. Check if participants can actually carry out the jobs they are trained to do: evaluate whether they can complete all the steps, and with appropriate speed and accuracy; evaluate the results of their work, and their ability to repeat a task precisely and with consistency. Use this as a basis for giving them a grade in OJT.
   c. Evaluate their submission of reports: Have them report on the knowledge and skills they have acquired, and on the positive impact this will have on the performance of their jobs. Treat this as the basis for giving a grade in OFF -JT.
   d. Get the instructor to evaluate whether the participants actually achieved their training targets.
   e. Get participants to report on actions where they applied the knowledge and skills they have acquired. This is an effective way of evaluating management training in Quality Control.

Figure 12.5a Check Sheet for Results of QC Seminar

Evaluate and improve your training programme

3. You should also carry out an overall evaluation of your training programme which will include a range of factors in addition to the test results. The person in charge of training should:
   a. Review the individual course evaluations, as described in paragraph 2. above.
   b. Review the company training plan at each stage: when it is drawn up, while it is being carried out, and after it has been completed.
   c. Examine the length of time that courses last, the training locations, the methods of selecting instructors, the procedures for approving courses, the procedures for informing employees about available courses, and the budgeting allocation for training.
   d. Examine the training records, the content of courses, the giving of homework assignments to participants, and the information they need in order to prepare for courses.

e. Use participant questionnaires: collect, summarize, analyse, and report on these.
f. Get feedback from instructors.
g. Check where improvements may be needed, and consider how these should be implemented.
h. Think pro-actively about other improvements that could be introduced in the future.

Figure 12.5b Internal TQM seminar questionnaire

Discussion

The following questions ask you to think about how the ideas in the text could be applied in your company. Some of the ideas may not be relevant to you. Concentrate on what is relevant. Keep notes of your conclusions – you will need them to prepare your action plan afterwards. Where appropriate ask yourself the RADAR questions.

Note: Always include in your discussion any figures referred to in the text, ***if*** you feel these are relevant to your company.

a. How does your company evaluate what your employees gain from their training? Where do you feel this evaluation could be improved?
b. Does your company ever carry out an evaluation of its overall training programme? If not, what benefits could be gained from doing so? If it does, how often does it do so, and how useful is it? Where do you feel the evaluation could be improved?
c. Apply the RADAR questions to the proposals in this text.

Action plan

Prepare a short action plan for improving the way your company evaluates its training. You might like to use the 6-Point Structure. Alternatively you may choose to combine your discussions of several texts in one action plan.

12.6 Encourage employees to pursue self-development

1. Best results will be achieved by those employees who are motivated to pursue their own development. Your company should encourage and facilitate such employees to undertake training in the skills and knowledge and for the licences, that each is interested in, and which are necessary both in their own work area and company-wide. This is particularly valuable when employees need to be able to respond effectively to changes in customer needs.

2. For self-development to be effective both for the employee and for the company, the employee should:
   a. Be aware of the company's business activities.
   b. Select the skills, licenses, and knowledge that they are interested in.
   c. Talk to their superior about their development interests, and decide how realistic they are.
   d. Make an effort to achieve them, and keep their superior informed of the outcome.

3. The company should:
   a. Tell the employee which specific skills, licenses, and knowledge will be most useful.
   b. Provide the necessary training.
   c. Provide the necessary financial support.
   d. Organize an internal system to make it easy to obtain skills, licenses and knowledge.
   e. Organize a merit system to recognise and reward employee achievements in self-development.

Discussion

The following questions ask you to think about how the ideas in the text could be applied in your company. Some of the ideas may not be relevant to you. Concentrate on what is relevant. Keep notes of your conclusions – you will need them to prepare your action plan afterwards. Where appropriate ask yourself the RADAR questions.

   a. Does your company encourage employees to independently develop their abilities? If so, how successful has this been? Would it be a good idea if it did this to a greater extent? What benefits would this bring to both the company and the employee?
   b. Apply the RADAR questions to the proposals in this text.

Action plan

Draw up a short action plan for introducing ways of encouraging your employees to pursue their own self-development, using the 6-Point Structure. Alternatively you may choose to combine your discussions of several texts in one action plan.

12.7 Set up a system for employees to acquire licenses

1. Establish a license qualification system that will certify that employees have achieved the level of skills and knowledge required to perform certain jobs. This system should specify the work that a license is required for, and the method by which qualifications will be awarded.

2. To set up a license qualification system, take the following steps:
   a. Clarify those jobs and work that require a license. These may include:
      i. Confirming a contract.
      ii. Examining a design.
      iii. Inspecting incoming purchased goods.
      iv. Inspecting internal processing.
      v. Inspecting finished goods.
      vi. Carrying out an internal quality audit.
      vii. Carrying out an external quality audit – a quality audit of subcontractor goods.
   b. Define the conditions needed to qualify for a license:
      i. Employees receive the training designated for a specific job and process, get actual experience on the job within an appropriate period, and acquire an appropriate level of knowledge.
      ii. Employees receive an internal or external license certification to conduct work for which this certification is judged especially important.
   c. Designate a person to be responsible for selecting and approving employees to perform work for which an internal license is required. Follow established laws and regulations for essential licenses.
   d. Create a ledger and register the names of qualified employees.
   e. Review qualified members on a regular and as-needed basis, and add and delete members from the ledger on the basis of this review.

Figure 12.7a Registration Form of members who perform work requiring a license

Discussion

The following questions ask you to think about how the ideas in the text could be applied in your company. Some of the ideas may not be relevant to you. Concentrate on what is relevant. Keep notes of your conclusions – you will need them to prepare your action plan afterwards. Where appropriate ask yourself the RADAR questions.

Note: Always include in your discussion any figures referred to in the text, ***if*** you feel these are relevant to your company.

a. Does your company already have a license qualification system? If so, what are its benefits and what are its shortcomings? If not, in what ways do you think you might benefit from having one?
b. Apply the RADAR questions to the suggestions in the text for setting up a license qualification system.

Action plan

Draw up a short action plan to set up a license qualification system in your company, using the 6-Point Structure. Alternatively you may choose to combine your discussions of several texts in one action plan.

12.8 Provide training in new products and new technology

1. Products and technology are always changing. Employees must often be given training that will keep them up to date with these changes. Such training will be required for:
   a. Engineers in the Research and Development Department: they will require both training in the new technology and the basic knowledge that will enable them to develop more advanced technology.
   b. Employees in the workplace who will have to become familiar with new raw materials and components, and with production and inspection methods for these.
   c. The sales representatives who will have to sell the new products.

   Keep training manuals that clearly present the details of new products and new technology, and always keep records of the training given.

2. To support the development of new technology, provide education in reliability technology, quality functional deployment, experimental design methods, and multivariate analysis methods.

Discussion

The following questions ask you to think about how the ideas in the text could be applied in your company. Some of the ideas may not be relevant to you. Concentrate on what is relevant. Keep notes of your conclusions – you will need them to prepare your action plan afterwards. Where appropriate ask yourself the RADAR questions.

Note: Always include in your discussion any figures referred to in the text, ***if*** you feel these are relevant to your company.

a. Which new products or new technology does your company provide, or need to provide training in? How successful has it been in doing so? What problems has it experienced?
b. Apply the RADAR questions to the guidelines in the text.

Action plan

Draw up a brief action plan for providing training in new products new technology in your company, using the 6-Point Structure. Alternatively you may choose to combine your discussions of several texts in one action plan.

Test

Answer these questions using **only** the information given in the text. For each question one, two or all three answers may be correct. Tick the answer or answers you think are correct for each question. Each question carries 3 points – you get one point for each correct answer that you tick, and one point for each wrong answer that you do not tick.

12.1 Establish an employee development policy.

1. The objectives of a good employee development policy are to:
   - ☐ a. Improve employees' understanding of their responsibilities.
   - ☐ b. Improve their understanding of the company's business activities.
   - ☐ c. Improve their capacity to solve problems.
2. Rules and procedures for education and training should describe how to:
   - ☐ a. Set up a schedule for education and training.
   - ☐ b. Evaluate education and training.
   - ☐ c. Set up a committee to promote employees.

12.2 Train employees to use machinery and other equipment.

3. Off-the-job training should provide instruction based on:
   - ☐ a. The product specification.
   - ☐ b. The operation manuals.
   - ☐ c. The company policy.
4. On-the-job training should have a special focus on:
   - ☐ a. The purpose of the work at hand.
   - ☐ b. Cutting costs.
   - ☐ c. Safety considerations.
5. Records should be kept of:
   - ☐ a. The names of employees who failed to attend.
   - ☐ b. The names of participants.
   - ☐ c. The name of the instructor.

12.3 Provide TQM education and training; set up a TQM education and training office

6. A company should have a well-structured TQM curriculum for:
   - ☐ a. Each level of management.
   - ☐ b. Each sub-department.
   - ☐ c. Each individual employee.
7. Top managers should:
   - ☐ a. Attend outside TQM seminars for managers given by external instructors.
   - ☐ b. Attend internal TQM lectures given by internal instructors.
   - ☐ c. Supervise the implementation of TQM in the company.

8. Middle managers should:
   - ☐ a. Attend external and internal TQM seminars for middle managers.
   - ☐ b. Attend leadership seminars.
   - ☐ c. Determine the company's TQM policy.
9. TQM promotional staff should:
   - ☐ a. Bring a list of problems related to their work to TQM seminars.
   - ☐ b. Determine the company's TQM policy.
   - ☐ c. Learn multivariate analysis and quality function deployment.
10. Foremen and group leaders should:
   - ☐ a. Study the implementation of TQM and QC circle operations.
   - ☐ b. Take tours of all the departments in the company.
   - ☐ c. Attend internal and external TQM seminars.
11. General employees should be educated to use the new seven QC tools effectively:
   - ☐ a. As far as their education level allows.
   - ☐ b. As far as their understanding allows.
   - ☐ c. As far as their number of years in the company allows.
12. The TQM education and training office should:
   - ☐ a. Determine the company's education and training policy.
   - ☐ b. Promote TQM on a company-wide basis.
   - ☐ c. Provide an exchange of information on the evaluation and improvement of training.
13. The TQM education and training office should:
   - ☐ a. Report to the CEO.
   - ☐ b. Come under the personnel department.
   - ☐ c. Be an independent department.

12.4 Maintain a resource of good training materials

14. To review internal teaching materials:
   - ☐ a. Examine the education records.
   - ☐ b. Get the teacher to give his/her opinion of them.
   - ☐ c. Read them carefully.
15. After an external seminar is over the education department should:
   - ☐ a. Make photocopies of the textbooks.
   - ☐ b. Keep the original textbooks.
   - ☐ c. Distribute the textbooks to the participants.

12.5 Evaluate and improve your training

16. When using a check sheet to check what participants and trainees have achieved, enter the details of what they should have achieved:
   - ☐ a. In advance.
   - ☐ b. At the time.
   - ☐ c. Later.
17. In checking if participants can carry out the jobs they are being trained for:
   - ☐ a. Evaluate whether they can complete all the steps, and with appropriate speed and accuracy.
   - ☐ b. Evaluate their ability to repeat a task precisely and with consistency.
   - ☐ c. Evaluate their ability to describe accurately how a task should be carried out.

18. Get participants to report on:
    - ☐ a. The knowledge and skills they have acquired.
    - ☐ b. The positive impact the training will have on the performance of their jobs.
    - ☐ c. The performance of their trainers.
19. To evaluate and improve your training programme, the person in charge of training should:
    - ☐ a. Test participants after they have completed a training course.
    - ☐ b. Examine the training records.
    - ☐ c. Get feedback from instructors.

12.6 Encourage employees to pursue self-development

20. Employee self-development should be in skills, licenses and knowledge that:
    - ☐ a. The employee is interested in.
    - ☐ b. Are necessary in his/her work area.
    - ☐ c. Improves the employee's resume.
21. The company should:
    - ☐ a. Provide the necessary training.
    - ☐ b. Provide financial support.
    - ☐ c. Make a list of employees who should undertake self-development.

12.7 Set up a system for employees to acquire licenses

22. A license is recommended for:
    - ☐ a. Inspecting incoming goods.
    - ☐ b. Inspecting internal processing.
    - ☐ c. Confirming a contract.
23. To qualify for a license an employee should:
    - ☐ a. Receive training designated for a specific job and process.
    - ☐ b. Get actual experience on the job as quickly as possible.
    - ☐ c. Obtain sufficient knowledge of the specific process.

12.8 Provide training in new products and new technology

24. Training in new products should:
    - ☐ a. Train sales representatives in the inspection methods for the new products.
    - ☐ b. Train employees in the workplace in changes in raw materials and production methods.
    - ☐ c. Train employees in the workplace in changes in inspection methods.

Relationship with ISO

12.1 Establish an employee development policy.
Relationship with ISO 9001:2000
5.5.1 Responsibility and authority
5.1 Management commitment
6.1 Provision of resources
6.2.2 Competence, awareness and training

12.2 Train employees in using machinery and equipment.
Relationship with ISO 9001:2000
4.2.3 Control of documents
6.2.2 Competence, awareness and training
7.5.1 Control of production and service provision

12.3 Provide TQM education and training; set up a TQM education and training office.
Relationship with ISO 9001:2000
6.1 Provision of resources
6.2.2 Competence, awareness and training
6.3 Infrastructure

12.4 Maintain a resource of good training materials.
Relationship with ISO 9001:2000
4.2.4 Control of records
6.1 Provision of resources
6.2.2 Competence, awareness and training

12.5 Evaluate and improve your training.
Relationship with ISO 9001:2000
6.2.2 Competence, awareness and training

12.6 Encourage employees to pursue self-development.
Relationship with ISO 9001:2000
6.2.2 Competence, awareness and training

12.7 Set up a system for employees to acquire licenses.
Relationship with ISO 9001:2000
6.2.1 General
6.2.2 Competence, awareness and training

12.8 Provide training in new products and technology.
Relationship with ISO 9001:2000
6.2.2 Competence, awareness and training

Unit 13

Production Control

Contents

Unit summary

Production control is the management of the production processes to ensure that the company produces goods of the quality that the market wants, in the right quantity, and ready for delivery at the right time - and that it continues to improve the efficiency with which it does so. The six texts of this unit present the key actions to take to achieve these goals.

13. 1 Prepare production and shipping plans

There are three key plans that the production department must prepare in order to have effective production control:

a. An annual production plan, based on the sales plan.
b. A daily or monthly production plan.
c. A shipping plan.

The daily or monthly plan is essential to ensure that production follows the annual plan. The shipping plan ensures that products are delivered from the production site to the delivery site on time.

13.2 Ensure that production keeps to plan – Part One

When the monthly production plan has been agreed, there are several important actions to take to ensure that production keeps to this plan. Four are dealt with in this text and three in Text 13.3:

a. Organise your production line in the best possible way.
b. Set and keep to standard times.
c. Know your production capacity.
d. Manage each process

13.3 Ensure that production keeps to plan – Part Two

The further three actions that you can take, in addition to those in Text 13.2, to ensure that your production keeps to the production plan are:

a. Prevent delays in production.
b. Manage operating ratios.
c. Plan a smooth supply of components and materials.

13.4 Deal with fluctuations in production

Changes in market demand may result in fluctuations in the required level of production. To anticipate or respond to such changes you may have to:

a. Reorganise the production system.
b. Allow for fluctuations in production when negotiating contracts with suppliers.
c. Adjust the internal stock of components and materials.
d. Develop multi-skilled employees who can be re-allocated to different jobs.

13.5 Plan and maintain inventories

To have a smooth production flow that meets shipping targets, but without high storage costs, you need to plan and maintain three inventories:

a. Product inventory.
b. Components and raw materials inventory.
c. WIP (work-in-process) inventory.

13.6 Inspect finished products, deal with abnormalities and seek continuous improvement

There are three further important actions to take to improve production control:

a. Inspect finished products with reference to the product standard.
b. Define what constitutes an abnormality in a product, and standardise the countermeasures to be taken.
c. Use Kaizen activities to continuously improve production control.

Learning tools

The RADAR questions

As you read each text you will discuss how it could be applied in your company. The RADAR questions will help you to focus this discussion:

R - Are these ideas **relevant** to my company?
A - How would I **apply** each of them in my company?
D - What **difficulties** might I meet and how would I overcome them?
A - Are there any **additional** actions that I might take that are not mentioned in the text?
R - What **resources** would be needed, what would these cost, and how could they be acquired?

There will of course be some discussion points where not all of these questions will be applicable.

The 6-Point Structure

After you have discussed the ideas in the text, you write an action plan in which you present practical proposals for implementing the conclusions you have reached in your discussion. The 6-Point Structure will help you to write your action plan:

1. **Problems:** Problems you have in your company in the area you have just discussed.
2. **Proposals:** Your proposals for improvement.
   a. Be specific and concrete.
   b. Include an implementation plan, with a time schedule and minimum and optimal implementation targets.
   c. Refer to any forms, charts, tables etc. that you would use, and include samples in an appendix.
3. **Obstacles:** Obstacles to implementation in employee attitudes, company organization and culture etc., and how these could be overcome.
4. **Resources:**
   a. The resources required: funds, equipment, materials, man-hours, expertise etc.
   b. The resources available within the company.
   c. Any resources that would have to be found outside the company.
   d. Alternatives that could be used to cover any shortfall in resources.
5. **Assessment:** Ways of assessing the results of implementing these proposals.
6. **Benefits:** The benefits your proposals would bring.

13.1 Prepare production and shipping plans

Introduction

1. There are three key plans that that the production department must prepare in order to have effective production control:
   a. An annual production plan, based on the sales plan.
   b. A daily or monthly production plan.
   c. A shipping plan.

   The daily or monthly plan is essential to ensure that production follows the annual plan. The shipping plan ensures that products are delivered from the production site to the delivery site on time

Annual production plan

2. Your annual production plan will cover your company's accounting period, which will usually be six to twelve months. This plan will determine:
   a. The type and quantity of products that will be produced during this period.
   b. The production conditions: location, materials and personnel, and the internal production departments and external suppliers which will participate.

   It may also include other detailed plans that support this basic plan.

3. The annual production plan will be largely determined by your sales plan. Before preparing it, look carefully at your sales plan and then look at the status of your production processes:
   a. Examine the amount of goods in the inventory, and the rate at which goods are being moved into and out of the inventory.
   b. Check if the current production capacity can produce the quantity required by the sales plan.
   c. If production capacity is insufficient, investigate what countermeasures can be taken.
   d. Investigate the time and expense needed to implement these countermeasures.
   e. Finally, prepare your production plan based on the results of all these investigations.

4. The annual production plan may have to be radically changed if there are changes in either the market or in production conditions. When this happens, review the plan and make whatever changes are needed, whether to the sales plan, or to the planned production quantity and methods, or to both. Dealing with changes in the market will involve three actions:
   a. Investigate the changed market needs.
   b. Decide on the company's sales strategy based on these needs.
   c. Decide on the estimated sales quantity.
5. A good annual production plan will help to ensure that your company:
   a. Produces the goods that the market wants.
   b. Delivers the right quantity of each type or model on time.
   c. Continues to improve the efficiency of its production processes.

Figure 13.1a Example of a production plan

Daily and monthly production plans

6. To ensure that production follows the annual production plan, it is important to also prepare daily or monthly plans, based on the annual plan. These should specify:
   a. How much is to be produced daily or monthly.
   b. Efficient methods for producing this quantity.
   c. How much this will cost.
   d. The target level of quality.

7. You should have a production administrator who will assess the situation in your section, and prepare a plan that will ensure the required production quantity. This requires regular meetings with related departments or sections to discuss any problems they may have. Take these into account in preparing the plans.

8. In general, in the machine industry, which includes assembly operations, the monthly and daily plans are based on a daily schedule. This schedule specifies the number of days required for each step, from receipt of the order through to the final product.

9. Figure 13.1b shows a typical daily schedule in the machine industry. Based on this schedule, each section in charge of a given step generates its own daily and monthly production plans. The "preparation number" shown on the horizontal axis gives the number of days needed to meet the shipment deadline, counted backwards. This includes both a) the number of days required for each step and b) the number of days required to prepare for each step.

10. Changes sometimes have to be made to the daily plan, for example when:
    a. A product has to be produced out of the scheduled order.
    b. Unscheduled work has to be done.
    c. Design changes have to be made.
    d. There are cancellations.

    Planning should allow for such events - it must take the realities of the job site into account.

Shipping plan

11. The purpose of a shipping plan is to make sure that products are delivered from the production site to the delivery site on time. This is essential to keep customers satisfied. The shipping plan requires detailed decisions on:
    a. Which products should be shipped.
    b. When they should be shipped.
    c. How they should be shipped.

12. Establish rules for administrative work procedures for the delivery of products, and keep records. Do not rely only on a computerised production control system, but check the actual goods regularly to confirm that the shipping plan is on schedule.

Figure 13.1c Flow of shipping procedures: Production Control System according to actual MRP (Material Requirement Planning) methods

13. There may sometimes be deviations from the shipping plan because:
    a. Defective goods emerge during the production process.
    b. The manufacturing equipment breaks down.
    c. Errors are made in adjusting the inventory.

14. When such a deviation occurs, take the following steps:
    a. Carry out a detailed check on the daily product shipping status.
    b. Identify the causes of the deviation.
    c. Investigate measures for preventing its recurrence.
    d. Check the effectiveness of these measures.
    e. Explain the situation to related parties and request their cooperation.

15. Remember that if the plan is not based on the actual situation at the production site, it may well fail. Management should be careful not to set unreal goals that are not based on experience.

Discussion

The following questions ask you to think about how the ideas in the text could be applied in your company. Some of these ideas may not be relevant to you. Concentrate on those that are relevant. Keep notes of your conclusions – you will need them to prepare your action plan afterwards. Where appropriate ask yourself the RADAR questions.

Note: Always include in your discussion any figures referred to in the text, ***if*** you feel these are relevant to your company.

The annual production plan

a. Do you have an annual production plan? If you do:
    i. What aspects of production does it include?
    ii. What benefits does it bring?
    iii. What weaknesses does it have?
    iv. What changes would improve it?

    If you do not:
    i. How do you produce the right quantities of each product on time?
    ii. What benefits do you think a plan might bring?
    iii. What aspects of production would you include in it?

b. Parag. 2 says what the annual production plan should determine. Discuss which of these you would include in a plan for your company. Are there any other items that you would also include? What exactly would you include under each of these items?

c. Do you have a sales plan? Do you base your production plan on it? If not, would it be a good idea to do so?

d. Parag. 3 suggests five actions to take to decide on the quantities to be produced to meet the sales plan. Apply the RADAR questions to these.

e. What changes in market or production conditions could affect your company?

f. Parag. 4 suggests three actions to take to deal with changes in the market. Apply the RADAR questions to these.
g. Parag 5 suggests three benefits of having an annual production plan. Would you expect these benefits to also apply in your company? What other benefits could a good plan bring to you?
h. Look at Figure 13.1a, an example of a production plan. Could you adapt this plan to suit your situation?

Monthly or daily production plan

i. Parag. 6. suggests four things that daily and monthly production plans should specify. Which of these do you already specify in your plans, or which would you specify in future plans? Is there anything else that you would specify? Discuss some of the details that you would include in your specifications.
j. Parag. 7 suggests the need to talk to related departments or sections before drawing up the production plan. Which other departments, sections or people would you need to talk to? What problems might you discuss with them?
k. Parag. 8: If it is relevant to your work situation, calculate what number of days your schedule requires for each step in some of your production processes.
l. Parag. 9: If it is relevant to your work situation, draw up a daily schedule similar to the one in Figure 13.1b. Alternatively, draw up a daily schedule to your own design.
m. Parag 10. suggests four reasons why the daily plan might have to be changed. How many of these could apply to your company? Are there any others that you would add?

Shipping plan

n. Do you already have a shipping plan? What improvements could you make to it?
o. Parag.11 suggests three main points to decide on when preparing a shipping plan. Is it easy for you to make these decisions? What information do you need, and where can you get it? Are there any problems or uncertainties in making these decisions? How can you deal with these?
p. Parag. 12: Do you already have rules for administrative work procedures for the delivery of products? Could these be improved? If you do not have any, what rules would you develop?
q. How do you check that your shipping is on schedule? How could you improve on this?
r. Figure 13.1c shows a chart of the flow of shipping procedures. Could this system be usefully applied in your company?
s. Parag 13: Which of these three causes of deviation from the shipping plans have you experienced? Which others have you experienced? How do you deal with them?
t. Parag. 14: Apply the RADAR questions to these suggestions.
u. Parag. 15: Which factors in the actual situation at your production site would you have to take into account? What past experience would help you to set realistic goals?

Action plan

Take the ideas you have found useful in the text, and in your discussion, and present them in a well-structured action plan for your company. Alternatively you may choose to prepare one action plan when you have discussed several texts. You might like to follow the 6-Point Structure.

13.2 Ensure that production keeps to plan – Part One

Introduction

1. When the monthly production plan has been agreed, there are several important actions to take to ensure that production keeps to this plan. Four are dealt with in this text and four in Text 13.3:
   a. Organise your production line in the best possible way.
   b. Set and keep to standard times.
   c. Know your production capacity.
   d. Manage each process.

Organise your production line in the best possible way

2. Organise the production line in the best possible way to carry out the monthly plan economically and efficiently. Take the following steps:
   a. Decide on the daily production quantity on the basis of the monthly plan.
   b. Decide on a suitable line speed to provide this production quantity.
   c. Decide on the best way to organise operations for the line speed.
   d. Allocate the work force according to this organization of operations.
   e. Arrange for the supply of components and materials.
   f. Give production instructions to the sections that produce related components, based on the line speed.

3. Hold regular meetings with sections related to the monthly production plan to review the plan, to investigate the problems in each section, and to decide on a strategy for handling these problems.

4. If the current production system is not capable of meeting the monthly production plan, it is better to review the equipment and the standards rather than to simply increase the workforce.

Figure 13.2a Example of line balance analysis

Set and keep to standard times

5. Standard time is the time required to perform a standardized operation. You need to manage production according to the standard times in order to keep production stable and to stay within the target production costs.

6. To set and keep to standard times:
   a. Check how long it takes to carry out the operation as specified in the operation standard, and then set this as the standard time.
   b. Remember that the time required to complete a given operation may vary not only

from one individual to another, but even when the same individual performs the same operation repeatedly.

c. Take into account the physical strength required.
d. Take into account the environment – is it noisy, is the floor slippery etc.?
e. Set hours separately for skilled employees and for general employees.
f. Educate and train employees so that they can perform standard operations within the standard times.
g. When operation conditions change because of changes in design or equipment, respond immediately: revise the operation standard and the standard time, and check the results.

Figure 13.2b Operation standard sheet

Know your production capacity

7. It is essential to know the precise production capacity of each process. This is the quantity that each process is capable of producing within a certain period. There are a number of points to consider here:
   a. A process may not actually produce to its full capacity because:
      i. Of defects in the production process.
      ii. Of failure of machinery or equipment.
      iii. A related process is producing at a lower capacity.
   b. Where a lower capacity process is slowing down production, synchronise capacity among the related processes: increase the capacity of the processes with lower capacity by improving equipment or by increasing the number of operators.
   c. When starting production of a new product, establish, in hard numbers, the production capacity of each process, and adjust the capacities of the different processes to create a balance in overall production. Examine the flow of components and WIP, and get a good sense of how many products can actually be produced in a given period.
   d. Production capacity can always be improved by regularly checking how many products are actually produced.

Figure 13.2c Process capacity chart

Manage each process

8. To manage each process properly you need to:
   a. Prepare a draft process schedule (by process and by date).
   b. Work with related sections to create an implementation plan based on this draft.
   c. Check progress several times a day with reference to the implementation plan.
   d. If there is a delay in a production process, immediately gather all the relevant information, check the situation, and decide on countermeasures. It is important to minimise any loss of production. (See also Text 13.3 .)

9. When a problem occurs in managing a process, the usual practice is to set up a system to immediately collect information and relay it to a central point. Some companies prepare indication lights so that employees can quickly recognize which process has a problem. People can then go quickly to the site, investigate what has happened, and take appropriate measures.

10. It is important to prepare standards that specify how to handle any abnormalities that may appear. (See Unit 8 for detailed guidelines on preparing standards.)

Figure 13.2d Flow of basic functions for a process management subsystem

Discussion

The following questions ask you to think about how the ideas in the text could be applied in your company. Some of these ideas may not be relevant to you. Concentrate on those that are relevant. Keep notes of your conclusions – you will need them to prepare your action plan afterwards. Where appropriate ask yourself the RADAR questions.

Note: Always include in your discussion any figures referred to in the text, ***if*** you feel these are relevant to your company.

Organise your production line in the best possible way

a. Parag. 2. suggests six steps to take to organize the production line. Apply the RADAR questions to these suggestions.
b. Parag. 3: How many different sections, or individuals, are involved in the monthly production plan? Is it easy to hold meetings with them? What are some typical problems and questions that you might have to discuss with them?
c. Parag. 4: If your production system is not capable of meeting the monthly production plan, what steps would you take? Is it possible for you to review equipment and standards, rather than take on new staff?

Set and keep to standard times

d. Parag. 5: How would you expect standard times to help to keep production stable and within target production costs?
e. Parag. 6 gives several actions to take to set and keep to standard times. Apply the RADAR questions to these.

Know your production capacity

f. Parag. 7: Have you had any experiences which would confirm that it is essential to know the precise production capacity of each process?
g. Parag. 7: Do you already know the precise production capacity for each process that you are responsible for? And the amount that is actually produced?
h. Parag. 7a suggests three reasons why full production capacity may not be achieved? Do these also apply in your company? Are there any other reasons that you experience? How do you deal with all of these?
i. Parag. 7b: What do you do in your company when a lower capacity process slows down production? Apply the RADAR questions to these suggestions.
j. Parag. 7c: How would you establish the production capacity of each process, when starting production of a new product? How would you gain a good understanding of how many products can actually be produced?

Manage each process

k. Parag. 8 gives four primary actions in managing each process. Take one of your typical processes and apply the RADAR questions to these actions in relation to this process.

l. Parag. 9 gives an example of a system for dealing with any problems that may arise in process management. Would this system work in your company? If not what alternative system might you use?

Action plan

Prepare an action plan to ensure that production in your company keeps to plan, using the ideas you have found useful in the text, and in your discussion, and following the 6-Point Structure. Alternatively you may choose to prepare one action plan when you have discussed Text 13.3 which is on the same subject.

13.3 Ensure that production keeps to plan – Part Two

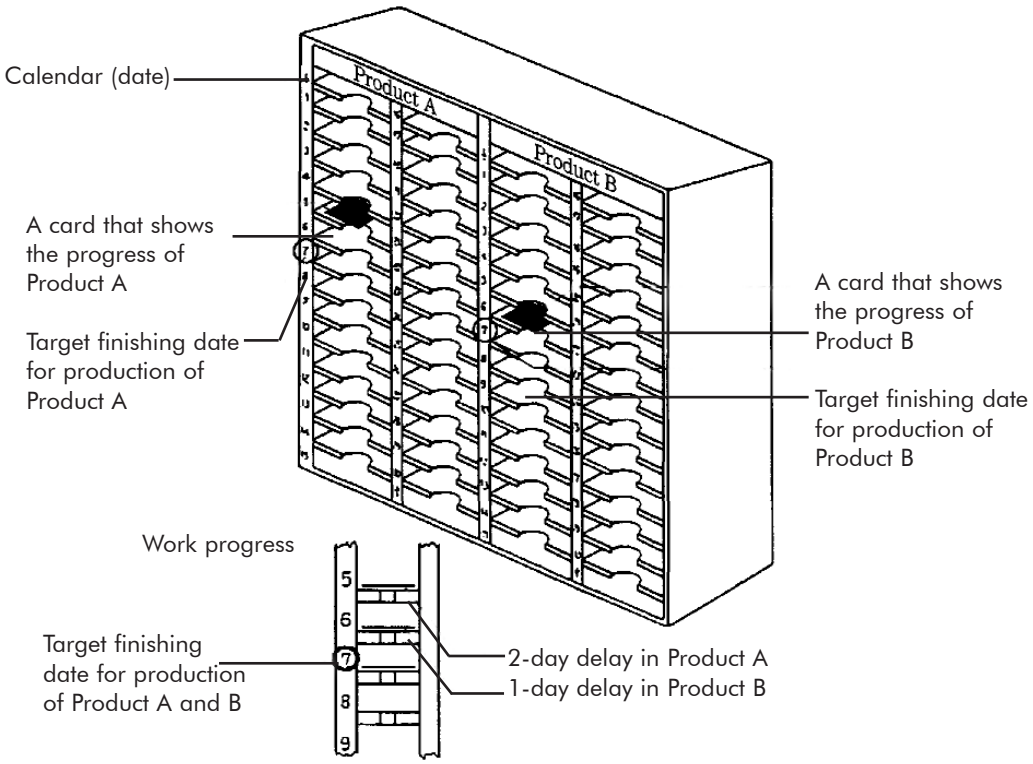
Introduction

1. The further three actions that you can take, in addition to those in Text 13.2 , to ensure that your production keeps to the production plan are:
   a. Prevent delays in production.
   b. Manage operating ratios.
   c. Plan a smooth supply of components and materials.

Prevent delays in production

2. To keep to the production schedule, it is essential to devise a system for monitoring it – a system that will allow you to see if production is on schedule. Figure 13.3a shows one method of monitoring the production schedule.

Figure 13.3a Progress management



3. When your monitoring system indicates a delay, find out the causes and deal with them:
   a. The reasons for failing to keep to the schedule are normally found in the "4M" – material, machinery, man, and methods of work. Examine these four areas to find the causes, and take temporary measures to deal with them.
   b. Decide on countermeasures to deal with these causes, and implement these with the cooperation of other related sections.
   c. Evaluate the results of these measures, and, if necessary, review the standards.
   d. The standards that you establish for the countermeasures should be appropriate for the specific situation: measures may differ depending on the degree of delay.
   e. Take measures to prevent delays recurring and check the effect of these measures.

   Remember that if production delays are not dealt with they will recur.

Figure 13.3b Progress management according to the weekly schedule

Manage operating ratios

4. A critical factor in keeping to the production plan is the level of productivity of both employees and equipment. One measure of this is the number of hours that operations are actually performed during the hours that they could be performed. This is the operating ratio. It can be put in percentage terms: Operating hours/Actual working hours x 100%.

5. To improve productivity, decide on effective operating ratios and establish standards for these using numbers as indices:
   a. Decide which non-operational tasks can be counted as actual work. Examples are:
      i. Going to pick up jigs or tools.
      ii. Refitting equipment and fixtures.
      iii. Fixing or adjusting equipment.
   b. Identify lost time for which employees are not responsible. Examples are:
      i. The production line is stopped.
      ii. Waiting for inspection.
      iii. Waiting for materials.
   c. Reduce indirect work – work not directly related to the production process.
   d. Establish a realistic standard time for each operation. (See Text 13.2.5/6)

Figure 13.3c shows one example of an operational analysis in a machine factory

The scientific study of manufacturing operations is called industrial engineering (I.E.). This is very effective in making operations more effective.

Plan a smooth supply of components and materials

6. Delay-free production depends on having a smooth supply of the various components and materials needed for daily production. Prepare a plan that will ensure this. Base your plan on the daily production plan and distribute it in advance to related sections.

7. Be aware of the following potential problems:
   a. Defective goods may be produced in the components and materials production process.

b. Breakdowns may occur in machinery or equipment in this process.
c. Transport problems may hold up the supply of components and materials.

8. To be prepared for these problems, standardize and implement a daily control system of the production process for each component and material. If a problem does occur, collect related information, and decide on recurrence prevention measures.

9. In many cases, companies hold a meeting when they are preparing the monthly plan in order to identify problems that might arise in supplying each component and material. They then make adjustments, determine a daily production plan based on the information they have gathered, and decide on the quantity of components and materials that should be supplied. If a defect is found in the components and materials that have been supplied, it is not unusual to stop production until the cause has been found and preventive measures have been taken.

   (See also Text 13.4.5 on adjusting the internal stock of components and materials in response to fluctuations in supply and demand, and Text 13.5.4 on maintaining a standard inventory of components and raw materials for each process.)

Discussion

The following questions ask you to think about how the ideas in the text could be applied in your company. Some of these ideas may not be relevant to you. Concentrate on those that are relevant. Keep notes of your conclusions – you will need them to prepare your action plan afterwards. Where appropriate ask yourself the RADAR questions.

Note: Always include in your discussion any figures referred to in the text, ***if*** you feel these are relevant to your company.

Prevent delays in production

a. Parag. 2: Do you have a system that allows you to see if your production is always on schedule? If not would it help if you had such a system? Look at the example in Figure 13.3a. Would this be suitable for any of your production processes? What alternative system could you use?
b. What are some typical production delays that you experience? What causes them, and what measures can you take to prevent them recurring?
c. Parag. 3. Apply the RADAR questions to these suggestions for identifying and dealing with the causes of production delays.

Manage operating ratios

d. Parag. 4: What would you guess the operating ratio is in some of your production processes? How do you think it could be improved?
e. Parag. 5: Discuss the following points in relation to your own company:
   i. Which non-operation tasks would you count as actual work?
   ii. Give examples of lost time for which employees are not responsible.
   iii. How would you reduce indirect work?
   iv. What factors would you take into account in establishing a realistic time for an operation?

v. Try to calculate approximate standard operation times for one or two of your operations, if you have not already done so in Text 13.2.5/6.

Plan a smooth supply of components and materials

f. Parag. 6: What kind of problems do you have in the supply of components and materials? How do you deal with them?
g. Parag. 7 suggests three potential problems in ensuring a smooth flow of components and materials for production requirements. Do you have the same problems? Other problems? How do you deal with them?
h. Parag. 8 suggests a daily control system for each component and material. What kind of system could you create?
i. Parag. 9 gives the approach that some companies take. Might this approach also work in your company? If so, how would you put it into practice?
j. Consider an overall approach that your company could take to ensure a smooth supply of components and materials. Use the RADAR questions.

Action plan

Prepare an action plan to ensure that production in your company keeps to plan, using the ideas you have found useful either in this text or in both this text and Text 13.2 . Follow the 6-Point Structure.

13.4 Deal with fluctuations in production

Introduction

1. Changes in market demand may result in fluctuations in the required level of production. To anticipate or respond to such changes you may have to:
   a. Reorganise the production system.
   b. Allow for fluctuations in production when negotiating contracts with suppliers.
   c. Adjust the internal stock of components and materials.
   d. Develop multi-skilled employees who can be re-allocated to different jobs.

Reorganise the production system

2. There are a number of ways that you can re-organise the production system:
   a. Change the number of employees.
   b. Allocate employees to different jobs.
   c. Change from a two-shift system to a single-shift system, or vice versa.
   d. Reduce the production quantity by stopping production of a certain process.
   e. Reduce the working hours.
   f. Adjust the speed of machinery and equipment.
   g. Borrow employees from other production sites.
   h. Adjust the conveyor speed to fit the quantity to be produced, and re-allocate employees according to the conveyor speed.

3. Keep the following points in mind:
   a. If you continue production at the same level after a drop in market demand you will not only increase the quantity of inventory and WIP that you are holding, but you will also incur the additional costs of producing these extra goods.
   b. Be flexible when making changes to processes: relate changes to the size of production fluctuations.
   c. Be careful when making changes: large fluctuations in production are a major cause of defects.
   d. Your monthly production plan should allow for adjustments based on sales and market demand, and also on the capacity of your suppliers to respond to such changes.

Figure 13.4a Capacity sheet by component, shows one example of understanding capacity by component, which is the basis for making changes to processes

Allow for fluctuations when negotiating contracts with external suppliers

4. When you are drawing up a contract with an external supplier it is essential to agree about what will be done if there are fluctuations in production as a result of changes in market demand. Such changes will obviously mean changes in supply requirements. Note the following:

a. When agreeing a contract, make a clear allowance in the contract for both increases and decreases in the quantity to be supplied.
b. If you have already made a contract with an external supplier without allowing for production fluctuations, then conditions must be agreed whenever such fluctuations occur.
c. When an excessive increase in the required supply quantity causes difficulties, consider the temporary use of a new external supplier.
d. When negotiating a reduction in the quantity supplied, it is often necessary to consider sharing financial responsibility and liability.
e. In general it is important to clearly reserve the right in the contract to make adjustments to the supply amount within a certain limited range of fluctuation, and to make a separate contract to handle changes beyond this limit.
f. Since the ability to absorb fluctuations in production differs widely among external suppliers, both parties should fully discuss in advance the measures to be taken.
g. Unreasonable demands can damage the relationship with external suppliers.
h. Take the capacity of your suppliers to respond to fluctuations in sales and market demand into account in your monthly production plans.

Items to clarify in the contract	Official amount as per the contract	Changes in the supply amount	Deadline for notification
Range of fluctuation	100	+/- 10%	One month prior to a change
		+/- 10% or more	Consult three months prior to a change

Adjust the internal stock of components and materials in response to fluctuations in production

5. It is important to be able to adjust the internal stock (inventory) of components and materials in response to fluctuations in production:
   a. Constantly monitor and manage the maximum and minimum stock levels for the components and materials needed for a particular product.
   b. Prepare measures to ensure that there are always enough components and materials available if production has to be increased.
   c. If production has to be reduced, it may be necessary to
      i. Stop the machinery and equipment in order to stop producing the components and materials, or
      ii. Change operation methods so as to be able to reduce the number of operators.
   d. If these measures can be taken smoothly this indicates flexibility in production capacity. This is one of the standards for measuring the extent to which production fluctuations can be absorbed.
   e. It is important to minimize the gap between maximum production capacity and actual production capacity.

(See also Text 13.3.6 on planning a smooth supply of components and materials, and Text 13.5.4 on maintaining a standard inventory of components and raw materials for each process.)

Figure 13.4b The role of related sections in making changes in the production plan

Develop multi-skilled employees

6. It is quite common to re-allocate employees to different jobs when there are fluctuations in production. Training employees in multiple skills is one of the best methods for responding flexibly to fluctuations in production. There are several steps that you can take:
   a. Educate and train employees systematically so that they will be able to perform a wider range of tasks, and can be re-allocated to different jobs.
   b. Introduce multi-skill training for employees, and establish an in-house qualification scheme.

7. In many companies, supervisors at the production site create a plan to educate and train each employee in multiple skills. Supervisors maintain records showing each employee's skill in each task in a process, and base the re-allocation of employees on these records. Where special licenses may be required, supervisors recommend employees they feel should obtain the license. They know who has which licenses and take this into consideration when allocating employees.

Figure 13.4c A Training plan for multi-skilled employees

Discussion

The following questions ask you to think about how the ideas in the text could be applied in your company. Some of these ideas may not be relevant to you. Concentrate on those that are relevant. Keep notes of your conclusions – you will need them to prepare your action plan afterwards. Where appropriate ask yourself the RADAR questions.

Note: Always include in your discussion any figures referred to in the text, ***if*** you feel these are relevant to your company.

a. Does your company experience changes in market demand? Does this affect your production process? If so how do you respond?
b. Parag. 2: Apply the RADAR questions to these suggestions. Consider also what other problems might arise from introducing your changes and what countermeasures you could take.
c. Parag. 3 mentions four points to keep in mind. Consider each of these in relation to your production situation.
d. Parag. 4: Do the quantities that you need from suppliers change when there are fluctuations in your production? What problems does this bring? What do you do about them?
e. Parag. 4: Discuss the relevance for your company of each of these comments and suggestions.
f. Parag. 5: Do you have problems with raising or lowering your internal stock of components and materials when there are fluctuations in production? How do you deal with these?
g. Parag. 5: Apply the RADAR questions to these suggestions.

h. Look at Figure 13.4b showing the role of related sections. If you feel it would be useful to do so, prepare your own table.
i. Parag. 6: Would reallocating employees to different jobs be a meaningful way for you to deal with fluctuations in production? If so, apply the RADAR questions to the steps suggested.
j. Parag. 7: Discuss how much of this plan could be applied in your company.

Action plan

Prepare an action plan for responding to production fluctuations in your company, based on the ideas in the text, and your discussions. You might like to follow the 6-Point Structure.

13.5 Plan and manintain inventories

Introduction

1. To have a smooth production flow that meets shipping targets, but without high storage costs, you need to plan three inventories:
   a. Product inventory.
   b. Components and raw materials inventory.
   c. WIP (work-in-process) inventory.

   To manage and maintain the levels of these inventories you should set up storage systems that:
   a. Allow people to see the inventory levels at a glance - known as inventory management at a glance.
   b. Provide a first-in first-out system for delivering and collecting items. (FIFO).

(See Texts 5.3 and 5.4 in Unit 5 for more general guidelines on storage and maintaining inventories.)

Product inventory

2. When market demand falls, companies that use the market production system may find themselves with excessive product inventories (the difference between the quantity produced and the quantity sold). This can become a serious business problem, resulting in:
   a. Additional storage costs.
   b. Products deteriorating, aging, or going out of fashion.

   On the other hand, if market demand increases, a shortage in product inventory can result in the loss of a sales opportunity.

3. For these reasons it is important to plan the product inventory carefully. Decide on the right level, and maintain this level by adjusting production. Take the following steps:
   a. Decide how many products have to be produced each day to meet the monthly shipping plan.
   b. If there is not enough production capacity, produce and store an appropriate amount of products in advance.
   c. Take into account any possible changes in the shipping plan, and establish a standard inventory quantity that includes some extra inventory.
   d. To decide how much this extra inventory should be, consider:
      i. Production capacity.
      ii. The production period.
      iii. Potential aging of the product over time.
      iv. Market trends.
      v. Possible product model changes.
      vi. The product's competitiveness.
      vii. Inventory costs.
   e. Maintain this quantity in the inventory.

Always be aware of the need to consider lead time (the time between ordering and receiving goods) and to keep your inventory cost-effective.

Figure 13.5a Sample standard inventory

Components and raw materials inventory

4. To make sure that you have enough components and raw materials for each production process, without excessive storage costs, take the following steps:
   a. Know the gap between the supply of the product itself, and the demand for the product, and the gaps between the supply and demand for components and raw materials.
   b. Decide on the standard inventory quantity, and maintain this level.
   c. Check the inventory regularly and, if necessary, revise the production plan, and/or adjust the plan for receiving goods from suppliers.
   d. Since both demand and supply must change together, revise the standard quantity when there are any changes in these.

Figure 13.5b Calculation of semi-manufactured inventory

(See also Text 13.3.6 on maintaining a smooth supply of components and raw materials, and Text 13.4.5 on adjusting the internal stock of components and materials in response to fluctuations in production.)

Work-in-process inventory

5. A WIP (work-in-process) inventory is essential to provide the right quantity of processed goods for all the production processes through to the completion of finished goods. Problems may arise because of:
   a. Differences in production capacity between one machine and another, one piece of equipment and another, or one process and another.
   b. Changes in the procedures for operating and maintaining the machinery and equipment due to changes to the product.
   c. Transportation difficulties due to the geographical situation of the production site.

6. When deciding on the proper WIP inventory, keep the following points in mind:
   a. The less inventory the better; but if the inventory is too low, downstream machinery, equipment and processes might have to wait for materials.
   b. When there are changes in production, such as the procedures for operating and maintaining machinery and equipment due to changes to the product, review the quantity of WIP inventory needed, and create an inventory plan that will ensure that the production process continues to run smoothly. Establish this changed inventory as the standard inventory level.
   c. A proper quantity of WIP should be kept at the appropriate location or process.

Figure 13.5c Management steps to be taken between processes

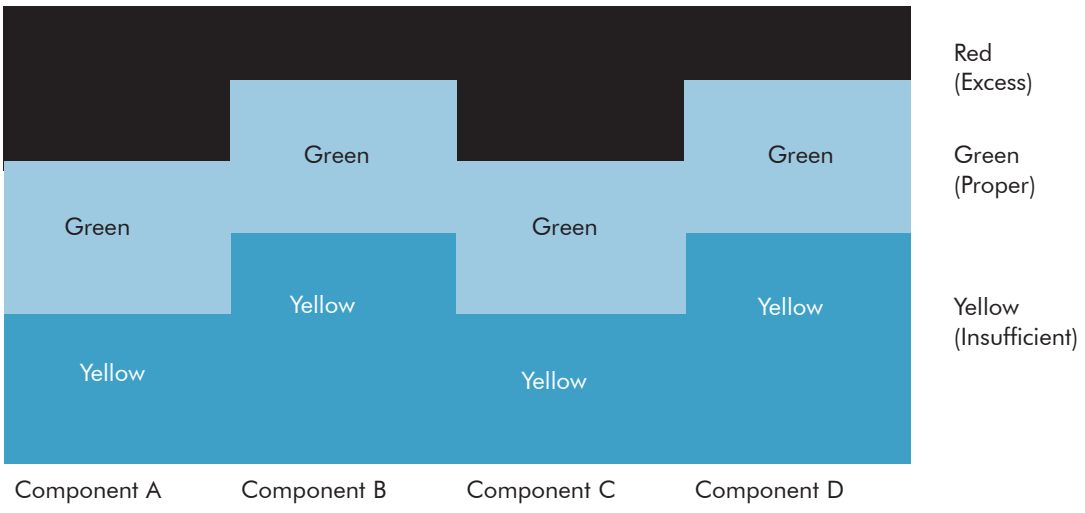
Inventory management at a glance

7. The best way to control inventory precisely is to have a system that allows people to see inventory levels at a glance – so that they can recognise immediately if the inventory level is too high or too low. To establish such a system:
   a. Decide which items in the inventory are to be managed in this way, and the quantities.
   b. Decide what inventory data should be displayed for people to quickly see:
      i. The standard amount, and the minimum and maximum amounts.
      ii. The amount already used and the balance remaining.
      iii. The refill orders that have been sent off, and the date of the incoming delivery.
   c. Decide on the method for displaying this data:
      i. PC screen.
      ii. Signs, standing plates, tags on articles.
      iii. Using different colours.
   d. Develop and standardize detailed measures for setting up and running the system.

   This system can be used to manage all inventories: finished products, semi-finished products, components and raw materials.

8. Examples:
   a. Decide where the inventory should be kept and then mark the height to which goods are to be stacked to provide the standard inventory quantity. When people compare the inventory level with the mark they can see at a glance the gap between the actual inventory level and the standard inventory level.
   b. Establish an area that can hold only a specified quantity of inventory. If someone tries to store excessive inventory, they will be unable to do so and will have to store the excess inventory somewhere else.
   c. Load the products onto a standardized pallet that can hold a certain quantity, decide where to store the pallet, and limit the number of pallets to be stored in this location.
   d. Decide on the standard quantity of semi-finished products to be kept between machines, and create a jig that can hold only this quantity.

Figure 13.5d Managing component storage (wall)



e. Put a mark on the vehicles used to transport goods to indicate the designated quantity, and use this mark to check that the quantity is right.
f. Figure 13.5d gives an example of storage at a coloured wall.

9. The effectiveness of these measures depends, of course, on how suitable they are for the actual conditions at the job site. It is difficult to always set the upper and lower limits of standard inventory quantity because these limits differ depending on various conditions of production. However, it is possible to gradually set stricter limits.

10. In general, most companies in the assembly industry in Japan check on quantity, yield, and quality every day for semi-manufactured goods and WIP and make adjustments accordingly. In many cases, companies check raw materials weekly or monthly, or when they receive these materials. It is always better to regularly check the actual goods at the job site rather than depend on computer systems.

First-in, first-out (FIFO)

11. Items received first should be used first to prevent their deterioration. "First-in" refers to the order of production. Otherwise goods manufactured first are likely to be piled in the lower layer simply as a matter of convenience. Newer goods will then be piled on top of them, and be taken out first. This also often happens during a mid-stream process or with raw materials.

12. Possible ways setting up a first-in, first out system:
    a. Put someone in charge.
    b. Establish a procedure to ensure that items entered into storage first are also the first to leave.
    c. Clearly mark items with their serial number, part number, production date, quantity, and date of entry into storage.
    d. Make clear the order in which items have arrived. You can, for example, classify goods using boxes according to the order received.
    e. Clearly mark their storage location and position.
    f. Establish a separate entrance and exit for raw materials.
    g. Place heavy goods, such as steel plates, in rows rather than stacking them.
    h. When storing important components, number each component sequentially and use them in order.

13. The first-in, first-out method may be difficult to use because it requires a lot of storage space and is often time-consuming. Nevertheless it is important to work out adequate storage methods.

Figure 13.1b Typical daily schedule for the machine industry

Discussion

The following questions ask you to think about how the ideas in the text could be applied in your company. Some of these ideas may not be relevant to you. Concentrate on those that are relevant. Keep notes of your conclusions – you will need them to prepare your action plan afterwards. Where appropriate ask yourself the RADAR questions.

Note: Always include in your discussion any figures referred to in the text, ***if*** you feel these are relevant to your company.

Product inventory

a. Parag. 2: Does market demand often change in your company? If so, what effect does this have on your product inventory? What business problems does this cause?
b. Parag. 3: Apply the RADAR questions to these suggestions for planning the product inventory.
c. Look at Figure 13.5a: If you feel it would be useful, prepare a similar chart for your inventory, giving approximate maximum and minimum levels.

Components and raw materials inventory

d. Parag. 4: Do you have problems with the gap between the amount of components and raw materials supplied for each production process and the amount actually used? How have you been able to deal with these problems?
e. Parag. 4: Apply the RADAR questions to these steps.
f. Look at Figure 13.5b . Could a similar diagram be used to calculate the inventory in some of your processes? If you think it could, try it out.

Work-in-process inventory

g. Parag.5: Do you experience any of these problems? How do you deal with their impact on your WIP inventory?
h. Parag. 6 makes some comments and suggestions about deciding on proper inventory levels. Apply the RADAR questions.
i. Look at Figure 13.5c . If you feel it would be useful, draw a similar chart for some of your processes.

Inventory management at a glance

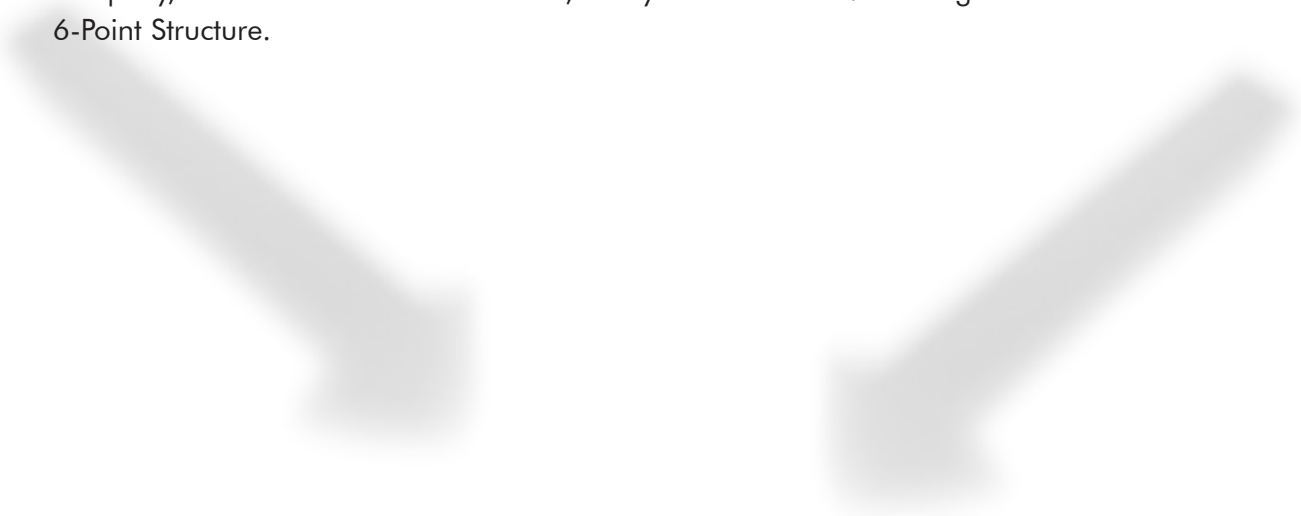
j. Is it easy for you to see your inventory levels at a glance? Would it be helpful if it were easier? How could you make it easier?
k. Parag. 7 gives two primary guidelines for setting up a system that allows people to see inventory levels at a glance, and parag. 8 presents five examples of practical ways of organising this:
    i. First look at the examples and discuss which of these might work for you – and any other useful methods that you could devise.
    ii. Then apply the RADAR questions to the two primary guidelines.
l. Parag. 10: How often do you check your inventories. How often do you think you should.

First-in, first-out

m. Parag. 11: Does it often happen in your company that more recent goods are piled on top of older ones? If so, is it a problem? What have you already tried to do about it?
n. Parag. 12: Apply the RADAR questions to these guidelines for setting up a first-in, first-out system.
o. Parag. 13: Would this method be as difficult for you as the text suggests?

Action plan

Prepare an action plan planning and maintaining production-related inventories in your company, based on the ideas in the text, and your discussions. You might like to follow the 6-Point Structure.



13.6 Inspect finished products, deal with abnormalities and seek continuous improvement

Introduction

1. There are three further important actions to take to improve production control:
   a. Inspect finished products with reference to the product standard.
   b. Define what constitutes an abnormality in a product, and standardise the countermeasures to be taken.
   c. Use Kaizen activities to continuously improve production control.

Inspect finished products

2. Inspect finished products with reference to the product standard. This will mean you can assure the customer that product quality has been met. Take the following steps:
   a. Establish an inspection standard that corresponds to the product standard.
   b. Attach an inspection certificate when the product is being shipped to the customer.
   c. Put an inspection mark on the product to indicate that it has passed inspection – the customer may not require this, but you should do it for the company's own purposes.
   d. If a product does not pass the inspection, fix the defect and re-inspect the product. If no further problems are found, process the product as a satisfactory product.
   e. Keep the inspection results for a certain period to satisfy the quality assurance requirements, and so that you can refer to them if a customer makes a claim.
   f. When any defects occur, inform the relevant section and ask them to take measures to prevent recurrence.
   g. For some products you can set up an inspection line just after the final process is complete.

(See Unit 15 for detailed guidelines on carrying out inspections.)

Define abnormalities and standardize countermeasures

3. Decide objectively what the limit is outside which something is regarded as an abnormality (i.e. something which is not as it should be), identify and analyse the causes, and decide on the countermeasures to be taken to prevent recurrence. When these are tested, standardise them. This will help you to immediately detect and deal with such abnormalities as:
   a. Quality problems.
   b. The deterioration of products and semi-finished products.
   c. Load shifts.
   d. Damage to packaging.
   e. The inventory is beyond the upper or lower limits of the standard inventory quantity.
   f. Abnormal inventory levels caused by delays in the production processes.
   g. Mistakes in checking the inventory quantity.

4. Take the following steps:
   a. Establish control points for managing progress in the production processes, and collect information on any abnormalities that appear in both quantity and quality. (Control points are different points in a process that can be examined to check that production is continuous and stable.)
   b. Standardize procedures for dealing with abnormalities. When the abnormality relates to several sections, immediately arrange a meeting with personnel from these sections to discuss countermeasures.
   c. Decide on and implement countermeasures to bring things back to normal.
   d. Standardize the countermeasures.

(See Unit 9 for detailed guidelines on dealing with abnormalities.)

5. Example: Packaging that was found to be contaminated:
   The first step was to collect information on the contamination of the packages. Employees found that there was a 20% occurrence rate of this contamination in the final process. They then worked back upstream from the final process to find the process that was generating the contamination. It was the packaging process that was causing the problem.

6. Oil was leaking from the arm of the robot that put the packages in place, and sticking to the packages. The oil gasket of the robot arm was worn, so the maintenance department:
   a. Replaced the gasket.
   b. Reviewed the standard for maintaining and checking the robot.
   c. Added a new check item.
   d. Standardized this procedure.

7. The related departments took the following actions:
   a. The maintenance department revised the standard for maintaining and checking the robot.
   b. The maintenance department maintained an inventory of arm oil gaskets.
   c. The production department issued an instruction sheet alerting employees to the danger of oil leakage from the arm.

Use Kaizen to continuously improve your production control

8. Kaizen is the Japanese term for the concept of continuous improvement. There are several Kaizen activities that can be used to improve production control:
   a. Avoid the three negative forms of behaviour in the workplace: "Muri" (unreasonableness), "Muda" (wastefulness), and "Mura" (untidiness) in production activities, and be alert for problems. This will bring a great deal of improvement.
   b. Present your colleagues with examples of improvement from past experience.
   c. Assess whether or not there are still problems in the workplace similar to those in the examples.
   d. Identify any such problems, try to assess quantitatively whether these problems have been reduced, and apply the results to future activities.

9. Examples:
    a. A review was carried out after establishing a precise, standard inventory quantity of WIP, and a great deal of WIP waste was detected and reduced.
    b. Work time was drastically reduced (30 minutes to 8) after it was discovered that, when replacing a mould, a partial replacing was possible within 10 minutes by using jigs creatively.
    c. The cause of the worst case of an uneven operation ratio in the finishing process was investigated by comparing it with a better case. Countermeasures were then implemented which solved the unevenness: the operation ratio was dramatically improved (50 minutes down to 15 minutes.)
    d. The movement of employees for a particular process was evaluated, and the layout of equipment was changed to reduce the amount of movement needed. This brought an increase in hourly production rates.

Figure 13.6a Example of Kaizen: How line balance was improved by changing the layout of the tank inner-plate welding process and thus reducing the need for one of the operators.

Discussion

The following questions ask you to think about how the ideas in the text could be applied in your company. Some of these ideas may not be relevant to you. Concentrate on those that are relevant. Keep notes of your conclusions – you will need them to prepare your action plan afterwards. Where appropriate ask yourself the RADAR questions.

Note: Always include in your discussion any figures referred to in the text, ***if*** you feel these are relevant to your company.

a. What kind of system do you use to inspect your finished products? How effective is it? Where does it need to be improved?
b. Parag. 2 suggest several steps to take to inspect finished products with reference to the product standard. Apply the RADAR questions to these suggestions.
c. Parag. 3 gives seven typical kinds of abnormality. How many of these occur in your company? How serious a problem are they? What other abnormalities do you experience, and how do you deal with them?
d. Parag. 4 proposes four major steps to take in dealing with abnormalities. Discuss concretely and in detail how you could take each of these steps in your company, the difficulties you would meet in doing so, and ways of overcoming these difficulties.
e. Parags. 5, 6 and 7 give a detailed example of an abnormality that was investigated. Have you had any similar experiences? How did you solve them? What actions, if any, did related departments take?
f. Parag. 8 suggests some Kaizen activities that you and your colleagues could use to improve the level of production control. Apply the RADAR questions to these suggestions.
g. Parag 9 gives some examples of improvements that were implemented using Kaizen. Are there any similar improvements that you have introduced? Do these examples suggest any areas where you might introduce improvements?

Action plan

Draw up an action plan for inspecting finished products, defining abnormalities and standardizing countermeasures, and using kaizen activities in your company, based on your discussions of the text. You might like to follow the 6-Point Structure.

Test

Answer these questions using **only** the information given in the text. For each question one, two or all three answers may be correct. Tick the answer or answers you think are correct for each question. Each question carries 3 points – you get one point for each correct answer that you tick, and one point for each wrong answer that you do not tick.

13.1 Prepare production and shipping plans

1. The annual production plan determines:
   - ☐ a. The type and quantities of products that will be produced during this period.
   - ☐ b. Which internal production departments and external suppliers will participate.
   - ☐ c. The range within which the sale price of the product should be set.
2. The production plan is determined largely by:
   - ☐ a. The annual plan.
   - ☐ b. The sales plan.
   - ☐ c. The market plan.
3. To decide on the quantities to be produced to meet sales requirements:
   - ☐ a. Check if the current production capacity can produce the quantity required.
   - ☐ b. Examine the amount of products in the inventory, and the rate at which products are being moved into and out of the inventory.
   - ☐ c. Prepare a sales plan based on all these investigations.
4. The production plan may have to be radically changed if there are changes in:
   - ☐ a. The market.
   - ☐ b. Research methods.
   - ☐ c. Production conditions.
5. An annual production plan is a valuable means of ensuring that the company:
   - ☐ a. Produces the products that the market wants.
   - ☐ b. Sells the right quantity of each type and model.
   - ☐ c. Continues to improve the efficiency of its production processes.
6. Monthly and daily plans should specify:
   - ☐ a. How much is to be produced.
   - ☐ b. How much it should cost.
   - ☐ c. How it should be sold.
7. The daily schedule in the machine industry specifies the number of days required for each step:
   - ☐ a. From receipt of the order through to the sale of the product.
   - ☐ b. From receipt of the raw materials through to the final product.
   - ☐ c. From receipt of the order through to the final product.
8. Changes may have to be made to the daily plan when:
   - ☐ a. There are cancellations.
   - ☐ b. Unscheduled work has to be done.
   - ☐ c. A product has to be produced out of the scheduled order.

9. A shipping plan is required to make sure that products are delivered from the production site to the delivery site.
   - ☐ a. As quickly as possible.
   - ☐ b. As cheaply as possible.
   - ☐ c. On time.
10. To confirm that the shipping plan is on schedule:
   - ☐ a. Rely on the computerized production control system.
   - ☐ b. Check the actual products regularly.
   - ☐ c. Check the records.
11. There may be deviations from the shipping plan because:
   - ☐ a. The manufacturing equipment breaks down.
   - ☐ b. Errors are made in adjusting the inventory.
   - ☐ c. An excessive inventory is maintained.
12. Steps to take when there is a deviation from the shipping plan include:
   - ☐ a. Carry out a detailed check on the monthly product shipping status.
   - ☐ b. Identify causes of deviation.
   - ☐ c. Investigate measures for preventing recurrence of these deviations.

13.2 Ensure that production keeps to plan – Part One

13. To organise the production line in the best possible way to carry out the monthly plan economically and efficiently, take two of the following steps:
   - ☐ a. Decide on the daily production quantity on the basis of the annual plan.
   - ☐ b. Decide on a suitable line speed to provide this production quantity.
   - ☐ c. Decide on the best way to organise operations for the line speed.
14. Hold regular meetings with sections related to the monthly production plan to:
   - ☐ a. Consider the plan.
   - ☐ b. Investigate problems in each section.
   - ☐ c. Decide on a strategy for holding future meetings.
15. When the current production system is not capable of meeting the monthly production plan:
   - ☐ a. Review equipment.
   - ☐ b. Review standards.
   - ☐ c. Increase the workforce.
16. Standard time is the time required to:
   - ☐ a. Perform an operation.
   - ☐ b. Perform a standardized operation.
   - ☐ c. Standardize an operation.
17. To set and keep to standard times:
   - ☐ a. Check how long it takes to carry out the operation as specified in the operation standard and then set this as the standard time.
   - ☐ b. Educate and train employees so that they can set standard times.
   - ☐ c. Revise the operation standard and the standard time when operations conditions change because of changes in design or equipment.
18. The precise production capacity for each process is the quantity that each process:
   - ☐ a. Is capable of producing.
   - ☐ b. Is capable of producing within a certain period.
   - ☐ c. Produces within a certain period.

19. Full production capacity may not be achieved because of:
    - ☐ a. Defects in the production process.
    - ☐ b. Changes in standard times.
    - ☐ c. Failure of machinery or equipment.
20. Which of the following actions could you take if a lower capacity process is slowing down production:
    - ☐ a. Synchronise capacity among the related processes.
    - ☐ b. Increase the capacity of the processes with lower capacity by improving equipment.
    - ☐ c. Lower the capacity of the processes with higher capacity by reducing the number of employees.
21. Production capacity can always be improved by:
    - ☐ a. Regularly checking how many products are stored in the inventory.
    - ☐ b. Regularly checking how many products are actually produced.
    - ☐ c. Increasing the movement of components and WIP.
22. To manage each process properly you need to:
    - ☐ a. Prepare a draft process schedule.
    - ☐ b. Check progress once a day.
    - ☐ c. Work with related sections to create an implementation plan.

13.3 Ensure that production keeps to plan – Part Two

23. To prevent delays in production:
    - ☐ a. Examine the 4M to find out the causes of delays.
    - ☐ b. Take measures to solve the immediate problem.
    - ☐ c. Decide on countermeasures to deal with these causes, and implement these measures with the cooperation of related sections.
24. To improve productivity:
    - ☐ a. Decide which non-operation tasks can be counted as actual work.
    - ☐ b. Identify lost time for which employees are responsible.
    - ☐ c. Establish a realistic time for an operation.
25. Examples of non-operational tasks which can be counted as actual work are:
    - ☐ a. Going to pick up jigs or tools.
    - ☐ b. Refitting equipment or fixtures.
    - ☐ c. Waiting for materials.
26. Lost time for which employees are not responsible includes:
    - ☐ a. Waiting for inspection.
    - ☐ b. Going to pick up jigs or tools.
    - ☐ c. Waiting for materials.
27. Potential problems in ensuring a smooth supply of components and materials for daily production include:
    - ☐ a. Defective products may be produced during the component and material production process.
    - ☐ b. Breakdowns may occur in machinery or equipment in this process.
    - ☐ c. Transport problems may hold up the shipment of finished products.
28. To be prepared for problems in the smooth supply of components and materials standardize and implement a ... control system of the production process for each component and material.

- ☐ a. Daily
- ☐ b. Monthly
- ☐ c. Annual

13.4 Deal with fluctuations in production

29. When market changes cause fluctuations in production levels, make changes to the production process by:
    - ☐ a. Allocating employees to different jobs.
    - ☐ b. Borrowing employees from other companies.
    - ☐ c. Adjusting the speed of machinery and equipment.
30. To continue production at the same level after a drop in market demand will:
    - ☐ a. Increase the quantity of inventory and WIP.
    - ☐ b. Bring the additional costs of producing these products.
    - ☐ c. Lower the price of products.
31. When drawing up a contract with an external supplier it is essential to agree about what will be done if there are fluctuations in production due to:
    - ☐ a. Employee absenteeism.
    - ☐ b. A breakdown in equipment.
    - ☐ c. Changes in market demand.
32. If a contract has already been made with an external supplier which does not include an agreement on how to handle fluctuations in production, then:
    - ☐ a. Conditions must be decided each time such a change takes place.
    - ☐ b. The contract must be immediately changed to include such an agreement.
    - ☐ c. A new supplier should be found.
33. To adjust the stock of components and materials in response to fluctuations in production:
    - ☐ a. Constantly monitor and manage the maximum and minimum stock levels of the components and materials needed for a particular product.
    - ☐ b. Always be aware of the maximum potential fluctuations.
    - ☐ c. Prepare measures to ensure that there are always enough components and materials available if production has to be increased.
34. To be prepared for fluctuations in production, educate and train employees systematically so that they will be able to:
    - ☐ a. Perform more effectively under pressure.
    - ☐ b. Perform a wider range of tasks.
    - ☐ c. Speed up the cycle time.

13.5 Plan and maintain inventories

35. Changes in market demand can result in:
    - ☐ a. Excessive sales of products.
    - ☐ b. Excessive production.
    - ☐ c. Excessive product inventories.
36. Shortage in product inventory can result in:
    - ☐ a. The loss of products.
    - ☐ b. The loss of a sales opportunity.
    - ☐ c. Savings in storage costs.

37. To set and maintain a suitable product inventory level:
    - ☐ a. Decide how many products have to be produced each day to meet the monthly shipping plan.
    - ☐ b. If there is not enough production capacity, produce and store an appropriate amount of products in advance.
    - ☐ c. Take into account any possible changes in the shipping plan, and establish a standard inventory quantity that will correspond exactly to the quantity needed.
38. To make sure that you have enough components and raw materials for each production process, without excessive storage charges:
    - ☐ a. Know the gap between the supply of the product itself, and the demand for the product, and the gaps between the supply and demand for components and raw materials.
    - ☐ b. Decide on a standard inventory quantity, and maintain this level.
    - ☐ c. Check the inventory regularly, and, if necessary, revise the production plan, and/or adjust the plan for receiving goods from suppliers.
39. Problems may arise in maintaining a work-in-process inventory because of:
    - ☐ a. Differences in production capacity between one machine and another.
    - ☐ b. Changes in the machinery due to changes in the sales plan.
    - ☐ c. Transportation difficulties due to the geographical situation of the production site.
40. To determine the proper WIP inventory keep the following points in mind:
    - ☐ a. The more inventory the better.
    - ☐ b. When you create a new inventory plan because of changes in production, establish the changed inventory as the standard inventory level.
    - ☐ c. Review standards in response to changes in production.
41. Inventory management at a glance is the best way to control inventory precisely, because:
    - ☐ a. Nobody is needed to manage the inventory.
    - ☐ b. People can immediately see the level of the inventory.
    - ☐ c. It allows a first-in, first-out system.
42. "First-in" refers to:
    - ☐ a. The order of arrival in the inventory.
    - ☐ b. The order of production or purchase.
    - ☐ c. The order of anticipated usage.
43. The first-in, first-out method may be difficult to use because:
    - ☐ a. It is very complicated.
    - ☐ b. It is often time-consuming.
    - ☐ c. It requires a lot of storage space.

13.6 Inspect finished products, deal with abnormalities and seek continuous improvement

44. A system of inspection of finished products requires the following steps:
    - ☐ a. Establish an inspection standard that corresponds to the product standard.
    - ☐ b. Attach an inspection certificate when the product is being shipped to the customer.
    - ☐ c. Mark the product to indicate that it has passed inspection only if the customer requires this.

45. Depending on the product, some inspections are carried out for all finished products by establishing an inspection line.
    - ☐ a. Just before the final process.
    - ☐ b. During the final process.
    - ☐ c. Just after the final process.
46. Decide objectively what the limit is ... which something is regarded as an abnormality:
    - ☐ a. Inside
    - ☐ b. Outside
    - ☐ c. Because of
47. To deal with abnormalities:
    - ☐ a. Establish control points for managing progress in production processes.
    - ☐ b. Standardize procedures for dealing with abnormalities in each process.
    - ☐ c. Standardise countermeasures.
48. To use Kaizen to improve production control:
    - ☐ a. Present examples of improvement from past experience to your senior manager.
    - ☐ b. Assess whether or not there are still problems in the workplace similar to those in the examples.
    - ☐ c. Present examples of improvement from past experience to your colleagues.

Relationship with ISO

13.1 Prepare production and shipping plans

Relationship with ISO 9001:2000

7.1. Planning of product realization

7.5.1. Control of production and service provision

8.2.3 Monitoring and measurement of processes

13.2 Ensure that production keeps to plan – Part One

Relationship with ISO 9001:2000

8.5.1 Continual improvement

7.5 Production and service provision

7.5.1 Control of production and service provision

7.5.2 Validation of processes for production and service provision

8.2.3 Monitoring and measurement of processes

8.4 Analysis of data

7.5.1. Control of production and service provision

13.3 Ensure that production keeps to plan – Part Two

Relationship with ISO 9001:2000

8.2.3 Monitoring and measurement of processes

7.5.1 Control of production and service provision

8.5.2 Corrective action

8.5.3 Preventive action

13.4 Deal with fluctuations in production

Relationship with ISO 9001:2000

7.5.1 Control of production and service provision

8.2.3 Measurement and monitoring of processes

7.4.1 Purchasing process

8.5.2 Corrective action

8.5.3 Preventive action

13.5 Plan and maintain inventories

Relationship with ISO 9001:2000

7.5.1 Control of production and service provision

8.2.3 Monitoring and measurement of process

7.5.3 Identification and traceability

7.5.5 Preservation of product

13.6 Inspect finished products, deal with abnormalities and seek continuous improvement

Relationship with ISO 9001:2000

7.5.3 Identification and traceability
8.2.4 Monitoring and measurement of product
8.5.2 Corrective action
8.5.3 Preventive action
8.5.1 Continual improvement

Unit 14

Process Control

Contents

Unit summary

Process control is about making sure that the manufacturing processes produce goods of the required quality in a continuous and stable manner. There are several mechanisms for maintaining process control.

14.1 Process control plan, and process capability study

The manufacturing of a product involves a lot of different processes. If any of these is not functioning properly, the quality of the product will be affected. Since a process usually consists of many different factors - employees, equipment, materials, facilities and methods, all of which can have an impact on the quality of the product – it can be quite difficult to check it. A Process Control Plan can check all of these factors, and identify where any problems may exist, while a Process Capability Study shows if the process is actually capable of producing products of the require quality.

14.2 Operation standards

Two factors are essential if a manufacturing process is to achieve the target quality efficiently. There must be operation standards that describe the best way to carry out the operations that make up the process, and there must be knowledgeable, skilled and motivated operators who will follow the standards. Texts 8.1 and 8.2 in Unit 8 Standardisation provide detailed guidelines on drafting and maintaining standards, and Text 8.3 gives guidelines on training operators to use standards. This brief text highlights:

a. The need to review standards when there are changes in the production process.
b. The importance of training the operator.

14.3 Dealing with out-of-control events and non-conforming products

A primary purpose of process control is to find anything that may be going wrong in the manufacturing process, and put it right. Problems may be indicated by:

a. Out-of-control events: processes that are not functioning as they are supposed to. The problems may lie in operators, equipment or materials.
b. Non-conforming products: products, parts or materials that are not of the required quality.

14.4. Early control system and foolproof operations

Out-of-control events and non-conforming products are most likely to occur when:

a. New equipment and techniques are introduced, often at the start of production of new products. An early control system will detect many such problems.
b. Operators make careless mistakes. Foolproofing operations can reduce operator mistakes significantly.

Learning tools

The RADAR questions

As you read each text you will discuss how it could be applied in your company. The RADAR questions will help you to focus this discussion:

R - Are these ideas **relevant** to my company?
A - How would I **apply** each of them in my company?
D - What **difficulties** might I meet and how would I overcome them?
A - Are there any **additional** actions that I might take that are not mentioned in the text?
R - What **resources** would be needed, what would these cost, and how could they be acquired?

There will of course be some discussion points where not all of these questions will be applicable.

The 6-Point Structure

After you have discussed the ideas in the text, you write an action plan in which you present practical proposals for implementing the conclusions you have reached in your discussion. The 6-Point Structure will help you to write your action plan:

1. **Problems:** Problems you have in your company in the area you have just discussed.
2. **Proposals:** Your proposals for improvement.
   a. Be specific and concrete.
   b. Include an implementation plan, with a time schedule and minimum and optimal implementation targets.
   c. Refer to any forms, charts, tables etc. that you would use, and include samples in an appendix.
3. **Obstacles:** Obstacles to implementation in employee attitudes, company organization and culture etc., and how these could be overcome.
4. **Resources:**
   a. The resources required: funds, equipment, materials, man-hours, expertise etc.
   b. The resources available within the company.
   c. Any resources that would have to be found outside the company.
   d. Alternatives that could be used to cover any shortfall in resources.
5. **Assessment:** Ways of assessing the results of implementing these proposals.
6. **Benefits:** The benefits your proposals would bring.

14.1 Process control plan, and process capability study

Introduction

1. The manufacturing of a product involves a lot of different processes. If any of these processes is not functioning properly, the quality of the product will be affected. Since a process usually consists of many different factors – employees, equipment, materials, facilities and methods, any of which can have an impact on the quality of the product – it can be quite difficult to check if it is functioning properly. A process control plan can check all of these factors and identify where problems exist. A process capability study, on the other hand, will show if the process actually has the capability to produce products of the required quality. (You should study Unit 9 Problem Solving before you read this text.)

Process Control Plan: the QC Process Chart

2. This text describes the use of a QC Process Chart as a process control plan. A QC Process Chart has two functions:
   a. Confirmation of results: To confirm that acceptable products have been produced, using control charts, graphs, check sheets etc.
   b. Process or factor analysis: To provide feedback for the process when abnormal values occur. In doing this it uses characteristic diagrams, scatter diagrams, stratification and other control techniques which show the cause and effect relationships. Factors that can be analysed include personnel, materials, equipment, operation methods, and environment. (See Unit 11 Statistics for guidelines on using these techniques.)

3. To prepare a QC Process Chart you need to take four actions:
   a. Briefly describe the manufacturing process (see parag. 4 below). Specify what constitutes quality in the process - what you regard as the right level of quality either in how the process functions or in the product that the process produces.
   b. Establish control criteria (the range of permissible limits to quality) to measure the level of quality achieved - decide on control points in the process which can be examined to see if production is going as it is supposed to, and in a continuous and stable manner.
   c. Choose a method of inspection to check that the right level of quality is being achieved, and the specific items that will be inspected or measured (inspection/ measurement items).
   d. Prepare a system to carry out this inspection.

4. Briefly describe the manufacturing process from start to finish using symbols such as: work O, storage ∇, inspection ◊, transport ⇒, staying □. The main points to include for each process are:
   a. Name of the process.
   b. Equipment, materials used.
   c. Control points.
   d. Control methods.
   e. Related standards.
   f. Inspection/measurement items and method.
   g. Supervisor.
   h. Criteria to be used to judge the results.
   i. Evaluators.
   j. Method of handling out-of-controls , defects etc.

Figure 14.1a QC process chart: Sample A
Figure 14.1b QC process chart: Sample B
Figure 14.1c Procedure of process analysis

Process capability study

5. One of the most critical aspects of process control is to make sure that a process actually has the capability to produce products of the required standard in a stable manner. Use a histogram to evaluate this. Collect statistical distribution data (mean value and dispersion) on the quality characteristics of the products when the process is operating in stable conditions. This data will allow you to estimate the probability that the process is meeting standard values.

6. To carry out a process capability study, first exclude dispersion due to abnormal causes. Use an $\bar{x}$-R control diagram, process capability diagram (transition graph including standard values) and histograms to show the process capability graphically. Use process capability index Cp or Cpk to indicate quantitatively the capability of the process to meet given standard values:

   $C_P = \frac{S_U - S_L}{6\hat{\sigma}_w}$ (specification with upper and lower limit)

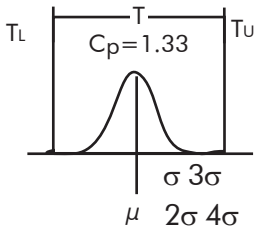
   $C_{pk} = \frac{max(S_U - \bar{x},\ S_L - \bar{x})}{3\hat{\sigma}_w}$ (specification with a single limit)

   S_U is the upper control limit and SL is the lower control limit. The index Cp is used for specifications with upper and lower limits when it is easy to adjust the mean of quality characteristics. In contrast, the index Cpk is used for specifications with upper and lower limits when the mean of quality characteristics cannot be easily adjusted.

(See also Text 9.8 on control charts.)

7. The capability index values obtained are evaluated as follows:

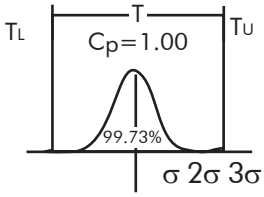
   a) Cp, Cpk >= 1.33. There is sufficient process capability.



E=0.000 031 8%
=31.8ppm

When Cp=1.33, both ranges outside 8σ are 63.6ppm (probability of defective).

b) 1.33 > Cp, Cpk >=1.00. Although not sufficient, the process capability is acceptable.



E=0.14%

(Source: UMEDA, Masao, "Seven Key Factors for success in TQM" Japanese Standards Association, P.171, 1993)

   c) 1.00 > Cp, Cpk. Process capability is insufficient and needs to be improved.
   d) Continue with the process capability study.

(See Text 11.3.3 in Unit 11, Statistical Methods, for more detailed guidelines on process capability.)

Discussion

The following questions ask you to think about how the ideas in the text could be applied in your company. Some of the ideas may not be relevant to you. Concentrate on those that are relevant. Keep notes of your conclusions – you will need them to prepare your action plan afterwards. Where appropriate ask yourself the RADAR questions.

Note: Always include in your discussion any figures referred to in the text, ***if*** you feel these are relevant to your company.

a. Parag. 1: How do you check that your manufacturing processes are functioning properly? Where do you feel this needs to be improved? List any points you can think of in your own manufacturing process which indicate if production is continuous and stable.
b. Parag. 3: Apply the RADAR questions to these actions for preparing a QC Process Chart.
c. Parag. 4: How would you describe one of your manufacturing processes from start to finish? How many of the points listed here would you include? Are there any others you would add to the list? Be as concrete as possible.

d. How do you presently check that acceptable products have been produced in your company? How helpful do you think a QC process chart would be in this?
e. How helpful do you think the QC process chart would be in giving you feedback when abnormal values occur in your manufacturing process?
f. Process capability: How do you evaluate whether your process is capable of producing products of the required standard? How successful are you?
g. Parags. 5, 6 and 7: If it is feasible for you, try to carry out a process capability study on one of your production processes. Then apply the RADAR questions to the use of a process capability study in your company.

Action plan

If you feel that your discussion has generated enough ideas, do the following:

a. Prepare a detailed outline of a process control plan for your manufacturing process, drawing on the ideas generated in your discussions, and draft a detailed QC process chart.
b. Prepare a process capability study of one of your manufacturing processes.

Otherwise include the ideas you have discussed here in a later action plan after you have discussed other texts.

14.2 Operation standards

Introduction

1. Two factors are essential if a manufacturing process is to achieve the target quality efficiently. There must be operation standards that describe the best way to carry out the operations that make up the process, and there must be knowledgeable, skilled and motivated operators who will follow the standards. Texts 8.1 and 8.2 in Unit 8 Standardization, provide detailed guidelines on drafting and maintaining standards, and Text 8.3 gives guidelines on training operators to use standards. This brief text highlights:
   a. The need to review standards when there are changes in the production process.
   b. The importance of training the operator.

Changing the production process

2. When you change any part of the production process, review the operation standards and, if necessary, revise them:
   a. Stipulate and document the procedures to be followed, because there are so many factors that can influence quality.
   b. Make sure that the change will not cause any unexpected problems.
   c. After the change has been made, gather and analyse the relevant data in order to check if the goals of the change have been reached, and how quality and productivity have been affected.
   d. Remove any operation standards that are no longer being used.
   e. Conduct periodic reviews to see how the new standards are being implemented, and how effective they are.

Training the operator

3. One of the factors in the production process which greatly affects quality is the operator. Because the operator is human, there will always be some variance in operations. An operator may carry out the same operation a little differently each time, and when the same operation is carried out by different operators, there is yet more risk of variance. What is important is to keep this variance to a minimum. Managers can try to minimize this variance in three ways – by educating, training and motivating operators. (See Unit 8.3 for full guidelines on educating, training and motivating operators in following the standards.)

Discussion

The following questions ask you to think about how the ideas in the text could be applied in your company. Some of the ideas may not be relevant to you. Concentrate on those that are relevant. Keep notes of your conclusions – you will need them to prepare your action plan afterwards. Where appropriate ask yourself the RADAR questions.

Note: Always include in your discussion any figures referred to in the text, ***if*** you feel these are relevant to your company.

a. Parag. 1: Do you use operation standards? If yes, how helpful are they? How do you feel you could make better use of them?
b. Parag. 1: How accurately do your operators follow the standards? Where do you think they may need training?
c. Parag. 2: Do you often have changes in your production process? Do you review and revise your standards when there are changes? Apply the RADAR questions to these guidelines for making changes in the production process.
d. Parag. 3: Read any parts of Texts 8.1 and 8.2 that you feel are relevant, and do the discussion questions that follow.
e. Parag. 3: If you feel it relevant at this point, read Text 8.3 and do the discussion questions that follow.

Action plan

Take the ideas you have found useful in the text, and in your discussion, and present them in a well-structured plan for introducing improvements in your company. Include any parts of units 8.1, 8.2 and 8.3 that you examined in your discussion. Alternatively, you may include these ideas in one action plan for the complete unit. You might like to follow the 6-Point Structure.

14.3 Dealing with out-of-control events and non-conforming products

Introduction

1. A primary purpose of process control is to find anything that may be going wrong in the manufacturing process, and put it right. Problems may be indicated by:
   a. Out-of-control events: events in a process which are well outside the control limits of what is acceptable. They show that processes that are not functioning as they are supposed to.
   b. Non-conforming products: products, parts or materials that are not of the required quality level.

Detecting and handling of out-of-controls

2. The source of out-of-controls may be found in operators, equipment or materials. Basically they are any events in the process, or outputs of the process, that do not meet the specifications (or criteria) that govern the process. If the process goes according to plan there should be no out-of-controls. The function of process control is to detect them, find out why they occur, and make whatever improvements are necessary to prevent them occurring again.

3. To detect and deal with out-of-controls take the following actions:
   a. Take emergency action to deal with the immediate situation.
   b. Investigate the cause of the out-of-control event.
   c. Inform related departments of what is happening.
   d. Take action to prevent further out-of-controls occurring.
   e. Confirm that this action has been effective.

4. Control chart: An essential tool in investigating the cause of out-of-controls is a control chart. Use control charts to examine the process and determine whether it is in a stable condition in terms of both quality and quantity. (See Text 9.8 for detailed guidelines on using control charts.)

5. Out-of-control report. Write up reports on out-of-controls and pass them on to whoever should know about them:
   a. Describe the process situation and give details of:
      i. The out-of-controls.
      ii. The investigation that was carried out.
      iii. The causes that have been identified.
      iv. Whatever countermeasures have been taken and their effectiveness.
      v. Any actions that are still to be taken.
   b. Record details of the actions and opinions of the department in charge of managing the handling of out-of-controls.

c. Specify the date and person in charge of implementation at each step, from detection of out-of-controls through to preventive action and confirmation of its effectiveness.
d. Provide columns for communication with related departments.
e. Establish handling criteria for the report.
f. Use a slip format and include an identification number.
g. After countermeasures have been taken the process averages or dispersion may change. If this happens, revise the control characteristics and control lines.

These reports are a good source of basic data that can be used on later occasions when emergency measures or countermeasures have to be taken.

Figure 14.3a Out-of-control report

Dealing with non-conforming products

6. Non-conforming products, or non-conformities, are products, parts, and materials, both finished and unfinished, which are found, usually on inspection, not to meet the required quality criteria. To deal with them take the following actions:
   a. Clarify who has the responsibility and authority for handling them.
   b. Separate them as soon as possible from conforming products and label them appropriately. Then remove them from the manufacturing process.
   c. Record their occurrence.
   d. Check whether there were any problems with previous manufacturing lots.
   e. Decide how to dispose of them. Depending on the nature of the non-conformity, they may be used as they are, reworked, regraded, or scrapped. This decisions should be taken in accordance with a predetermined procedure by those with responsibility and authority. Depending on the circumstances, a review committee may discuss the issues involved.
   f. Once this decision has been made, act on it as quickly as possible.
   g. When non-conforming products have been reworked they must be re-inspected. Check both the inspection items where the original problem arose, and any inspection items that could have been affected by the reworking. (Inspection items are predetermined points in a process or product that are inspected. See Unit 15 for more detailed guidelines on carrying out inspections.)
   h. Implement recurrence prevention measures.
   i. Record the results of these measures in a report. These records can then be used as basic data to help analyse the cause of any future non-conforming products and decide on appropriate action.

Data management

7. To ensure that effective countermeasures (and, when necessary, emergency actions) are taken to eliminate out-of-controls and non-conforming products, it is important to have all the relevant data at hand and to manage it properly. When collecting, recording and using this data you need to:
   a. Specify the objectives that the data is to be used for. Different objectives require different types of data and different methods of collection.
   b. Plan a system for collecting and documenting the data.
   c. Decide where each type of data is to be gathered and how often.

d. Assign people to collect, record and process the data.
e. Summarize the data in a chart.
f. Use a QC process chart to clarify the cause and effect relationships in the data.
g. Keep data which indicates the time sequence so that you can identify when the non-conforming product or out-of-control occurred and what caused it. This includes such details as material lot, equipment and personnel.

Data from inspections and quality checks can be shown to people from outside the company as evidence that improvements have been implemented, when customer audits or product liability issues arise.

Discussion

The following questions ask you to think about how the ideas in the text could be applied in your company. Some of the ideas may not be relevant to you. Concentrate on those that are relevant. Keep notes of your conclusions – you will need them to prepare your action plan afterwards. Where appropriate ask yourself the RADAR questions.

Note: Always include in your discussion any figures referred to in the text, ***if*** you feel these are relevant to your company.

a. Parag. 1: Give some examples of typical out-of-controls and non-conforming products in your manufacturing process. How do you usually deal with them? How successful is your approach?
b. Parag. 3: Apply the RADAR questions to these guidelines for detecting and handling out-of-controls.
c. Parag. 4: Are you familiar with control charts? If yes, how useful do you find them and what challenges have you met in using them?
d. Parag. 5: Apply the RADAR questions to these guidelines for writing out-of-control reports.
e. What would you put in a report like that in Figure 14.3a for a typical out-of-control event in your workplace.
f. Parag. 6: What are some typical non-conforming products that occur in your manufacturing process? How satisfactory is your way of detecting and dealing with them?
g. Parag. 6: Apply the RADAR questions to these guidelines for dealing with non-conforming products.
h. Parag. 7: Why do you think it is important to have relevant data at hand when you have to take emergency action and countermeasures to eliminate out-of-controls and non-conforming products? Think of some situations where you had to take such emergency action. What data helped you take the right action? – and what data did you not have that would have helped you? What type of data would you now want to have available for future needs?
i. Parag. 7: Apply the RADAR questions to these guidelines for managing data.

Action plan

Take the ideas you have found useful in the text, and in your discussion, and present them in a well-structured action plan for introducing improvements in your company. You might like to use the 6-Point Structure. Alternatively, you may include these ideas in one action plan for the complete unit.

14.4 Early control system and foolproof operations

Introduction

1. Out-of-control events and non-conforming products are most likely to occur when:
   a. New equipment and techniques are introduced, often at the start of production of new products. An early control system will detect many such problems.
   b. Operators make careless mistakes. Foolproofing operations can reduce operator mistakes significantly.

Early control system

2. An early control system will detect a variety of problems at an early stage in the production of new products, help to solve them quickly, and stabilise the new manufacturing process. To establish an early control system take the following actions:
   a. Decide in advance a period during which countermeasures may be introduced to correct any problems in the new process. The length of this period will depend on the product, the equipment being introduced, and how new the manufacturing technique is.
   b. Analyse in detail any factors in the current situation that could effect the new process and product quality, so that latent defects can be recognized and removed as soon as possible.
   c. Form a project team to quickly solve any problems. Decide how many people are needed and what skills they should have.
   d. Use marks and other symbols to differentiate problem operations and equipment from other processes, and focus control measures on them.

Foolproofing operations

3. Operators can easily make careless mistakes. Foolproof operations in order to prevent this. The best way to do this is by establishing a process in which mistakes are less likely to occur: make various adjustments to operation methods, and to the way that parts, materials, equipment, jigs, and tools are handled. There are two ways to foolproof operations:
   a. Preventive: design operations so that there is no possibility of mistakes being made regardless of the operator. This method includes eliminating certain operations, replacing them with risk-free operations, or making them easier to carry out.
   b. Reductive: try to spot mistakes as soon as they occur, so that their effects can be reduced or eliminated. This method involves two stages: defect detection where mistakes are discovered, and effect mitigation where the effects of the mistake are reduced or eliminated.

4. When deciding what measures to introduce, analyse the probability of mistakes being made, and the actual rate at which they have been made in the past. It is especially important to deal with the problem as a process related problem and not as an individual operator's problem. Implement any improvements on a company-wide basis.

Figure 14.4a Errors
Figure 14.4b Ensuring foolproof operation
Figure 14.4c Explanation of foolproof operation

Discussion

The following questions ask you to think about how the ideas in the text could be applied in your company. Some of the ideas may not be relevant to you. Concentrate on those that are relevant. Keep notes of your conclusions – you will need them to prepare your action plan afterwards. Where appropriate ask yourself the RADAR questions.

Note: Always include in your discussion any figures referred to in the text, ***if*** you feel these are relevant to your company.

a. Parag. 1: Have out-of-controls and non-conforming products occurred when you introduced new equipment or techniques? How did you deal with them? How do you think you could have dealt better with them?
b. Parag. 2 . Apply the RADAR questions to these guidelines for setting up an early control system.
c. Parag. 3: Give some examples of careless mistakes by operators in your manufacturing process. What steps have you taken to reduce the occurrence of such mistakes? How successful have they been?
d. Parags. 3a and 3b: Give examples of how you might apply these two approaches in your company.
e. Look at Figure 14.4a. Tick off any of these mistakes that also occur in your company.
f. Look at Figure 14.4b. Do any of these examples bring experiences of your own to mind? – or suggest foolproofing steps that you might now introduce?
g. Parag. 5: Why is it important to analyse the probability of mistakes being made, and the actual rate at which they have been made?
h. Parag. 5: Do you agree that it is important to deal with such mistakes as process problems and not individual operator problems. Why?

Action plan

Take the ideas you have found useful in the text, and in your discussion, and present them in a well-structured plan for introducing improvements in your company. Alternatively you may include these ideas on one action plan for the complete unit. You might like to use the 6-Point Structure.

Test

Answer these questions using **only** the information given in the text. For each question one, two or all three answers may be correct. Tick the answer or answers you think are correct for each question. Each question carries 3 points – you get one point for each correct answer that you tick, and one point for each wrong answer that you do not tick.

14.1 Process control plan; process capability study

1. A process control plan is used to control:
   - ☐ a. Materials.
   - ☐ b. Costs.
   - ☐ c. Equipment.
2. Which of the following are functions of a QC process chart?
   - ☐ a. Confirmation of plans.
   - ☐ b. Confirmation of results.
   - ☐ c. Factor analysis.
3. Control points will show whether production is:
   - ☐ a. Continuous and flexible.
   - ☐ b. Stable and controlled.
   - ☐ c. Continuous and stable.
4. To prepare a QC Process Chart you will need to:
   - ☐ a. Establish control criteria to measure the level of quality achieved.
   - ☐ b. Choose a method to confirm that quality has been achieved.
   - ☐ c. Choose a system for changing the process.
5. Match symbols with words:

a. Work	1. $\Rightarrow$
b. Storage	2. O
c. Transport	3. σ

   ☐ a. a1, b2, c3 ☐ b. a3, b2, c1 ☐ c. a2, b3, c1
6. A QC Process Chart should include:
   - ☐ a. Equipment and materials used.
   - ☐ b. Method of handling out-of-controls.
   - ☐ c. Control levers.
7. Which of the following can be used to confirm that acceptable products have been produced?
   - ☐ a. Cost analysis.
   - ☐ b. Control charts.
   - ☐ c. Graphs.
8. Which of the following are used to provide feedback for the process when abnormalities occur?
   - ☐ a. Characteristic diagrams.
   - ☐ b. Multiplication.
   - ☐ c. Stratification.

9. Factors that can usually be analysed to provide feedback when abnormal values occur include:
   - ☐ a. Personnel.
   - ☐ b. Equipment.
   - ☐ c. Symbols.
10. A process capability study is used to evaluate whether a process has the capability to produce products of:
   - ☐ a. The required standard in the fastest time possible.
   - ☐ b. The highest standard whatever time it takes.
   - ☐ c. The required standard in a stable manner.
11. A process capability study collects and uses statistical distribution data on the quality characteristics of the products manufactured when the process:
   - ☐ a. Is operating in stable conditions.
   - ☐ b. Is stopped.
   - ☐ c. Is operating under maximum pressure.
12. The purpose of this study is to estimate the probability that:
   - ☐ a. The process meets company expectations.
   - ☐ b. The process meets standard values.
   - ☐ c. The process meets operator values.

14.2 Operation standards

13. Which of the following should be kept in mind when any part of the production process is to be changed?
   - ☐ a. When planning a change, make sure that it does not cause any surprises.
   - ☐ b. Stipulate and document the procedures to be followed.
   - ☐ c. Be sure to remove operation standards that are no longer being used.
14. There will always be some variance in operations because:
   - ☐ a. Operators are difficult to train.
   - ☐ b. Operators are human.
   - ☐ c. Operators are not motivated.

14.3 Dealing with out-of-control events and non-conforming products

15. The function of process control is to:
   - ☐ a. Detect out-of-controls and non-conforming products.
   - ☐ b. Find out why these occur.
   - ☐ c. Improve the operators.
16. Detecting and handling out-of-controls involves:
   - ☐ a. Investigating the cause of the out-of-control event.
   - ☐ b. Communicating with all the other departments in the company.
   - ☐ c. Taking emergency action to deal with the immediate situation.
17. A control chart is used to examine a process and determine whether it is in a stable condition in terms of:
   - ☐ a. Quality and efficiency.
   - ☐ b. Quality and quantity.
   - ☐ c. Quality and process.

18. Use out-of-control reports to:
    - ☐ a. Record actions that have been taken and actions still to be taken.
    - ☐ b. Record the details and effectiveness of whatever preventive action is taken.
    - ☐ c. Record out-of-controls accurately and communicate them to whoever should know about them.
19. Nine actions are listed for the control of non-conforming products, including the following. Which of these three is incomplete or incorrect?
    - ☐ a. Separate non-conforming products as soon as possible from conforming products and identify them appropriately. Then remove them from the manufacturing process.
    - ☐ b. Confirm that there are no problems in the inspection items where the original problem arose.
    - ☐ c. Record the results of the measures taken in a report. These records can then be used as basic data when analysing the cause of non-conforming products and for developing appropriate actions.
20. Managing data that can be used to assist in eliminating out-of-controls and non-conforming products involves:
    - ☐ a. Specifying the objectives that the data is to be used for.
    - ☐ b. Planning a system for documenting the data.
    - ☐ c. Ensuring that the data has an access code.
21. Which of the following actions for collecting, recording and using this data is presented incorrectly or incompletely?
    - ☐ a. Specify the objectives for which the data will be used. Different objectives require different types of data and different methods of collection.
    - ☐ b. Plan where each type of data is to be gathered in the manufacturing process, by whom and how often. Summarize the results in a chart.
    - ☐ c. Keep data which indicates the time sequence so that you can identify who was responsible for the non-conforming product.

14.4 Early control system and foolproof operations

22. Non-conforming products or out-of-controls are most likely to occur.
    - ☐ a. At the start of production of new products.
    - ☐ b. When the production of a new product is being planned.
    - ☐ c. When a new operator begins to work on a manufacturing process.
23. To establish an early control system to stabilize a new manufacturing process:
    - ☐ a. Decide in advance a period for implementing countermeasures depending on the product, the equipment and how new the manufacturing technique is.
    - ☐ b. Form a project team to quickly solve any problems.
    - ☐ c. Analyse in detail any factors in the current situation that could effect the new process.
24. Operations need to be foolproofed in order to prevent:
    - ☐ a. Interference by other departments.
    - ☐ b. Careless mistakes by operators.
    - ☐ c. Malfunctioning of machinery.
25. One of the two ways of foolproofing operations is “preventive”. This includes:

- ☐ a. Eliminating certain operations.
- ☐ b. Reducing the effects of mistakes.
- ☐ c. Making operations easier to carry out.

26. The other way of foolproofing operations is "reductive". Which two of the following does this include?
    - ☐ a. Replacing operations with less risky ones.
    - ☐ b. Detecting mistakes when they occur.
    - ☐ c. Reducing the effects of mistakes.
27. When deciding on specific measures for foolproofing operations:
    - ☐ a. Analyse the probability of mistakes being made.
    - ☐ b. Consider how to deal with the operator.
    - ☐ c. Analyse the actual rate at which mistakes have been made in the past.
28. Any improvements that are made should be implemented:
    - ☐ a. Only in the workplace where the problem arose.
    - ☐ b. Only in the department where the problem arose.
    - ☐ c. Throughout the company.

Relationship with ISO

4.1 Process control plan; process capability study
Relationship with ISO 9001:2000
Process Control Plan: the QC Process Chart:
7.1 Planning of product realization
7.5.1 Control of production and service provision
Process capability study:
8.2.3 Monitoring and measurement of processes
8.2.4 Monitoring and measurement of product
8.4 Analysis of data

14.2 Operation standards
Relationship with ISO 9001:2000
Changing the production process:
4.2.3 Control of documents
7.5.1 Control of production and service provision
8.4 Analysis of data
Training the operator:
6.2. Competence, awareness and training

14.3 Dealing with out-of-control events and nonconforming products
Relationship with ISO 9001:2000
Detecting and handling of out-of-controls:
8.2.3 Monitoring and measurement of processes
8.2.4 Monitoring and measurement of product
8.5.2 Corrective action
8.5.3 Preventive action
Dealing with nonconforming products:
8.3 Control of nonconforming products
Data management:
4.2.4 Control of records
8.4 Analysis of data

14.4 Early control system and fool-proof operations
Relationship with ISO 9001:2000
7.1 Planning of product realization
8.3 Control of nonconforming product
8.4 Analysis of data
8.5.2 Corrective action
8.5.3 Preventive action

Unit 15

Inspection

Contents

Unit summary

Inspections are essential to make sure that your products have the specific quality features that your customers want.

15.1 Decide which features of a product to inspect

Inspectors do not look at every feature of a product. This would take too much time and would be too expensive. Instead, they inspect certain quality characteristics which are identified in advance. The most important quality characteristics are those that your customers want.

15.2 Establish inspection standards

There are four common inspections in manufacturing: acceptance inspections, intermediate or process inspections, final inspections, and delivery inspections. You need to establish standards for these to make sure that they are always carried out in the same way.

15.3 Establish specific inspection standards

As well as the inspection standards, you also need to establish more specific standards:

a. Standards for preparing inspection standards.
b. Standards for inspecting specific products and product types.
c. Standards for inspecting new and modified products.

15.4 Select, train and monitor inspectors

To ensure that inspections are carried out to the highest degree of accuracy:

a. Make sure that your inspectors follow the standards exactly.
b. Check that inspections have been carried out properly - inspect the inspections.
c. Educate and train your inspectors.

15.5 Use boundary samples for sensory inspections

There are some products that cannot be inspected with instruments. Many of these have to be inspected physically by taste, touch, sight, hearing or smell. In these sensory inspections the products are compared with samples that have the correct quality characteristics. These are called boundary samples - for example pieces of cloth that show the acceptable colour. When using boundary samples inspectors need to regularly refresh their sensory skills.

15.6 Deal with defective products; make use of inspection data

In inspections you will normally find defective products - but you will also find useful information for improvements in design and production:

a. Deal with defective products: make sure that they are not mixed up with accepted products. If they are repaired, make sure they are inspected again after the repair.
b. Try to reduce the defect rate in product types that are often found to be defective.
c. Use the data found in inspections to improve your design and production processes.

15.7 Keep inspection records

Inspection records will provide a clear picture of the quality of processes and finished products, and will indicate where improvements are needed.

a. Keep inspection records for each process.
b. Keep records of the measures taken with defective products.
c. Store the inspection records carefully.

15.8 Deal with after-sales product problems

In spite of all the inspections that are carried out, defects may still be found in products that have been sold to customers. To deal with these your company should set up a system to receive early feedback on after-sales problems, especially from customer complaints, and to route this information to the relevant departments.

15.9 Use market research to improve your inspections

The after-sales feedback that you receive from your customers about defective products is only one form of market feedback. Your company should carry out systematic market research, even when no defects are reported, to find out how well your products meet the quality levels your customers want. Whenever you learn something new about what they want you should review your product design and, of special interest in this unit, review your inspection standards.

Language Note

The terms “examiners” and “inspectors” are often used together as one term, “examiners and inspectors”. In this unit, except for examples from other sources, we use only the terms “inspectors” and “inspections” for ease of reading, and for ease of use in discussions. The examination of products should be understood as part of the inspection process.

Learning tools

The RADAR questions

As you read each text you will discuss how it could be applied in your company. The RADAR questions will help you to focus this discussion:

R - Are these ideas **relevant** to my company?
A - How would I **apply** each of them in my company?
D - What **difficulties** might I meet and how would I overcome them?
A - Are there any **additional** actions that I might take that are not mentioned in the text?
R - What **resources** would be needed, what would these cost, and how could they be acquired?

There will of course be some discussion points where not all of these questions will be applicable.

The 6-Point Structure

After you have discussed the ideas in the text, you write an action plan in which you present practical proposals for implementing the conclusions you have reached in your discussion. The 6-Point Structure will help you to write your action plan:

1. **Problems:** Problems you have in your company in the area you have just discussed.
2. **Proposals:** Your proposals for improvement.
   a. Be specific and concrete.
   b. Include an implementation plan, with a time schedule and minimum and optimal implementation targets.
   c. Refer to any forms, charts, tables etc. that you would use, and include samples in an appendix.
3. **Obstacles:** Obstacles to implementation in employee attitudes, company organization and culture etc., and how these could be overcome.
4. **Resources:**
   a. The resources required: funds, equipment, materials, man-hours, expertise etc.
   b. The resources available within the company.
   c. Any resources that would have to be found outside the company.
   d. Alternatives that could be used to cover any shortfall in resources.
5. **Assessment:** Ways of assessing the results of implementing these proposals.
6. **Benefits:** The benefits your proposals would bring.

15.1 Decide which features of a product to inspect

Introduction

1. Inspectors do not look at every feature of a product. This would take too much time and would be too expensive. Instead, they inspect certain quality characteristics. These are the features of a product, identified in advance, that are evaluated to decide if it is of the right quality. The most important quality characteristics are those that your customers want.

Prepare quality tables

2. To prepare a product for inspection, decide on the quality characteristics which that product should have. Then for each characteristic, choose one or more inspection items. (For example, if the customer wants the quality characteristic of colour fastness in a dress, the inspection items that the inspector would check are its fastness in sunlight, its fastness in washing etc.). Present all of these, the quality characteristics and the inspection items, in a quality table, as in the matrix chart for a blouse below. By testing the inspection item the inspector can assess whether the quality characteristics are present and at the right level. In some cases the quality characteristics and the inspection items may be the same.

Figure 15.1a Quality table for cloth for blouses

Inspection items: **Quality characteristics required by customer:**	External inspection	Inspect strength by stretching	Inspect strength of seam	Inspect the contraction ratio
External appearance	O			
Strong cloth		O		
Strong seams			O	
No shrinking when washing				O

Select inspection items

3. It may not always be desirable to inspect all the items in the quality table. Maintain a balance: if you select too many, costs rise, but if necessary items are left out, serious defects can go unnoticed. The items selected must, of course, include those that your customers regard as important. Otherwise products could be supplied as non-defective, even though their quality does not satisfy customers.

Figure 15.1b Inspection items in cloth for blouses

• Colour fastness: ♦ Fastness against sunlight ♦ Fastness against washing ♦ Fastness against abrasion ♦ Fastness against sweat • Ratio of contraction by washing	• Strength against stretching • External appearance ♦ Scars ♦ Stains ♦ Dye finish

Discussion

The following questions ask you to think about how the ideas in the text could be applied in your company. Some of the ideas may not be relevant to you. Concentrate on those that are relevant. Keep notes of your conclusions – you will need them to prepare your action plan afterwards. Where appropriate ask yourself the RADAR questions.

Note: Always include in your discussion any figures referred to in the text, ***if*** you feel these are relevant to your company.

a. What products are inspected in your company? What procedures are used to prepare them for inspection? How well do these work? How do you think the system could be improved?
b. What are the quality characteristics that your customers demand from your products? How do you know what these should be? How could you get a better idea of what they are?
c. Give some examples of inspection items that you already use, or that you could use?
d. Draw a quality table for one or two of your company's products.
e. How would you go about choosing inspection items for every product or part that has to be inspected in your company? Make lists for a few of them.
f. Which of your products could you imagine being supplied as non-defective, but not having the specific quality characteristics that your customers want?

Action plan

Take the ideas you have found useful in the text, and in your discussion, and present them in a well-structured plan for introducing improvements in your company. Alternatively, you may include these ideas in one action plan after you have discussed several texts. You might like to follow the 6-Point Structure.

15.2 Establish inspection standards

Introduction

1. There are four common inspections in manufacturing: acceptance inspections, intermediate or process inspections, final inspections, and delivery inspections. You need to establish standards for these to make sure that they are always carried out in the same way.

Standards for common inspections

2. **Acceptance inspections** are conducted when accepting materials and parts into your factory or workplace. Standards for these should always specify the following points:
   a. That the number of accepted units is confirmed.
   b. Procedures for selecting a sampling method.
   c. Inspection items.
   d. Acceptance values: what level of quality is acceptable.
   e. Methods for inspections without testing. (See paragraph 6 below.)

3. **Intermediate inspections,** also known as process inspections, are conducted between processes. Standards for these inspections specify:
   a. Procedures for selecting a sampling method.
   b. Inspection items.
   c. Inspection methods.
   d. Acceptance values.
   e. What to do with defective items.

4. **Final inspections** are conducted after all the processes are completed. Standards for these, like those for intermediate inspections, specify:
   a. Procedures for selecting a sampling method.
   b. Inspection items.
   c. Inspection methods.
   d. Acceptance values.
   e. What to do with defective items.

5. **Delivery inspections** are conducted before shipping out finished products. They sometimes overlap with final inspections, and have similar specifications.

6. Inspection without testing: In some cases, inspections are carried out without testing. In acceptance inspections, for example, there may be no actual examination but instead data is collected during the manufacturing processes. In this case examination certificates issued by third-party agencies may be used as substitutes. Look at Example 1 below.

Ensure consistency

7. Inspections may be held in different places, over different periods of time, with different instruments, and by different inspectors. There is therefore always the risk of differences both in the criteria on which judgement is based, and in the results. To minimize these differences it is especially important that the standards for each type of product clearly specify the following points in a addition to those given above:
   a. The inspection sites.
   b. The inspection periods.
   c. The sampling method.
   d. Sample inspection methods.

   Look at Examples 2, 3 and 4 below.

Consult official standards

8. Consult official standards such as national and international standards, and adopt official inspection methods wherever possible. If you use these methods you can communicate inspection details using only the reference numbers of the standards. This also ensures that everyone will understand the quality standards.

Base standards on what customers want

9. Quality standards means giving priority to what the customers want. This point should be strictly observed, both by third-party inspection agencies and by ordinary companies. Market research and customer complaints will help to show this. Take the following actions:
   a. If any existing standards are found to differ from what customers want, revise them immediately.
   b. Make sure that your system allows standards to be changed in response to changes in what customers want.
   c. When products are specially ordered by the customer, allow the customer to take part in the preparation of draft plans for revising inspection standards. Always get the customer's consent before setting standard values. (See also Text 15.3 on inspection standards, and Unit 8 for detailed guidelines on standards.)

Note: In Unit 11, Statistics, in Text 11.1.1 you will find details of the inspection records used in these various inspections. When you print out Text 15.2, you should also print out Text 11.1.1.

Examples

Example 1. Inspection methods for women's blouses.

a. Acceptance inspections: Inspect samples from the front ends when accepting cloths, padding, sewing thread, and appurtenances (buttons, embroidery threads, trinkets etc.).
b. Intermediate inspections: Inspect the exterior appearance of all units for sewing flaws after all the stitching processes have been completed (before the final pressing).
c. Final inspections: Inspect the external appearance for sewing flaws and inferior finishes.
d. Delivery inspections: Inspect the external appearance, and internal and external finishings on 30 sampled units per lot. Inspect all units when more than one defect is found among the samples. Replace defective units found in the inspections with good units before shipment.

Example 2. Final inspections.

a. The inspection period – when product lots are completed: Lots must consist of goods which have the same product number, and are manufactured continuously on the same line and on the same day.
b. Inspection sites: Designate suitable areas for holding inspections.
c. Sampling methods: Take random samples from lots using tables of random sampling numbers.
d. Sample inspection methods, e.g. n = 30 and c = 1: If only one defect is found among 30 samples the lot is acceptable. Replace defective samples with good units.
e. Actions against defective lots: If repair is judged to be possible, return the defective units to the manufacturing process. Then re-inspect the repaired units according to the inspection standards. If repair is judged to be impossible, dispose of the defective units according to the procedure prescribed in the inspection standards.

Example 3. Acceptance inspections and final inspections of mechanical parts.

a. Acceptance inspections:
    i. Confirm the delivery statements (the product names and quantities) and the written final inspection reports submitted by the suppliers.
    ii. Inspect diameters as follows:
    Standard value – 8 mm or more.
    Single sampling inspections by variables based on operating characteristics (standard deviation value is unknown).
    $p_0 = 0.5\%$ $p_1 = 6\%$ $\alpha = 0.05$ $\beta = 0.10$
b. Final inspections:

Inspection items	**Standard values**	**Examination methods**	**Sampling**
Diameter	8 mm +/- 0.1 mm	Use vernier callipers	All units
Length	100 mm +/- 0.5 mm	Use vernier callipers	All units

Example 4. Acceptance inspections for blouse materials.

Examination and inspection items	**Standard values**
Colour fastness:	
• Fastness against sunlight	Class 4 or higher
• Fastness against washing	Class 4 or higher
• Fastness against abrasion	Class 4 or higher
• Fastness against sweat	Class 4 or higher
Contraction ratio in washing	Within +/- 3%
Strength against stretching	40kgf or more
Scars	absent
Stains	absent
Uneven dyeing	absent

Discussion

The following questions ask you to think about how the ideas in the text could be applied in your company. Some of the ideas may not be relevant to you. Concentrate on those that are relevant. Keep notes of your conclusions – you will need them to prepare your action plan afterwards. Where appropriate ask yourself the RADAR questions.

Note: Always include in your discussion any figures referred to in the text, ***if*** you feel these are relevant to your company.

a. Does your company conduct the four kinds of inspection described in the text? Which products does it conduct each of these inspections for?
b. Parags 1, 2, 3, 4 and 5: Look at the procedures that the standards should specify. Then consider in detail how you would establish standards for these inspections in your company. Apply the RADAR questions to each point.
c. Draft standards for one or two of your products.
d. Parag. 7: What differences are there in the times, places etc. in which your inspections are held? How can these differences affect the results? How do you try to minimize this? What points could you specify in your standards that would help?
e. Parag. 8: Which official standards could you consult, and which official inspection methods could you adopt? How would this help you?
f. Parag. 9 recommends basing standards on what customers want. Do you already take customer wishes into account in your inspections? Apply the RADAR questions to the actions recommended here.
g. Look the examples. Which of these relate to your situation? Can you give similar examples from your own company?

Action plan

Take the ideas you have found useful in the text, and in your discussion, and present them in a well-structured action plan for introducing improvements in your company. You might like to use the 6-Point Structure. Alternatively, you may include these ideas in one action plan after you have discussed several texts.

15.3 Establish specific inspection standards

Introduction

1. In addition to the common inspection standards, you also need to establish more specific standards:
   a. Standards for preparing inspection standards.
   b. Standards for inspecting specific products and product types.
   c. Standards for inspecting new and modified products.

Establish standards for preparing inspection standards

2. In Text 15.2 we looked at the typical content of inspection standards. But your company must also establish standards that describe how to prepare, revise and review the inspection standards. These standards for preparing inspection standards should specify:
   a. Date, month and year of preparation and revision of the inspection standards.
   b. The department or section in charge of issuing the inspection standards.
   c. Forms for keeping records.
   d. The scope of the standard: what does it cover?
   e. Meanings of terms.
   f. Other standards referred to in the standard.
   g. Inspection items – the features in a product that are examined or inspected.
   h. Inspection methods.
   i. Standard values – what is acceptable.
   j. How to designate lots.
   k. Methods for selecting samples, sampling size, the number of samples necessary for judging acceptability, and judgment criteria.
      (In principle, sampling is performed randomly. Random sampling means all units in a lot have an equal chance of being selected as test samples. Tables of random numbers are often used to choose samples.)
   l. Review periods – when should regular reviews be carried out?
   m. Methods for revising the standards.

3. The departments in charge of operations propose drafts for these standards. These drafts are then reviewed by the standards examination committee, and authorised by the manufacturing plant director. When the standards are properly established, the contents of related standards can be synchronised.

Establish standards for inspecting specific products and product types

4. Classify products and product types in a well-structured way that is easy to follow, establish inspection standards for them, and link the standards to these classification tables. When product types are not clearly distinguished this can be difficult. The best

solution is to prepare comparison tables using matrices. (Matrix – a rectangular chart that presents information in rows and columns.) Make clear the areas that these standards apply to.

Figure 15.3a

Merchandise classifications	Product names	Product numbers	Names of examination and inspection standards	Standard numbers
Ladies' outerwear	Suits	w01	Examination and inspection standards for ladies' outer wear	w0
Ladies' clothing	Coats Skirts	w02 w03	Same as above Same as above	
Ladies' underwear	Blouses	w11	Examination and inspection standards for ladies' clothing	w1
	Sweaters	w12	Same as above	
	Shorts	w31	Examination and inspection standards for ladies' underwear	w3
Men's outerwear	Suits	w01	Examination and inspection standards for men's suits	M1

Establish standards for inspecting new and modified products

5. You need to be especially strict in establishing standards for inspecting new and modified products. Since there is little past quality-related information to refer to, you will need to inspect their external appearance carefully. The best way to do this is to increase the number of inspection items, increase the number of samples, or follow other special standards. Wherever necessary you should fully inspect the functions of the products. Improve management systems to prevent defective units from being accepted or shipped.

   Note: New items are original products designed and produced for the first time. Modified items are existing products whose shapes and materials have been renewed or revised.

   Example: Special inspection procedures for new and modified products:
   a. Use a checklist for external inspections on all new and modified items.
   b. Use tape measures to confirm the measurements of the main sections of one of the new or modified items.
   c. Use points from a checklist for external inspections of a blouse:
      i. Is the cloth cut obliquely or horizontally?
      ii. Are the seams even?
      iii. Is there sufficient space for sewing?
      iv. Are the cut sections sewn properly?
      v. Are measurements of the following sections correct: length, neck, chest, and sleeve?

Discussion

The following questions ask you to think about how the ideas in the text could be applied in your company. Some of the ideas may not be relevant to you. Concentrate on those that are relevant. Keep notes of your conclusions – you will need them to prepare your action plan afterwards. Where appropriate ask yourself the RADAR questions.

Note: Always include in your discussion any figures referred to in the text, ***if*** you feel these are relevant to your company.

a. Parag. 2 lists the points that standards for preparing standards should specify. How relevant would each of these points be to your situation? Give concrete examples of what you would specify.
b. Parag. 3 describes how to prepare these standards. Apply the RADAR questions.
c. Parag. 4: How many different products, and product types do you need to inspect? How would you classify them in a way that is easy to follow? Do you have any product types that are not clearly distinguished? If appropriate, prepare a classification table similar to the one in the example – make it as concrete as you can.
d. Parag. 5: Do you have to conduct inspections of new or modified products? If so, what particular problems do you associate with inspecting them? Apply the RADAR questions to the suggestions in this paragraph for dealing with them. Include the examples in your discussion if you feel they are relevant.

Action plan

Take the ideas you have found useful in the text, and in your discussion, and present them in a well-structured plan for introducing improvements in your company. You might like to use the 6-Point Structure. Alternatively, you may include these ideas in one action plan after you have discussed several texts.

15.4 Select, train and monitor inspectors

Introduction

1. To ensure that inspections are carried out to the highest degree of accuracy:
   a. Make sure that your inspectors follow the standards exactly.
   b. Check that inspections have been carried out properly - inspect the inspections.
   c. Educate and train your inspectors.

Make sure that inspectors follow the standards

2. Inspectors must follow the standards precisely, otherwise there will be variances even when inspections are carried out by the same inspectors and certainly when they are carried out by different inspectors. They must know exactly what to do, and must be competent to do it. To make sure that this is so:
   a. Prescribe clearly the methods for designating lots for inspection, choosing sampling methods, conducting inspections, judging acceptance, identifying accepted units, and processing defective units and lots.
   b. Set up an official company system that allows only properly trained and qualified people to be appointed as inspectors. They and their assistants must be authorised by the directors of the business facilities where they are working. Assistants must always work under the direction of inspectors.
   c. Set the required qualifications. These will normally be:
      Inspectors:
      i. Have completed a natural science or engineering course at a vocational training school or university.
      ii. Have worked as an inspection assistant for two years or longer.
      iii. Have been authorized by directors of business facilities.
      Inspection assistants:
      i. Have completed a natural science or engineering course at a vocational training school or university.
      ii. Have been authorized by directors of business facilities.

Check inspections

3. Set up a system to check that inspections are being carried out according to the standards. Appoint individuals to carry out these checks, and set up corrective systems, whenever necessary, to correct things that have gone wrong. There are two types of periodic inspection:
   a. Inspection of documents.
   b. On-site inspection of actual operations.
   You should also set up a procedure for receiving complaints from those who have been inspected and have been asked to correct their operational methods, and a unit to evaluate these complaints.

4. Inspection of documents:
   a. Study the reports submitted after completion of all inspections.
   b. Confirm whether inspections have been carried out as prescribed.

c. Give a seal of authorization to acceptable reports.
d. Give immediate instructions on any corrections that are required, and confirm the results of these corrections.

5. On-site inspections:
   a. Managers of inspection departments, or their agents, inspect the status of inspections twice a year and report their findings to the directors of the business facilities they have inspected.
   b. When cases of non-conformance are found, or corrections are judged necessary for other reasons, they give instructions on which corrective actions should be taken. They do this in the names of the directors of the business facilities.
   c. The inspectors carry out these corrective actions immediately and submit reports to the directors of the business facilities.
   d. When necessary, managers or their agents inspect the results of the corrective actions.

Educate and train inspectors

6. Set up a programme to educate and train new inspectors in the specific skills and knowledge they will require, including the ability to make impartial judgments, and establish standards for their certification (including working experience).

7. A curriculum for new inspectors should cover:
   a. Basic chemistry and physics.
   b. Methods for operating measuring devices.
   c. Data processing methods.
   d. Inspection methods.
   e. Methods for judging if units can be accepted.

8. Provide periodic education and training for inspectors who are already working with you so that they can update their skills and technical knowledge, and remain at the cutting edge of their profession. One company, for example, provides special three-hour seminars on the latest technical developments once a month. Inspectors who carry out sensory inspections should have training to refresh their sensory skills at least once a year, so that their judgment will remain consistent.

Discussion

The following questions ask you to think about how the ideas in the text could be applied in your company. Some of the ideas may not be relevant to you. Concentrate on those that are relevant. Keep notes of your conclusions – you will need them to prepare your action plan afterwards. Where appropriate ask yourself the RADAR questions.

Note: Always include in your discussion any figures referred to in the text, ***if*** you feel these are relevant to your company.

a. Are you confident that your inspectors always follow your company's inspection regulations precisely? If not, what problems occur? How do you think the situation could be improved?
b. Parag. 2 suggests several steps to take to make sure that inspections are carried out precisely. Apply the RADAR questions to all of these suggestions.
c. Parag. 2: Do you have a system for checking that inspections are being carried out properly? If so, what is it and how well does it work? If not, what problems do you have that such a system might remove?
d. Parags. 3, 4 and 5 describe how to set up such a checking system. Apply the RADAR questions to these guidelines.
e. Parag. 6: What skills and knowledge does your company expect of its inspectors? How does it educate and train them? How adequate do you think this training is? How would you like to see it improved?
f. Parag. 7 presents a curriculum for new inspectors. Does this seem appropriate for your company? If so, apply the RADAR questions to implementing it.
g. Parag. 8 recommends ways of providing periodic education and training for your present inspectors. What does your company already do in this area? Apply the RADAR questions to these recommendations.

Action plan

Take the ideas you have found useful in the text, and in your discussion, and present them in a well-structured plan for introducing improvements in your company. You might like to use the 6-Point Structure. Alternatively, you may include these ideas in one action plan after you have discussed several texts.

15.5 Use boundary samples for sensory inspections

1. There are some products that cannot be inspected with instruments. Many of these have to be inspected physically by taste, touch, sight, hearing or smell. In these sensory inspections the inspected products are compared with samples that have the correct quality characteristics. These are called boundary samples – for example pieces of cloth that show the acceptable colour. When using boundary samples inspectors need to regularly refresh their sensory skills.

2. To establish regulations for boundary samples:
   a. Set maximum and minimum limits outside which units are not acceptable; prepare boundary samples that demonstrate these limits.
   b. Prescribe methods for storing boundary samples that will prevent them from changing for a long time.
   c. Set the periods of validity for any boundary samples that can change over a period of time. (Some boundary samples will change even if they are kept in excellent storage conditions.)
   d. Use materials that are most resistant to change.

3. To manage and store some typical colour boundary samples:
   a. Prepare one boundary colour sample as a standard and two or more boundary colour samples to be used in the actual inspections. The standard boundary sample can be used to check that the working samples continue to be acceptable.
   b. Place the standard boundary samples in prescribed cases and store them away from direct sunlight and where the relative humidity is between 50% and 70%. Replace these samples once every three years.
   c. Place the working boundary samples in their prescribed cases and store them away from direct sunlight where the relative humidity is between 30% and 90%. Replace these samples once a year.
   d. Use the standard boundary samples to confirm the effectiveness of the working boundary samples once every month.

4. Boundary samples are essential standards for sensory inspections. The senses are generally good at assessing one item in comparison to another, but they are not so good at making absolute appraisals, without any comparisons. Experienced inspectors should therefore always use boundary samples to attune their senses before conducting inspections. Some boundary samples are prescribed under official regulations, while many others are chosen by companies in consultation with their customers.

5. Inspectors who carry out sensory inspections should have training to refresh their senses at least once a year. This should be one of the certification requirements for inspectors. These requirements include:
   a. Relevant sensory inspection experience of at least one year, and success in aptitude tests (tests to predict people's ability to learn certain skills).
   b. Recommendation by the managers of the inspection department and authorization by the manager of the business facility.

   Your company should also take into account the need for keen senses when it decides on the retirement age for inspectors.

Discussion

The following questions ask you to think about how the ideas in the text could be applied in your company. Some of the ideas may not be relevant to you. Concentrate on those that are relevant. Keep notes of your conclusions – you will need them to prepare your action plan afterwards. Where appropriate ask yourself the RADAR questions.

Note: Always include in your discussion any figures referred to in the text, ***if*** you feel these are relevant to your company.

a. What is your company's experience of using boundary samples:
   i. What boundary samples do you use?
   ii. What regulations do you have for using them?
   iii. How effective are they?
   iv. How could you use them more effectively?
b. Parag 2 presents guidelines for establishing regulations for boundary samples. Apply the RADAR questions to these.
c. Parag. 3 presents some typical ways of managing and storing boundary samples. Apply the RADAR questions.
d. Parag. 4: Why are the senses not suitable for making absolute appraisals?
e. Does your company train its inspectors in sensory skills? If yes, how does it do so, and how effective is this training? If not, how would you benefit from better training?
f. Parag. 5: Do these certification requirements also seem appropriate for your inspectors? Are there any others that you would like to include on the list? Do you think that there should be a special retirement age for sensory inspectors?

Action plan

Take the ideas you have found useful in the text, and in your discussion, and present them in a well-structured plan for introducing improvements in your company. You might like to use the 6-Point Structure. Alternatively, you may include these ideas in one action plan after you have discussed several texts.

15.6 Deal with defective products; make use of inspection data

Introduction

1. In inspections you will normally find defective products that have to be dealt with - but you will also find useful information for improvements in design and production:
   a. Deal with defective products: make sure that they are not mixed up with accepted products; if they are to be repaired, make sure they are inspected again after repair.
   b. Try to reduce defect rate in product types that are often found to be defective
   c. Use the data found in inspections to improve your design and production processes.

Deal with defective products

2. Standardize the following procedures:
   a. With lots that have not been accepted, remove the defective units and re-inspect the lots again as if for the first time.
   b. Label defective units that can be reworked and send them for repairs.
   c. Dispose of those that cannot be reworked.
   d. Inspect all the units again after they have been repaired.
   e. Use defective units as downgraded products, or try to find other appropriate uses for them.

   The proper processing of defective units found in inspections is an essential inspection function, especially in sample inspections. It is also important that you have a system that prevents an entire batch or lot being rejected before further samples are re-inspected. (See the examples of procedures for dealing with defective products at the end of this text.)

Try to reduce defect rate in product types that are often found to be defective

3. Some types of products are often found to be defective in inspections. To reduce the defect rate in these, take the following actions:
   a. Analyse the inspection results on a continuous basis.
   b. Establish a system for dealing with product types that are frequently found to be defective, and make effective use of this system.
   c. Improve processes that often produce defective products.

4. To put these steps fully into practice, the quality assurance department should:
   a. Analyse inspection results.
   b. Publish lists of frequently defective product types every six months.
   c. Provide instructions to the design and production departments and other sections on how to take measures for improvement.

   It is usually best to apply this approach to one process at a time.

5. The manufacturing departments should:
   a. Form improvement teams.
   b. Set targets for reducing the number of defects that appear repeatedly in inspections, based on instructions from the quality assurance department and others.
   c. Establish a system for achieving these targets within fixed periods of time.
   d. Report the results of improvements to the managers of the quality assurance and manufacturing departments, and receive their confirmation.

   If the improvement targets are not achieved within the designated periods, the manufacturing and quality assurance departments should hold discussions and decide on the next step.

Use inspection data to improve design and production processes

6. Valuable data is often found in inspections, especially in final inspections, that can be used for maintaining and improving quality. The inspection departments should pass this data on to the other departments:
   a. The inspection departments establish a system for reporting their results speedily to the quality assurance department, using prescribed slips.
   b. The quality assurance department analyses these results and presents its conclusions to the design and production departments.
   c. These departments then set up systems to use this information to improve product design and production processes.
   d. They then report their results to the quality assurance department, which confirms the effectiveness of the improvements they have made.

Figure 15.6a Information data flowchart
(Note that the dotted line in this figure indicates the flow of information. The unbroken line represents the flow of goods and written reports.)

Examples of procedures for dealing with defective products

Assembly Work:

a. Defective units found in acceptance inspections are put in boxes for unaccepted units and returned to the subcontractors.
b. When reworking is possible, order reworking and then re-inspect as a new lot.

Intermediate Inspections:

a. Defective units found in intermediate inspections are classified according to whether they can be reworked, and placed in separate boxes.
b. Defective units that can be reworked are returned to the processes with the defective sections labelled and product slips affixed to them.
c. Defective units that cannot be reworked are scrapped with the authorization of the supervisor of the manufacturing section.

Final Inspections:

a. Defective units that can be reworked are forwarded to employees in charge of repairs with product slips.
b. Defective units that cannot be reworked are scrapped with the authorization of the supervisor of the manufacturing section.

Discussion

The following questions ask you to think about how the ideas in the text could be applied in your company. Some of the ideas may not be relevant to you. Concentrate on those that are relevant. Keep notes of your conclusions – you will need them to prepare your action plan afterwards. Where appropriate ask yourself the RADAR questions.

Note: Always include in your discussion any figures referred to in the text, ***if*** you feel these are relevant to your company.

a. Does it ever happen that defective products found in your inspections are mixed up with accepted products? Or that repaired products are not inspected again? If so, give one or two examples.
b. Parag. 2 suggests procedures for dealing with defective products found in inspections. Apply the RADAR questions to these.
c. Look at the examples of typical procedures for dealing with defective units. If you think these are relevant to your company, apply the RADAR questions to them.
d. Do you have certain types of products that are often found to be defective? What do you think is the reason for this? What do you do about them?
e. Parags. 3, 4 and 5 present procedures to reduce the defect rate in such types of products. Apply the RADAR questions.
f. Parag 6: Is useful data often found in your inspections? What do you do with it? Do you think you could make better use of it?
g. Parag. 6 describes how to use data found in inspections to improve design and production processes. Apply the RADAR questions.

Action plan

Take the ideas you have found useful in the text, and in your discussion, and present them in a well-structured plan for introducing improvements in your company. You might like to use the 6-Point Structure. Alternatively, you may include these ideas in one action plan after you have discussed several texts.

15.7 Keep inspection records

Introduction

1. Keep inspection records. These will provide a clear picture of the quality of processes and finished products, and will indicate where improvements are needed.
   a. Keep inspection records for each process.
   b. Keep records of the measures taken with defective products.
   c. Store the inspection records carefully.

Keep inspection records for each process

2. Record inspection results at regular intervals according to inspection types (acceptance, intermediate, final and delivery) and manufacturing processes. These records will also make it easy to trace the history of specific products. They should be maintained for designated periods of time and should show:
   a. The products that are inspected.
   b. The time, date, and location of the inspections.
   c. The inspection results.
   d. The defect ratio (the ratio of defective items in a group), the nature of the defects and the circumstances at the time of their occurrence.
   e. The lot size.
   f. The names of the inspectors in charge.
   g. Clear descriptions of any related matters.

   When this data is arranged in a time series chart (that shows how things change over a period of time) it can reveal a great deal of information. The data can also be converted into control charts and used for statistical analysis. (See Text 9.8 and Unit 11 for more details on these procedures.)

Figure 15.7a

Name of product ..... Process .....

Date and month	Lot size	Sample size	Number of defects (ratio of defects)	Acceptance/ non-acceptance	Inspector	Individual responsible for inspections
Nov. 25	1250	100	4%	Accepted	Mr. AAA	Mr. BBB
Nov. 27	800	80	5%	Accepted	Mr. AAA	Mr. BBB
Nov. 29	1000	100	4.5%	Accepted	Mr. AAA	Mr. BBB

Figure 15.7b

Inspection time and date:	March 5, 1996
Inspection site:	First inspection ground within the company XXXX Co., Ltd.
Inspected party:	XXX Co., Ltd.
Inspected item volume:	Mechanical part No.1212, lot No.119/1,000 units
Inspection item:	Measurement
Number of samples (n):	30
Number of identified defects (c):	0
Inspection result:	Acceptable
Inspector in charge:	Ichiro Itoh

Keep records of the measures taken with defective products

4. Keep records of the measures taken with defective products in prescribed forms and for designated periods of time. These records should include:
   a. The names of those who prepared them or are responsible for them.
   b. The names of the products.
   c. Specific information about the defects.
   d. The reasons for taking countermeasures.
   e. The cause of the defects.
   f. The conditions prior to the implementation of countermeasures.
   g. The places and names of processes where countermeasures were taken.
   h. The times and dates of countermeasures.
   i. What the countermeasures should consist of.
   j. The confirmed effects of countermeasures.
   k. Revision of the standards.

5. This reference data will show the actions already taken to improve quality, and will serve as an important guide for dealing with future defects. The records can also be used for teaching employees. It is essential to analyse the factors that contribute to defects and take appropriate countermeasures. (See Figure 15.7c on page 25.)

Store the inspection records carefully

6. To store your inspection records properly:
   a. Keep them in secure storage, well protected against winds, rain, sunlight, vermin, and theft and loss, and at an appropriate room temperature and humidity.
   b. Use storage systems that allow easy data search, preferably a computerised system.
   c. Store them for as long as they are needed. This will usually be for three to five years but sometimes for 10 years if product liability law requires this.

Figure 15.7c Sample of records

Date/month/year Prepared by: Individual responsible for the record

Records of measures against defective units

Specific defects: Measurements of an important section of part A did not conform to standards: reprocessing was necessary.

Reason for taking countermeasures (date/month/year): Measurements of part A deviated from the standards at ratios in excess of 5% for two months in a row. To correct this situation, the section chief instructed subordinates to undertake improvement measures (date/month/year).

Cause of the defects: The part was fixed in an unstable manner. Contents of countermeasures: The number of nailing positions during machine processing was increased from two to three.

Confirmed effects of the countermeasures: The average ratio of defective units dropped to 0.2% two weeks after implementation of the countermeasure.

Revision of standards: The corresponding section of the written operational standard was revised to stipulate three nailing positions, and this revision was made known to all operators.

Discussion

The following questions ask you to think about how the ideas in the text could be applied in your company. Some of the ideas may not be relevant to you. Concentrate on those that are relevant. Keep notes of your conclusions – you will need them to prepare your action plan afterwards. Where appropriate ask yourself the RADAR questions.

Note: Always include in your discussion any figures referred to in the text, ***if*** you feel these are relevant to your company.

a. Does your company keep records of inspections? If yes:
   i. How effective is its system?
   ii. What benefits does it bring?
   iii. How could it be improved?
   If not, what benefits do you think such records would bring?
b. Parag. 2 presents procedures for keeping inspection records and information to include in the records. Apply the RADAR questions.
c. Look at the examples. Would these be useful models for your inspection records? How would you adapt them to your needs?
d. Parag. 4 lists the points to include in records of measures taken with defective products. How many of these would be appropriate in your company? Are there any others you would add?
e. Parag. 5: Would such records have these uses in your company? Would they have any additional uses?
f. Is this example record relevant to your company? Can you prepare a similar record for one of your products that was found to be defective?
g. Parag. 6: Apply the RADAR questions to these guidelines for storing inspection records.

Action plan

Take the ideas you have found useful in the text, and in your discussion, and present them in a well-structured plan for introducing improvements in your company. You might like to use the 6-Point Structure. Alternatively, you may include these ideas in one action plan after you have discussed several texts.

15.8 Deal with after-sales product problems

1. In spite of all the inspections that are carried out, defects may still appear in products that have been sold to customers. To deal with these your company should set up a system to receive early feedback on after-sales problems, especially from customer complaints, and to route this information to the relevant departments.

   (A claim is where a customer seeks compensation, repair or replacement of a defective product that has a warranty, and likewise with a service; a complaint is where they express dissatisfaction and may or may not make a demand for compensation. For simplicity we use "complaints" in this text.)

2. Introduce the following procedures:
   a. Set up a system to receive early reports of customers' complaints and other forms of after-sales feedback.
   b. This information is reported to the quality assurance department.
   c. The quality assurance department analyses the feedback and passes its findings to the design and production departments.
   d. The design and production departments take appropriate countermeasures.
   e. The quality assurance department confirms the effectiveness of countermeasures.

   Such a system must be in operation at all times, and should be specified in the company regulations. Normally the technical department will take the lead in analysing the products.

3. To process customer complaints quickly, take the following actions:
   a. Decide:
      i. Which departments or sections should respond to complaints.
      ii. How to process them.
      iii. Which departments should receive reports.
      iv. Which departments should take improvement measures.
   b. Specify this procedure in the regulations, and establish a system to reinforce it.

   Many companies assign the processing of customer complaints to their quality assurance department.

4. In complaint processing the first priority is to explain the nature of the problem to customers, and give them appropriate compensation. This takes priority over preventing repeated complaints and providing information feedback to the design and manufacturing departments.

(See Texts 19.3 and 19.4 in Unit 19 for more detailed guidelines on processing customer claims and complaints.)

5. *Example:* In one company the customer service department and the repair department record the details of defective products and their causes, add them up at the end of each month, and report their findings to the quality assurance department. The quality assurance department analyses this data and reports its analysis at its monthly quality assurance meetings. Members of the design, technical, and manufacturing departments take part in these meetings.

Figure 15.8a Flowchart for dealing with after-sales problems

Discussion

The following questions ask you to think about how the ideas in the text could be applied in your company. Some of the ideas may not be relevant to you. Concentrate on those that are relevant. Keep notes of your conclusions – you will need them to prepare your action plan afterwards. Where appropriate ask yourself the RADAR questions.

Note: Always include in your discussion any figures referred to in the text, ***if*** you feel these are relevant to your company.

a. Does your company have a system for receiving and acting on after-sales feedback about defective products? How effective is it, and how do you think it could be improved?
b. Parag. 2 presents procedures for receiving and processing after-sales feedback on defective products. Apply the RADAR questions.
c. Parag. 3 presents a number of actions to take to process complaints quickly. Apply the RADAR questions to these.
d. Parag. 4: Do you agree the first priority in complaint processing is to give good explanations and appropriate compensation to customers? Why do you agree or disagree?
e. Parag. 5: Is this example one that you could follow in your company?

Action plan

Take the ideas you have found useful in the text, and in your discussion, and present them in a well-structured plan for introducing improvements in your company. You might like to use the 6-Point Structure. Alternatively, you may include these ideas in one action plan after you have discussed several texts.

15.9 Use market research to improve your inspections

1. The after-sales feedback that you receive from your customers about defective products is only one form of market feedback. Your company should carry out systematic market research, even when no defects are reported, to find out how well your products meet the quality levels your customers want. Whenever you learn something new about what they want, you should review your product design, and, of special interest in this unit, review your inspection standards.

2. Introduce the following market research procedures:
   a. Decide on your research objectives.
   b. Select the items to research.
   c. Decide which markets to research.
   d. Choose sampling methods.
   e. Choose methods for analysing the data that is collected.
   f. Set up procedures to gather the data periodically, and to report it accurately to the departments that will use it.
   g. Prepare forms for reporting the data, and establish reporting routes. These forms should have plenty of space for recording a broad range of information without any restrictions. The data recorded should include:
      i. Inspection results.
      ii. Periodic review of the values that are used for accepting items.
      iii. Reports on complaints that have been processed.
      iv. Other market feedback information.
      v. What competitors are doing.

Figure 15.9a Example of a report form

3. Normally companies set up a special department to do market research, or they assign the task to the quality assurance department. This department should make sound judgements about what customers want, based on market information. It will usually then hold discussions with the development and design department and the technical department, and revise the drawings and manufacturing specifications.

4. The quality assurance department should also be pro-active in proposing revisions in the inspection procedures for the products that are to be improved - revisions in inspection items, in methods and in standard values. When these revisions have been made you can be confident that only products that satisfy your customers will pass the inspections. You should then set up a system that allows quick revisions as soon as further market feedback is obtained.

5. In one company, for example, whenever market information indicates that current inspection procedures are inappropriate, the quality assurance department calls a meeting, attended by members of the quality assurance, design and development, technical, and inspection departments, and discusses the revision of these methods. This meeting determines the establishment, revision, and abolition of inspection procedures. Actions decided by the meeting take effect when they are authorized by the chief executive officer.

(See Unit 19 for more detailed guidelines on after-sales services.)

Discussion

The following questions ask you to think about how the ideas in the text could be applied in your company. Some of the ideas may not be relevant to you. Concentrate on those that are relevant. Keep notes of your conclusions – you will need them to prepare your action plan afterwards. Where appropriate ask yourself the RADAR questions.

Note: Always include in your discussion any figures referred to in the text, ***if*** you feel these are relevant to your company.

a. Does your company seek market feedback that it can use to improve its products, and its inspection methods? If so, how successful is it? If not, what concrete benefits do you think such feedback would bring?
b. Parag. 2 presents market research procedures. Apply the RADAR questions to introducing these in your company.
c. Parags. 3, 4 and 5: Apply the RADAR questions to these proposals for applying the information acquired through market research.

Action plan

Take the ideas you have found useful in the text, and in your discussion, and present them in a well-structured plan for introducing improvements in your company. You might like to use the 6-Point Structure. Alternatively, you may include these ideas in one action plan after you have discussed several texts.

Test

Answer these questions using only the information given in the text. For each question one, two or all three answers may be correct. Tick the answer or answers you think are correct for each question. Each question carries 3 points – you get one point for each correct answer that you tick, and one point for each wrong answer that you do not tick.

15.1 Decide which features of a product to inspect

1. To prepare for the inspection of a product, identify the quality characteristics that ... want(s).
   - ☐ a. The marketing department.
   - ☐ b. Customers.
   - ☐ c. The design department.
2. If too many inspection items are selected:
   - ☐ a. Inspection costs will rise.
   - ☐ b. More mistakes will be made.
   - ☐ c. Inspectors will not be able to stay on schedule.

15.2 Establish inspection standards

3. How many types of inspection are there?
   - ☐ a. Two
   - ☐ b. Three
   - ☐ c. Four
4. Which two types of inspection sometimes overlap?
   - ☐ a. Acceptance and delivery.
   - ☐ b. Acceptance and final.
   - ☐ c. Delivery and final.
5. If acceptance inspections are carried out without testing:
   - ☐ a. Inspection certificates issued by third parties may be used as substitutes.
   - ☐ b. Data is collected during the manufacturing processes.
   - ☐ c. Boundary samples are used.
6. Revise existing standards immediately:
   - ☐ a. If defective products are found.
   - ☐ b. If the standards are found to be different from what customers want.
   - ☐ c. If inspections have to be carried out on different sites.

15.3 Establish specific inspection standards.

7. Standards for the preparation of standards should specify:
   - ☐ a. The meanings of terms.
   - ☐ b. Other standards referred to in the standard.
   - ☐ c. Inspection methods.

8. Standards for the preparation of standards should be authorised by:
   - ☐ a. The standards examination committee.
   - ☐ b. The manufacturing plant director.
   - ☐ c. The person in charge of inspections.
9. Since little past quality-related information is available for new and modified products:
   - ☐ a. They cannot be inspected.
   - ☐ b. They should be inspected by an external agency.
   - ☐ c. Their external appearance should be carefully inspected.

15.4 Select, train and monitor inspectors

10. The qualifications required for inspectors should include:
   - ☐ a. Completed a natural science or engineering course at a vocational training school or university.
   - ☐ b. Been authorised by directors of business facilities.
   - ☐ c. Worked as an inspection assistant for one year or longer.
11. Periodic inspections include:
   - ☐ a. Inspection of documents.
   - ☐ b. On-site inspection of operations.
   - ☐ c. Inspection of sites.
12. A curriculum for new inspectors should include:
   - ☐ a. Methods for operating measuring devices.
   - ☐ b. Methods for judging if units can be accepted.
   - ☐ c. Data processing methods.
13. Inspectors who are already working should receive periodic training:
   - ☐ a. When new methods are introduced.
   - ☐ b. For the first four years that they are working.
   - ☐ c. Throughout their working lives.

15.5 Use boundary samples for sensory inspections

14. Boundary samples are used to inspect units that:
   - ☐ a. Are not easy to inspect.
   - ☐ b. Have limited quality characteristics.
   - ☐ c. Have to be inspected physically.
15. To establish regulations for boundary samples:
   - ☐ a. Set maximum and minimum limits for acceptable and unacceptable units.
   - ☐ b. Set the periods of validity for any boundary samples that can change over extended periods of time.
   - ☐ c. Prescribe methods for storing boundary samples.
16. Inspectors who carry out sensory inspections need periodic training at least once:
   - ☐ a. Every three months.
   - ☐ b. Every six months.
   - ☐ c. Every year.
17. Experienced inspectors should use boundary samples to attune their senses:
   - ☐ a. Once a day.
   - ☐ b. Once a week.
   - ☐ c. Before conducting inspections.

15.6 Deal with defective products; make use of inspection data

18. The things that can go wrong when products are found to be defective are:
    - ☐ a. They will be sent back to the manufacturing process.
    - ☐ b. They will be mixed up with products that have been accepted.
    - ☐ c. They will be returned for further inspection without having been repaired.
19. To ensure that defective products are properly dealt with, carry out the following procedures:
    - ☐ a. With unaccepted lots, remove the defective units and re-inspect the lots as if for the first time.
    - ☐ b. Send all defective units to be repaired.
    - ☐ c. Inspect all the units that have been repaired.
20. To implement a system to deal with product types that are often found to be defective the quality assurance department:
    - ☐ a. Analyses the inspection results.
    - ☐ b. Sets targets for reducing the number of defects that appear repeatedly in inspections.
    - ☐ c. Forms improvement teams.
21. To implement such a system, the manufacturing department:
    - ☐ a. Analyses inspection results.
    - ☐ b. Reports the results of improvement to the inspection department.
    - ☐ c. Sets targets for reducing the number of defects that appear in inspections.

15.7 Keep inspection records

22. The results of inspections should be recorded:
    - ☐ a. For each manufacturing process.
    - ☐ b. According to inspection types.
    - ☐ c. At regular intervals.
23. The records of inspections should show:
    - ☐ a. The size of a lot.
    - ☐ b. The defect ratio.
    - ☐ c. The period that the records are to be stored.
24. Records of measures taken against defective items should include:
    - ☐ a. Specifics of defects.
    - ☐ b. Times and dates of countermeasures.
    - ☐ c. Storage conditions of defective products.
25. Records can be used:
    - ☐ a. To deal with future defects.
    - ☐ b. To show the actions already taken to improve quality.
    - ☐ c. As teaching materials.
26. Records should usually be stored for:
    - ☐ a. 1 to 2 years.
    - ☐ b. 3 to 5 years.
    - ☐ c. 6 to 8 years.

15.8 Deal with after-sales product problems

27. To know immediately if any of the products are found to be defective after they enter the market:
    - ☐ a. After-sales feedback information is sent to the quality assurance department.
    - ☐ b. The quality assurance analyses this information and passes its findings to the design and production departments.
    - ☐ c. The design and production departments take appropriate countermeasures.

15.9 Use market research to improve your inspections

28. The market research procedures to be introduced should include:
    - ☐ a. Decide on your research objectives.
    - ☐ b. Decide which markets to research.
    - ☐ c. Prepare a sales plan.
29. The department that has a central role in ensuring that inspection procedures are in line with what customers want is:
    - ☐ a. The marketing department.
    - ☐ b. The quality assurance department.
    - ☐ c. The design department.
30. The forms used to report market feedback should include:
    - ☐ a. Inspection results.
    - ☐ b. Reports on processed complaints.
    - ☐ c. Proposed new product designs.

Relationship with ISO

15.1 Features of a product
Relationship with ISO 9001:2000
7.1 Planning of product realization
8.2.4 Monitoring and measurement of product

15.2 Establish inspection standards
Relationship with ISO 9001:2000
4.2.3 Control of documents
7.4.3 Verification of purchased product
8.2.3 Monitoring and measurement of processes
7.1 Planning of product realization
7.2.1 Determination of requirements related to the product

15.3 Establish specific inspection standards
Relationship with ISO 9001:2000
4.2.3 Control of documents
7.1 Planning of product realization

15.4 Select, train and monitor inspectors
Relationship with ISO 9001:2000
6.2.2 Competence, awareness and training
7.5.3 Identification and traceability

15.5 Use boundary samples for sensory inspections
Relationship with ISO 9001:2000
7.6 Control of monitoring and measuring devices
8.2.3 Monitoring and measurement of processes
6.2.2 Competence, awareness and training

15.6 Deal with defective products; make use of inspection data
Relationship with ISO 9001:2000
7.5.3 Identification and traceability
8.3 Control of non-conformance product
8.5.2 Corrective action
8.5.3 Preventive action
8.5.1 Continual improvement
4.2.4 Control of records
5.5.3 Internal communication
7.3.7 Control of design and development changes
8.5.1 Continual improvement

15.7 Keep inspection records

Relationship with ISO 9001:2000

4.2.4 Control of records

7.5.3 Identification and traceability

15.8 Deal with after-sales product problems

Relationship with ISO 9001:2000

5.2 Customer focus

7.2.3 Customer communication

7.5.1 Control of production and service provision

5.2 Customer focus

7.2.3 Customer communication

5.5.3 Internal communication

8.5.2 Corrective action

8.2.1 Customer satisfaction

15.9 Use market research to improve your inspections

Relationship with ISO 9001:2000

8.4 Analysis of data

5.2 Customer focus

8.5.1 Continual improvement

Unit 16

Management of Facilities and Equipment

Contents

Unit summary

Managing facilities and equipment involves carrying out regular inspections; dealing with any problems and making sure they do not happen again; deciding which forms of maintenance to use; and keeping records of maintenance.

16.1 Keep the workplace neat and clean

The first step in maintaining facilities and equipment is to keep the workplace neat and clean. Defects are much more likely to occur where these practices are not adhered to – when, for example, oil or water is spilled, papers are scattered, tools are left lying around, or dust is allowed to gather.

16.2 Follow the user manual

It is important that machine operators understand the functions of facilities and equipment and can use them properly. Use the user manual to train them in the operation procedures so that they will not cause abnormalities or failures.

16.3 Carry out daily and periodic inspections

Facilities and equipment deteriorate with use. Inspect important facilities, equipment, machines and parts each day for abnormalities and failures, both at the start of operations, and during operations. Carry out periodic inspections at longer intervals – in these, operation may be suspended and the machine disassembled.

16.4 Deal with abnormalities

An abnormality is anything that is not as it should be. You should have a procedure in place for dealing with abnormalities whenever they are detected: report them, process them, and report the processing.

16.5 Deal with failures

A failure is when the facility or equipment ceases to function, either partly or completely. When a failure occurs it is important to get operations started again as quickly as possible. The three steps are: find where the failure emerged, investigate the causes, and process the failure.

16.6 Manage periodic repairs

Periodic maintenance, whether daily or at longer intervals, will often show where repairs are needed. These repairs, which you should do at a minimum cost, will reduce the deterioration of facilities and equipment and prolong their life. Draft and schedule repair plans, assign personnel and allocate materials, and manage the progress of the repairs.

16.7 Manage the procurement of repair parts and materials

Periodic repairs require the suspension of facilities and equipment. The longer the repairs take the greater the losses. One factor that can cause delays is not having the repair parts in stock. Place orders well in advance and maintain appropriate inventory levels.

16.8 Prioritise the maintenance of principal facilities and equipment

To achieve optimal maintenance, base the kind of maintenance you choose to do on the importance of the particular facility or equipment. To decide which are most important consider:

a. The effects of a failure on safety, the environment, product quality, and loss of production.
b. The frequency of failure.
c. The cost of repairs and recovery.

16.9 The different forms of maintenance

Maintenance is a general term for activities like inspection, adjusting parts, replacing material, and carrying out repairs. There are a several different forms of maintenance.

16.10 Decide what form of maintenance to use

The decision about the style and frequency of the maintenance you will use can be a complicated one. Normally your choice will be between periodic maintenance, condition-based maintenance, and breakdown maintenance.

16.11 Condition-based maintenance

Carry out condition-based maintenance to continuously monitor your more complex facilities and equipment, especially those where failure could lead to large production losses. This will enable you to detect at a an early stage any signs of deterioration or any incidents that could lead to failures.

16.12 Breakdown maintenance

However good your management may be, there will always be accidental failures. As well as that, there are also some facilities and equipment that are so difficult and expensive to inspect that it is best to leave repairs until a failure actually occurs. When a failure does occur, repairs must be carried out immediately to minimize production losses. This is breakdown maintenance.

16.13 Recurrence prevention

When you have removed the results of an abnormality or failure - usually by getting the machinery operating again – you need to investigate the causes and take recurrence prevention measures to prevent it happening again.

16.14 Keep maintenance records

Keep records of maintenance activities and analyze them. There are two main categories of records that you should keep: records of the results of your maintenance activities, and records of the appraisal of your maintenance activities.

16.15 Consider maintenance costs before purchasing new facilities and equipment

Maintenance costs are a key factor to consider when you are buying facilities and equipment. Even if the purchase cost is low, facilities and equipment can end up being expensive if their maintenance and repair costs are high. Take into account their reliability –

how likely they are to have failures, and their maintainability – how easy they are to maintain, and then assess the total life-cycle costs.

16.16 Total preventive maintenance

Total preventive maintenance means that everyone is involved in maintenance activities. Establish a comprehensive maintenance system that covers the entire lifespan of facilities and equipment, and get everyone, from CEOs to frontline employees, to participate.

Learning tools

The RADAR questions

As you read each text you will discuss how it could be applied in your company. The RADAR questions will help you to focus this discussion:

R - Are these ideas **relevant** to my company?
A - How would I **apply** each of them in my company?
D - What **difficulties** might I meet and how would I overcome them?
A - Are there any **additional** actions that I might take that are not mentioned in the text?
R - What **resources** would be needed, what would these cost, and how could they be acquired?

There will of course be some discussion points where not all of these questions will be applicable.

The 6-Point Structure

After you have discussed the ideas in the text, you write an action plan in which you present practical proposals for implementing the conclusions you have reached in your discussion. The 6-Point Structure will help you to write your action plan:

1. **Problems:** Problems you have in your company in the area you have just discussed.
2. **Proposals:** Your proposals for improvement.
   a. Be specific and concrete.
   b. Include an implementation plan, with a time schedule and minimum and optimal implementation targets.
   c. Refer to any forms, charts, tables etc. that you would use, and include samples in an appendix.
3. **Obstacles:** Obstacles to implementation in employee attitudes, company organization and culture etc., and how these could be overcome.
4. **Resources:**
   a. The resources required: funds, equipment, materials, man-hours, expertise etc.
   b. The resources available within the company.
   c. Any resources that would have to be found outside the company.
   d. Alternatives that could be used to cover any shortfall in resources.
5. **Assessment:** Ways of assessing the results of implementing these proposals.
6. **Benefits:** The benefits your proposals would bring.

16.1 Keep the workplace neat and clean

Introduction

1. The first step in maintaining facilities and equipment is to keep the workplace neat and clean. In Japan this is referred to as the 3-S, the principles of seiri, seiton and seiso – orderliness, neatness and cleanliness respectively. Defects are much more likely to occur where these principles are not adhered to – when, for example, oil or water is spilled, papers are scattered, tools are left lying around, unnecessary objects are left in the workplace, or dust is allowed to gather. Some of these, spilled water and oil for example, can also be dangerous. The 3-S should be promoted to provide a safe, comfortable and pleasant working environment.

The 3-S Housekeeping Campaign

2. One way of putting these principles into practice is the 3-S Housekeeping Campaign. Underlying this campaign is the concept of employees looking after their own facilities and equipment. To do this they should regularly check the condition of facilities and equipment, using a check sheet with pre-determined check points. These check points (also referred to as inspection points or items) will be ones that they themselves have already determined, and will cover all the places, tasks, machinery and equipment in their charge.

Figure 16.1a 3-S Check Points

The 3-S	Actions	Check points/inspection items
Seiri (orderliness)	Separate necessary and unnecessary items and dispose of the latter.	1. Have any unnecessary items been disposed of? 2. Have any objects been left in the passageways? 3. Have tools been neatly arranged?
Seiton (neatness)	Store necessary items in their designated place so that they can be easily found.	1. Has the storage method been decided on? 2. Have storage locations for items been decided on? 3. Can necessary items be accessed quickly? etc.
Seiso (cleanliness)	Remove dirt and rubbish from the workplace.	1. Are workplaces free of garbage? 2. Have facilities and equipment been dusted? 3. Are floors etc. clean?

3. To make the campaign as effective as possible:
   a. Hang slogans like "Keep the workplace neat and tidy" and "Keep the workplace beautiful" on the walls of workplaces.
   b. Give recognition to employees who follow these principles.

(See Text 16.3 for more details about check sheets.)

Note: seiri, seiton and seiso are the first three of the 5-S – (see also Texts 6.2 and 8.3.7).

Discussion

The following questions ask you to think about how the ideas in the text could be applied in your company. Some of these ideas may not be relevant to you. Concentrate on those that are relevant. Keep notes of your conclusions – you will need them to prepare your action plan afterwards. Where appropriate ask yourself the RADAR questions.

Note: Always include in your discussion any figures referred to in the text, ***if*** you feel these are relevant to your company.

a. Parag. 1: How would you describe your workplace in terms of seiri, seiton and seiso? To what extent could the lack of orderliness, neatness and cleanliness of your workplace be a cause of defects? Give one or two examples.
b. Parag. 2: Apply the RADAR questions to the idea of running a 3-S Housekeeping Campaign in your workplace. Give an example of some checkpoints that you would use.
c. Parag. 3: How would your employees respond to the idea of hanging slogans in your workplace. What additional or alternative ideas could you use?

Action plan

Take the ideas you have found useful in the text, and in your discussion, and present them in a well-structured plan for your company. Alternatively you may choose to prepare one action plan when you have discussed several texts. You might like to follow the 6-Point Structure.

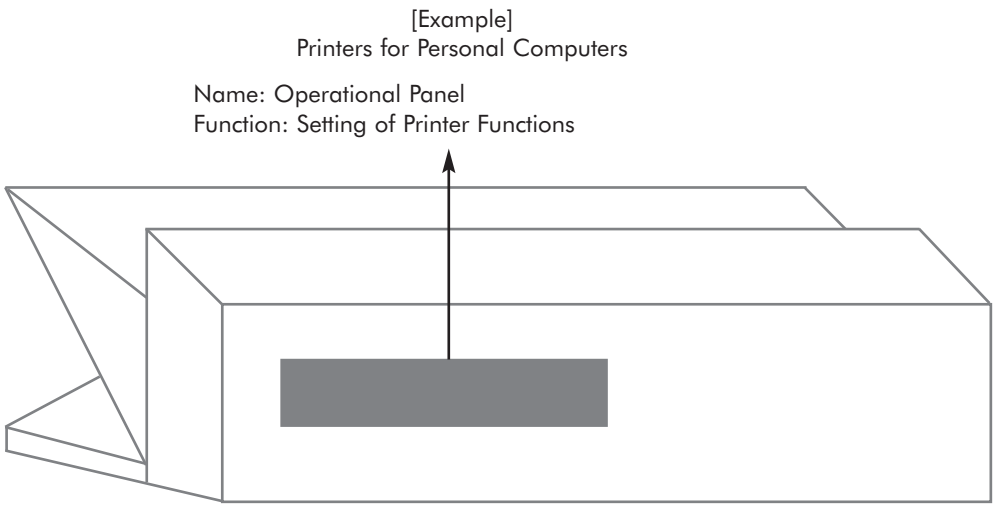
16.2 Follow the user manual

1. It is important that machine operators understand the functions of facilities and equipment and can use them properly. Use the user manual to train them in the operation procedures so that they will not cause abnormalities or failures. (An abnormality is anything that is not as it should be; a failure is when the facility or equipment ceases to function.)

2. The user manual (also referred to as the operation manual, or the machine operation procedure) prescribes the operation procedure for facilities and equipment, the tools and materials that are to be used, the handling methods, and any operational points that need special care.

3. The user manual should include:
   a. The main characteristics of the facilities or equipment and an explanation of technical terms.
   b. The functions, tools, and parts, and their names.
   c. How to install and assemble the facilities or equipment.
   d. Methods for making adjustments:
      i. Setting initial values, for example printing speed.
   e. Preparing to begin operation.
   f. The operation procedure, for example:
      i. Press the on-line switch.
      ii. Confirm that the lamp is lit.
   g. Any abnormalities that can emerge when the equipment is installed, and during trial operation, and the countermeasures that are to be taken, for example:
      i. The printer does not turn on – The power adaptor is disconnected.
      ii. The printer does not print – Cables are not connected.

Figure 16.2a



h. Abnormalities that can emerge:
    i. Papers get jammed – the wrong type of paper is being used.
    ii. Black spots appear on printed pages – the cartridge needs to be replaced.
i. List of specifications.

Discussion

The following questions ask you to think about how the ideas in the text could be applied in your company. Some of these ideas may not be relevant to you. Concentrate on those that are relevant. Keep notes of your conclusions – you will need them to prepare your action plan afterwards. Where appropriate ask yourself the RADAR questions.

Note: Always include in your discussion any figures referred to in the text, ***if*** you feel these are relevant to your company.

a. Parags. 1 and 2: Do you feel that your machine operators can use the facilities and equipment properly? Are your user manuals adequate? Where do you feel there is room for improvement?
b. Parag. 3 lists some of the most important items that should be included in the user manuals. Which of these do you already have? Which points would you include from this list? Are there any other points that you would now want to include in your manual?

Action plan

Take the ideas you have found useful in the text, and in your discussion, and present them in a well-structured action plan for introducing improvements in your company. You might like to follow the 6-Point Structure. Alternatively you may choose to prepare one action plan when you have discussed several texts.

16.3 Carry out daily and periodic inspections

Introduction

1. Facilities and equipment deteriorate with use. Inspect important facilities, equipment, machines and parts each day for abnormalities and failures, both at the start of operations, and during operations. Carry out periodic inspections at longer intervals – in these, operation may be suspended and the machine disassembled.

Inspection procedures

2. Follow these inspection procedures:
   a. Operators familiar with the facilities and equipment conduct normal daily inspections, while worksite patrols from the maintenance section conduct specialized inspections.
   b. Use a check sheet on which the inspection items and methods have been written in advance. Choose inspection items primarily on how they relate to product quality. They will typically include:
      i. Mechanical looseness caused by vibrations.
      ii. Blockages and stoppages caused by dust or garbage.
      iii. The presence of foreign objects.
      iv. Oil leakage and scattering.
      v. Damage to wires.
   c. Base inspection methods primarily on the five senses (sight, touch, hearing, taste and smell). Inspect the fumes, sounds, smells, and vibrations that the machines generate during operation, and note also how easy they are to operate. Those that are monitored with measuring devices, like oil pressure gauges, should be inspected every day. Be creative in finding ways to identify abnormalities more easily and more accurately, especially when you are inspecting by sight. Rules will of course differ according to the item and the objective – the kind of abnormality you are looking for. What is important is that they help everyone to identify abnormalities, and correct them at once.
   d. Report inspection results: enter details of the inspection on the check sheet and get the manager or supervisor to confirm them.
   e. Process any abnormalities that are found according to the "Rules for processing abnormalities". (See Text 16.4.)

Figure 16.3a Sample check sheet (page 12)

Discussion

The following questions ask you to reflect on your company's daily and periodic inspections, and how the ideas in the text could help to improve them. Where appropriate ask yourself the RADAR questions.

Note: Always include in your discussion any tables or charts referred to in the text.

a. Parag. 1: How frequently do you carry out inspections of your important facilities and equipment? Do you think this is often enough? What do you include in these inspections? Is there anything else that you feel you ought to include?
b. Parag. 2: Who normally carries out your inspections? Would it be a good idea to change this?
c. Parag. 2: What are some typical inspections items that you use? How do you inspect them?
d. Parag. 2: How could you make it easier to identify abnormalities in your processes? After looking at these examples, can you think of any other ways that would make it easier to spot them?
e. Apply the RADAR questions to the procedures in this text.

Action plan

Take the ideas you have found useful in the text, and in your discussion, and present them in a well-structured action plan for introducing improvements in your company. You might like to follow the 6-Point Structure. Alternatively you may choose to prepare one action plan when you have discussed several texts.

Figure 16.3a Sample check sheet

	Sections	Inspection areas	Inspection items	Inspection methods	Inspection results
1.	Driving gear	Motor	Are tightening bolts loose?	Inspect by sight and touch	
2.	Driving gear	Motor	Are there any stains from oils or powders?	Inspect by sight	
3.	Driving gear	Agitator	Are shafts loose?	Inspect by sight and touch	
4.	Driving gear	Stopper	Does it stop at the right position?	Inspect by sight	

16.4 Deal with abnormalities

Introduction

1. An abnormality is anything that is not as it should be. You should have a procedure in place for dealing with abnormalities whenever they are detected. This procedure will include:
   a. Report the abnormalities.
   b. Process them.
   c. Report the processing.

2. Abnormalities may be classified into those which occur a) occasionally b) regularly and c) repeatedly and chronically. Many abnormalities are to do with temperature, pressure and general operations. These are typically caused by liquid and powder leakages, the spilling of gas and the release of vapor, and by soiling and blockage caused by garbage and dust.

3. Abnormalities may be detected by the senses in odors, sound, and vibrations. In statistics-based inspections, they will appear in significant deviations in value where the cause of the deviation is unknown – when conditions are uniform, when items are measured quantitatively and when process conditions are clearly understood.

(See Unit 9 for more detailed guidelines on dealing with abnormalities.)

Write an abnormality report

4. Include the following in the abnormality report:
   a. Names of the section or parts of the facility or equipment.
   b. The type of abnormality.
   c. The normal conditions – when operations are carried out correctly.
   d. Possible causes.
   e. Methods for processing the abnormality.
   Take action at once against any abnormalities that can be dealt with easily, for example by supplying oil.

Process the abnormality

5. If the cause of the abnormality cannot be found, get approval from the manager or supervisor to suspend the operation, and then disassemble and inspect the facilities or equipment. When a precision inspection of the disassembled equipment shows the causes, take immediate measures to eliminate them.

Write a report on the processing of the abnormality

6. Write a report of the procedure taken to process the abnormality and submit it to the appropriate people for their confirmation. Then revise the standards if any change is needed in the normal operation.

Permanent measures

7. Sometime the actions taken are only short-term emergency measures. If it is necessary to consider more permanent changes, hold discussions with managers or supervisors, operators, those in charge of maintenance, and technical staff. Use data and statistical methods like histograms, scatter diagrams, and cause and effect diagrams. (See The Seven QC Tools, in Text 16.16.) These discussions may take place at the regular morning meetings or at meetings held specifically for this purpose.

Discussion

The following questions ask you to think about how the ideas in the text could be applied in your company. Some of these ideas may not be relevant to you. Concentrate on those that are relevant. Keep notes of your conclusions – you will need them to prepare your action plan afterwards. Where appropriate ask yourself the RADAR questions.

Note: Always include in your discussion any figures referred to in the text, ***if*** you feel these are relevant to your company.

a. Parag. 1: Do you have a procedure in place for dealing with abnormalities? How effective is it?
b. Parag. 2: Give examples of some typical abnormalities in your processes. How are they usually detected?
c. Parags. 2 and 3: How would you fit them into these classifications? What are their usual causes?
d. Parag. 4: Would you include all of these items in your abnormality report? Would you add any others? Give some brief examples of what you would put in an abnormality report under each of your items.
e. Parags. 5: How often do you have to disassemble facilities and equipment to find the cause of an abnormality? Give a typical example.
f. Parags. 6 and 7: Apply the RADAR questions to these suggestions.

Action plan

Take the ideas you have found useful in the text, and in your discussion, and present them in a well-structured action plan for introducing improvements in your company. You might like to follow the 6-Point Structure. Alternatively you may choose to prepare one action plan when you have discussed several texts.

16.5 Deal with failures

Introduction

1. A failure is when the facility or equipment ceases to function, either partly or completely. When a failure occurs it is important to get operations started again as quickly as possible. The three steps are: find where the failure emerged, investigate the causes, and process the failure.

2. Failures can be classified under:
   a. The type of failure: early in the life of the equipment, accidental, or due to abrasion or degradation.
   b. The cause: single-cause failures or multiple-cause failures.
   c. The degree of loss of function: partial failure or complete failure.
   d. The seriousness of the failure: failures that caused death or injury, serious failures, or minor failures. (This includes latent failures that have not yet emerged, and manifest failures that have emerged.)

Preliminary failure reports by operators

3. When a failure occurs, the operators should complete a preliminary report, giving the facilities or equipment that caused the failure, the date, the type of failure, and an outline of what happened.

Analysis of failures

4. The maintenance department should use these preliminary reports to inspect the failure. They should:
   a. Detect the failed sections.
   b. Assess the failure.
   c. Classify the failure.
   d. Investigate the cause.

Processing methods

5. Use these processing methods:
   a. When there are minor failures, carry out repairs and replace parts on the spot.
   b. When there are serious failures, conduct precision inspection to determine the causes, and implement appropriate countermeasures.
   c. If recovery after serious failures will take a long time, examine the feasibility of emergency countermeasures or repairs, and implement them wherever possible.

Processing report

6. To prepare and maintain processing reports:
   a. Report the causes of failures, the countermeasures taken, the date of their implementation and those responsible for them, production-suspension periods, repair costs, the date of finalizing countermeasures, those who examined the countermeasures, and actions to be taken in the future.
   b. Store reports as reference materials for future examination.

Permanent countermeasures

7. Often the first actions taken will be only emergency countermeasures. Take permanent countermeasures later to prevent recurrence (recurrence prevention measures), and improve the structures of the facility and equipment as well as the operational and maintenance methods.

Discussion

The following questions ask you to reflect on your company's procedure for processing failures, and how the ideas in the text could help to improve it. Some of these ideas may not be relevant to you. Concentrate on those that are relevant. Keep notes of your conclusions – you will need them to prepare your action plan afterwards. Where appropriate ask yourself the RADAR questions.

Note: Always include in your discussion any figures referred to in the text, ***if*** you feel these are relevant to your company.

a. Parag. 1: Does it usually take long to get your facilities and equipment back into operation after a failure? Do you think this could be done quicker? If so, how?
b. Parag. 2: How can a typical failure in your company fit into this classification?
c. Parag. 3: Do you get your operators to submit preliminary failure reports? If yes, how useful are they? If not, how would they be helpful?
d. Parag. 4: Apply the RADAR questions to using this approach to analyzing failures in your company.
e. Parag. 5: Apply the RADAR questions to using these processing methods.
f. Parag. 6: Would you include all of these points in your processing report? Are there any additional points that you would add?
g. Parag. 7: Give some examples of recurrence prevention measures that you have taken or would now take. What steps have you taken to improve structures, or what steps can you think of that ought to be taken in relation to one or two typical failures?

Action plan

Take the ideas you have found useful in the text, and in your discussion, and present them in a well-structured action plan for introducing improvements in your company. You might like to follow the 6-Point Structure. Alternatively you may choose to prepare one action plan when you have discussed several texts.

16.6 Manage periodic repairs

Introduction

1. Periodic maintenance, whether daily or at longer intervals, will often show where repairs are needed. These repairs, which you should do at a minimum cost, will reduce the deterioration of facilities and equipment and prolong their life. You should:
   a. Draft and schedule repair plans, and assign personnel and allocate materials.
   b. Manage the progress of repairs.

2. The PERT method is often used to manage periodic repair work. PERT is an abbreviation for "program evaluation and review technique". It is a schedule management method for large-scale repair plans and complex repair work. It presents the sequence of repair processes in the form of a network and creates a repair work schedule on the basis of the time required and the costs, e.g. the number of employees.

Figure 16.6a PERT– Programme Evaluation and Review Technique (pages 18 and 19)

Draft and schedule repair plans

3. To draft repair plans and assign personnel and materials:
   a. Identify job activities: Confirm the contents of the job, and estimate the man-days (numbers of days x the number of employees) and the amount of materials required.
   b. Prepare a job network: Present the number of job activities and their relationship to each other in the form of a network. Show the points at which jobs can be started and concluded and arrange them in sequence. Jobs that can be performed simultaneously should be set parallel to each other.
   c. Estimate the work schedule: Enter the time required for each job on the network, and make a final estimate of how long it will take to complete all the work. Identify the successive groups of jobs that will make up this final estimate of the completion period. These are known as critical paths. At this point, set up the network according to a time scale. Distinguish jobs that will take time from those that must be performed quickly. Make a total of the job loads (the numbers of employees needed and the material). Put all the different job loads on the time-scale network. This may show a very biased distribution of job loads.
   d. Shorten the work schedule: Review the number of employees assigned to perform each job and the time allowed. Attempt to shorten the job schedule by changing the number of those employed on critical paths. Make changes to less urgent jobs first. It should be possible to shorten the schedule in this manner.
   e. Draft the work schedule: Prepare the work schedule through this trial and error process.

Manage the carrying out of repairs

4. Pay attention to job groups on critical paths during repairs. If the job is likely to take a longer period of time than originally scheduled, something must be done. Consider relocating employees and materials from non-critical jobs, or assigning additional

employees. But keep personnel and material costs in mind, and the losses that can result from a delay in completing repairs.

Discussion

The following questions ask you to reflect on how your company manages its periodic repairs, and how the ideas in the text could help to improve this. Some of these ideas may not be relevant to you. Concentrate on those that are relevant. Keep notes of your conclusions – you will need them to prepare your action plan afterwards. Where appropriate ask yourself the RADAR questions.

Note: Always include in your discussion any figures referred to in the text, ***if*** you feel these are relevant to your company.

a. How effectively does your company manage its periodic repairs? Where would you say there is room for improvement?
b. Parags. 2 and 3: Use the PERT method to draft a sample set of repair plans for one of your facilities or pieces of equipment. If you do not have all the information immediately at hand while working on this exercise make your best guess. Be as concrete and specific as you can.
c. Apply the RADAR questions to using the PERT method in your company.

Action plan

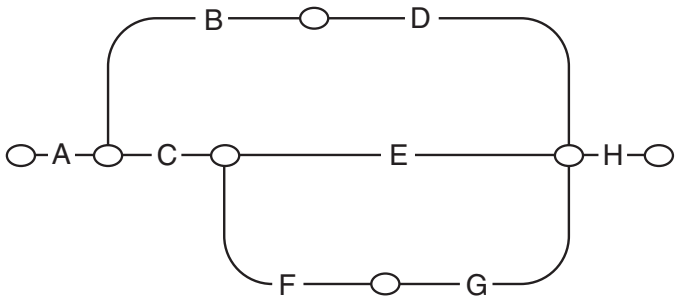
Take the ideas you have found useful in the text, and in your discussion, and present them in a well-structured action plan for introducing improvements in your company. You might like to follow the 6-Point Structure. Alternatively you may choose to prepare one action plan when you have discussed several texts.

Figure 16.6a PERT – Programme Evaluation and Review Technique

1. [Figure 1] Identification of Job Items and Estimation of Man-Days

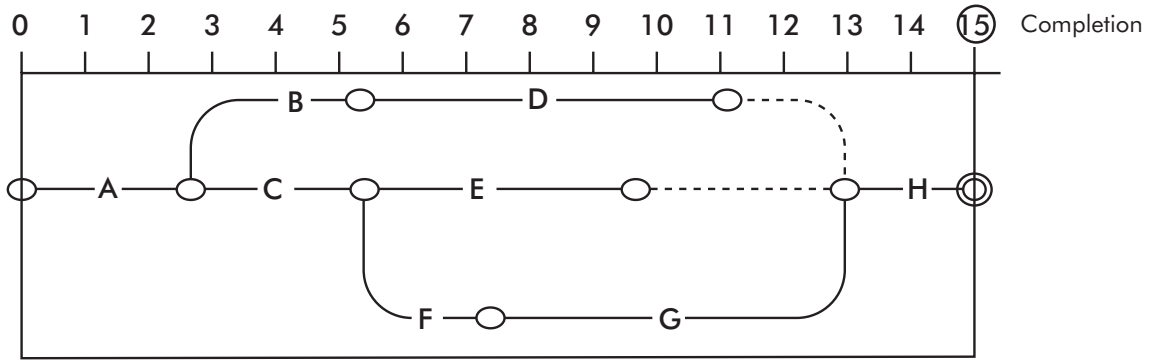
Activities			
A	Activities	Days	Persons
B	E	3.0	4
C	F	2.0	3
D	G	4.0	3
	H	3.0	3

2. [Figure 2] Preparation of Job Network



Note 1: The duration of activities has no relation to the number of days required. Rather, it is expressed through a relationship with preceding and subsequent activities.

3. [Figure 3] Estimation of Work Schedule



Note 2: The group formed by consecutive activities A,C,F,G and H represents a critical path (indicated by a line).

4. [Figure 4] Shortening of Work Schedule

Countermeasure-1.
Relocate one worker from activity E to activities F and G.
Countermeasure-2
Advance the starting time of activity H. (Break down the activity H into two parts, H_1 and H_2.)

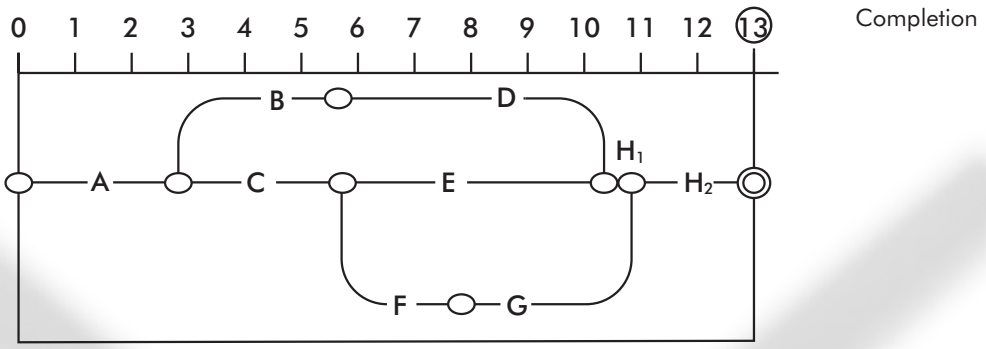
Activities	Activities	Days	Persons
A	E	3.0	4
B	F	2.0	3
C	G	4.0	3
D	H	3.0	3

⇨

	Days	Persons
	4.0	3
	1.5	4
	3.0	4
H_1	0.5	3
H_2	2.5	3

Mark* indicates revised activities

5. [Figure 5] Drafting of Work Schedule



16.7 Manage the procurement of repair parts and materials

Introduction

1. Periodic repairs usually require the suspension of facilities and equipment. The longer the repairs take the greater the losses. One factor that can cause delays is not having the repair parts in stock. You should place orders well in advance and maintain appropriate inventory levels. To manage this efficiently:
   a. Decide what repairs you are going to carry out.
   b. Place orders for materials and repair parts.
   c. Prepare ledgers and slips.
   d. Choose a purchasing order system.

Decide what repairs you are going to carry out

2. Select the machines, tools and parts that you are going to repair or replace on the basis of their level of deterioration and according to your overall repair schedule. Establish priorities among these, since the money available for repairs and replacements is limited. Give higher priority to:
   a. Those required in management inspection procedures or where inspection is required by law.
   b. Those that require preferential treatment because of:
      i. The failure rate.
      ii. The size of production loss in the event of a failure.
      iii. Repair cost in the event of a failure.

   Use this concept of priority: Priority = production loss x failure emergence ratio x repair cost. When you have decided which repairs to carry out, prepare a repair work schedule.

Figure 16.7a Estimation of parts-replacement period based on service-life estimate

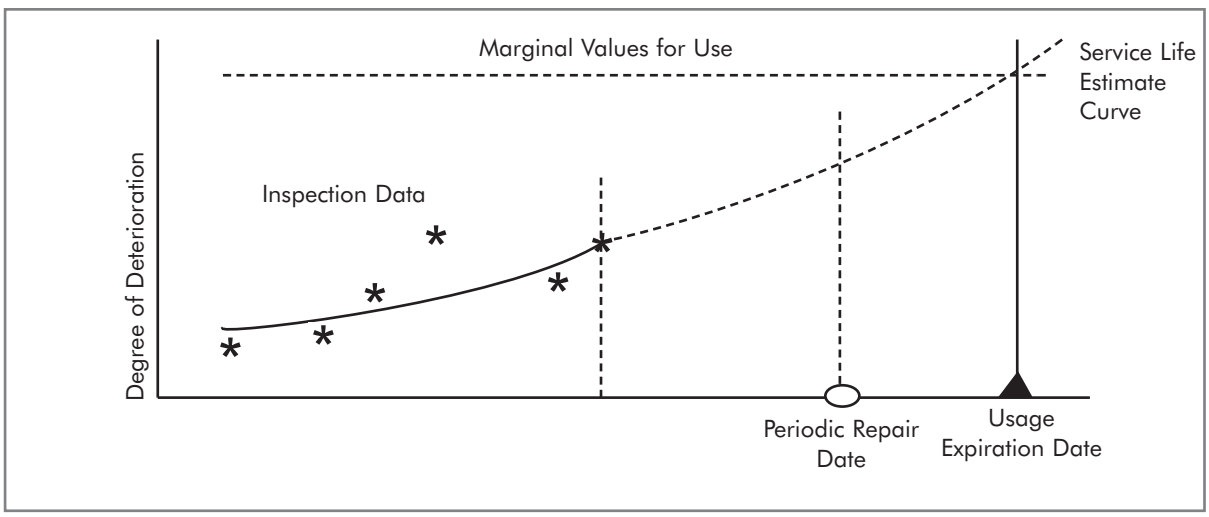


Figure 16.7b Repair work schedule

Place orders for materials and repair parts

3. Decide when to order parts and materials, keeping in mind when parts need to be replaced, and the time required for procuring them.

Figure 16.7c List of parts used in repair work

Repair case name	Product name	Type	Work	Quantity & unit	Amount	Next scheduled repairs
Replacement of B in Facility A	Bearing	UCP206	Replacement	10,000 units	$1000	April 6th 2005

Figure 16.7d List of arrived orders

Repair case name	Next scheduled repairs	Product name	Type	Quantity & unit	Amount	Next scheduled repairs
Replacement of B in Facility A	Sept 5th 2005	Bearing	UCP206 3/4-10	10,000 20,000	$1000 $1500	April 6th 2005 April 6th 2005

Prepare ledgers and slips

4. Prepare a number of books and slips for supply and demand management, and inventory of maintenance materials, the control of fixed assets, and the management of unused goods. Examples of these include: fixed asset ledger; stock registration ledger; warehousing, stocktaking and inventory quantity; and list of materials scheduled for use.

Choose a purchasing order system

5. You can select one of two methods to order parts and materials: the mixed period ordering method or the fixed quantity ordering method. You choice will depend on how often you use the parts and materials, and the time required for their procurement:

   Fixed Period Ordering Method. Fix the ordering interval in advance, and determine the order quantity each time according to the current inventory levels and the quantity required. Keep in mind the time needed for procurent as well as the time until the next order, and add on a safety margin.

   Fixed Quantity Ordering Method (re-ordering point method). Do not fix ordering intervals in advance. Order a prescribed number of units or a fixed quantity (cost-effective ordering quantity) when the inventory falls to a certain level – the re-ordering point. The re-ordering point is where you still have the quantity needed for the time that it will take to procure more, plus enough for a safety margin. Cost-effective ordering quantity is the amount that minimizes storage and ordering costs for a fixed period.

Figure 16.7e Fixed period ordering method

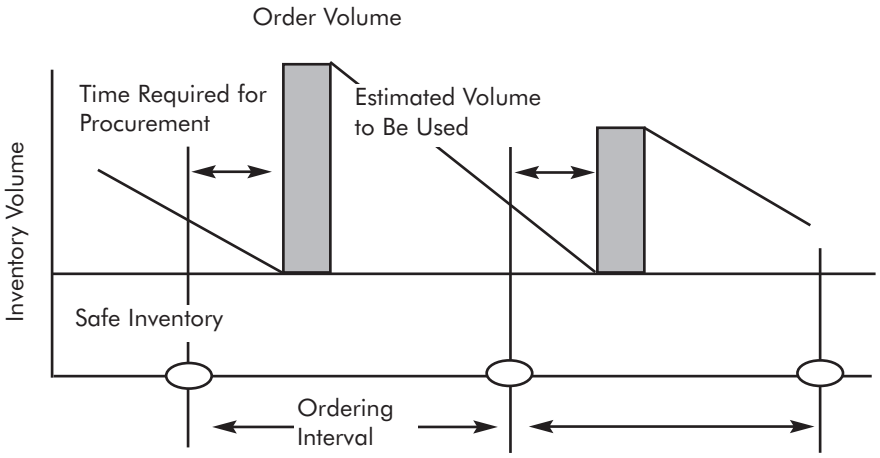
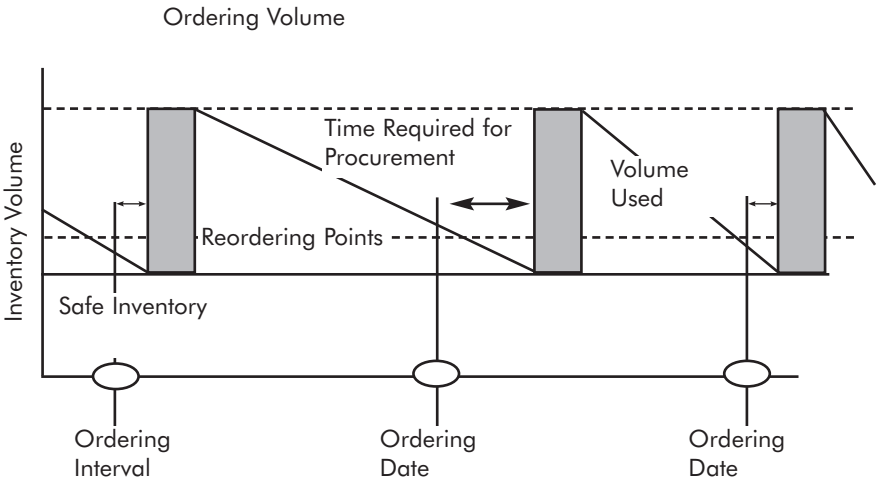


Figure 16.7f Fixed quantity ordering method



Discussion

The following questions ask you to reflect on your company's management system for repair parts and materials, and how the ideas in the text could help to improve this. Some of these ideas may not be relevant to you. Concentrate on those that are relevant. Keep notes of your conclusions – you will need them to prepare your action plan afterwards. Where appropriate ask yourself the RADAR questions.

Note: Always include in your discussion any figures referred to in the text, ***if*** you feel these are relevant to your company.

a. Parag. 1: How does your company manage the procurement of parts and materials for repairs? What problems have you experienced? Where do you think improvements are needed?
b. Parag. 2: How valid do you think these criteria are for your company? How appropriate do you think the prioritization formula is?

c. Parag. 2: Select some of your machines, tools and parts, and prioritize them according to the criteria given here. Then draw up a repair work schedule like the one in Figure 16.7b.
d. Parag. 3: What factors do you take into account when ordering repair parts? Give concrete examples. Would you use forms like these to list parts and arrived orders?
e. Parag. 4: Which of these ledgers and slips do you already use? How would you prepare those that you do not have?
f. Parag. 5: Do you already use these ordering systems? If so, how effectively do you feel you use them? What improvements could you make? If you do not use them apply the RADAR questions to the idea of using them.

Action plan

Take the ideas you have found useful in the text, and in your discussion, and present them in a well-structured action plan for introducing improvements in your company. You might like to follow the 6-Point Structure. Alternatively you may choose to prepare one action plan when you have discussed several texts.

16.8 Prioritise the maintenance of principal facilities and equipment

1. To achieve optimal maintenance, base the kind of maintenance you choose to do on the importance of the particular facility or equipment. To decide which are most important consider:
   a. The effects of a failure on safety, the environment, product quality, and loss of production.
   b. The frequency of failure.
   c. The cost of repairs and recovery.

2. The importance of the same facilities and equipment will vary from company to company, according to the production methods and product types. You should therefore determine which facilities and equipment are most important for you. However, you may be able to use these general ranking criteria:
   a. Rank A: boilers, turbines etc. that have the most substantial effect.
   b. Rank B: rotating machines, reactors, vessels and tanks that have a medium level effect.
   c. Rank C: general machines and equipment that have a small effect.

3. Maintenance methods for Rank A: These usually only have a small number of failures, but repair and recovery costs are high. Members of the maintenance section:
   a. Carry out daily, prioritized inspection.
   b. Use diagnostic technology to examine the facility and equipment conditions (condition-based maintenance).
   c. Do periodic repairs and maintenance work.

4. The standards in Figure 16.8a can be used to determine the levels of importance.

Figure 16.8a

Items for appraisal		**Standards for determining importance levels**
Safety	Effect of accidents caused by failures.	Duration of production suspension.
Environment	Effect of failures on the environment.	Effects both inside and outside the manufacturing plants.
Quality	Effect of failures on product quality.	Effects on users, and on the next process.
Production	Effect of production suspension caused by failures.	Production suspension period.
Reliability	Frequency of failures.	Times per year.
Maintainability	Cost of repairs and recovery.	Specific costs.

5. Prepare master tables, showing the importance levels, and attach cards to the principal facilities and equipment showing the maintenance methods to be used (for example, inspection frequency and inspection items). This will ensure that nothing is overlooked.

Figure 16.8b Example of standards for appraising the importance of facilities and equipment

Figure 16.8c Example of ranking by importance: ranks should be decided by totalling the importance levels of appraised items

Ranking of Importance	Total Scores
Rank A	15 < Total Score < 20
Rank B	10 < Total Score < 14
Rank C	5 < Total Score < 9
Rank D	0 < Total Score < 4

Note: In actual practice, optimal maintenance specifications are determined according to changes in environmental conditions, e.g. working conditions and the manufacturing environment. In other words, the importance of facilities and equipment is appraised by weighting environmental conditions.

Figure 16.8d Example of facility and equipment registration: a master table showing the levels of importance of all facilities and equipment

Process	Facility or equipment	Machine or tool	Date of operation launch	Machine or tool type	Level of importance	Manufacturer	Maintenance specifications
Coarse rolling	Roller	Cylinder	May 29th 2003	Axial flow pump	A	SH machinery	CBM
	Roller	Tool	May 29th 2003	Axial flow pump	A	SH machinery	CBM

Discussion

The following questions ask you to think about your company's maintenance of its principal facilities and equipment, and how the ideas in the text could help to improve this. Some of these ideas may not be relevant to you. Concentrate on those that are relevant. Keep notes of your conclusions – you will need them to prepare your action plan afterwards. Where appropriate ask yourself the RADAR questions.

Note: Always include in your discussion any figures referred to in the text, ***if*** you feel these are relevant to your company.

a. What approach does your company take to the maintenance of its principal facilities and equipment? Where do you feel there may be a need for improvement?
b. Parag. 1 presents criteria for deciding on the levels of importance of different facilities and equipment. Would all of these be relevant in your company? Are there any others you would add? Apply them in general terms to the evaluation of the importance of some of your facilities or equipment.
c. Parag. 2: Rank some of your facilities and equipment according to this A, B, C system.
d. Parag. 3: Apply the RADAR questions to these suggestions.
e. Parag. 4: How appropriate would these standards be in your company? Give one or two concrete examples of how you would apply them.
f. Parags 5: Apply the RADAR questions to these suggestions.
g. Look carefully at the three examples. If you feel they are relevant to your company, consider how you could apply or adapt them.

Action plan

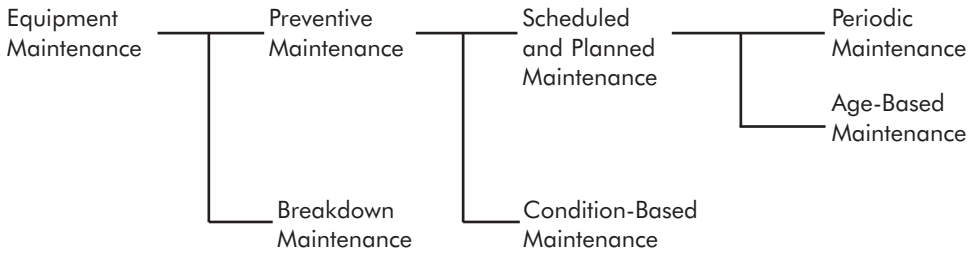
Take the ideas you have found useful in the text, and in your discussion, and present them in a well-structured action plan for introducing improvements in your company. You might like to follow the 6-Point Structure. Alternatively you may choose to prepare one action plan when you have discussed several texts.

16.9 The different forms of maintenance

1. Maintenance is a general term for activities like inspection, adjusting parts, replacing material, and carrying out repairs. There are several different forms of maintenance. Maintenance refers in particular to activities aimed at:
   a. Preventing deterioration, e.g. oiling, adjusting and cleaning.
   b. Identifying and measuring deterioration, e.g. inspecting and testing.
   c. Recovering after deterioration, e.g. periodic repairs and post-failure repairs.

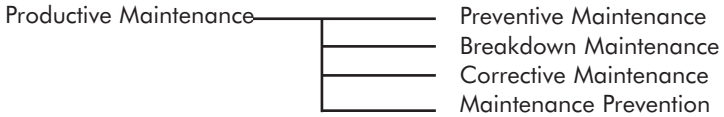
2. There are two styles of maintenance:
   a. Preventive maintenance: prevent deterioration and failures emerging.
   b. Breakdown maintenance: quickly restore functions after failures.
   Maintenance activities are further classified by the Japanese Industrial Standards (JIS) as Figure 16.9a shows.

Figure 16.9a



3. In recent years, corrective maintenance and maintenance prevention have been added to the list under the broader category of productive maintenance. The focus is on preventing failure recurrence, extending facility or equipment life, and shortening repair times. Productive maintenance therefore consists of preventive, breakdown and corrective maintenance, and maintainance prevention.

Figure 16.9b



4. The maintainance classifications can be defined as follows:
    a. Preventive maintenance is based on the examination of facilities and equipment when they are being designed or installed. It is aimed at preventing deterioration and failures from occurring.
    b. Planned maintenance incorporates periodic and age-based maintenance as ways of implementing preventive maintenance.
    c. Periodic maintenance refers to inspection and repairs at regular intervals.
    d. Condition-based maintenance involves constant monitoring of the condition of facilities and equipment. It may also be classified as part of planned maintenance. (See also Text 16.11.)
    e. Breakdown maintenance is used to get facilities and equipment functioning again after failures. (See also Text 16.12.)
    f. Corrective maintenance prevents the recurrence of failures and is based on maintenance activity records.
    g. Maintenance prevention – the facilities and equipment are designed to require less maintenance and to have a longer life span.

5. Modernization and the increasing complexity and size of facilities and equipment, have increased the number of unexpected failures in recent years, and their impact on production and quality. Special importance should therefore be given to:
    a. Preventive maintenance, especially condition based maintenance.
    b. Maintenance prevention.

Figure 16.9c Adaptive Maintenance System flow chart

Discussion

The following questions ask you to think about your company's management of maintenance, and how the ideas in the text could help to improve this. Some of these ideas may not be relevant to you. Concentrate on those that are relevant. Keep notes of your conclusions – you will need them to prepare your action plan afterwards.

Note: Always include in your discussion any examples or figures referred to in the text, ***if*** you feel these are relevant to your company.

a. How effectively does your company manage the maintenance of its equipment? Where do you feel there is room for improvement?
b. Parag. 1: What do you think of these ways of defining maintenance? How appropriate are they for your maintenance activities?
c. Parags. 2, 3 and 4: Look at these different ways of classifying maintenance, and their definitions. Try to relate your own maintenance activities to these classifications.
d. Parag. 5: Are these priorities also true for your company? Discuss in particular the concept of maintenance prevention.

Action plan

Take the ideas you have found useful in the text, and in your discussion, and present them in a well-structured action plan for introducing improvements in your company. You might like to follow the 6-Point Structure.

16.10 Decide what form of maintenance to use

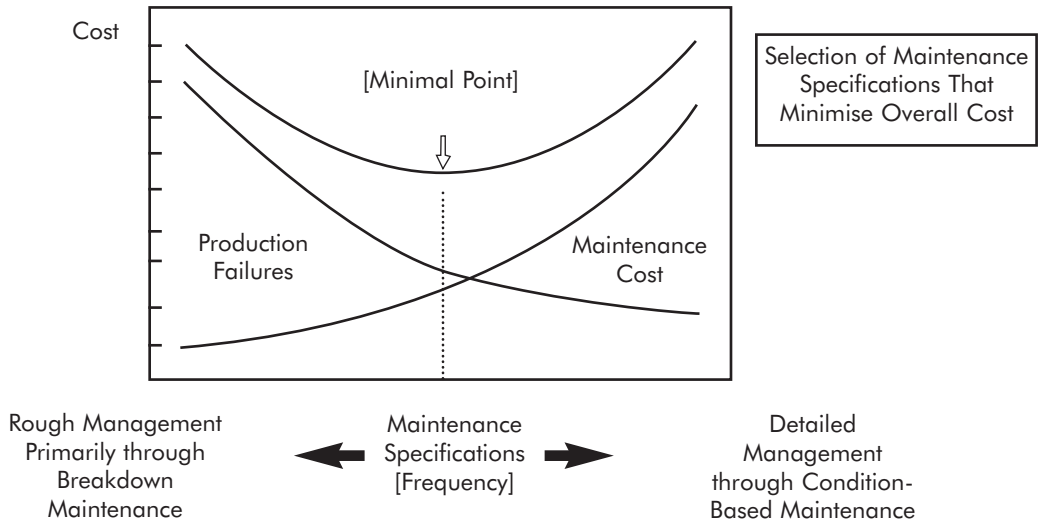
1. The choice of style and frequency of maintenance can be a complicated one. There are two approaches that you can use to make this decision:
   a. The quantitative method.
   b. The qualitative method.

2. Normally your choice will be between periodic maintenance, condition-based maintenance, and breakdown maintenance.
   a. Periodic maintenance, with inspections and repairs at regular intervals, is the one that is most often chosen. It is carried out at intervals that suit the different facilities and equipment.
   b. Condition-based maintenance – constant monitoring of the condition of facilities and equipment – is usually chosen for facilities and equipment where failures could cause large production losses.
   c. Breakdown maintenance – used to get facilities and equipment functioning again after failures – is usually chosen when maintenance costs are high.

Quantitative method

3. Use this method to select the style and frequency of maintenance that brings the lowest costs, as shown in Figure 16.10a.

Figure 16.10a The relationship between the frequency of maintenance and its overall cost



Use the following formulas to calculate the total cost of maintenance:

a. Overall maintenance cost = maintenance cost plus loss from failures.
b. Maintenance cost = breakdown maintenance cost times the frequency of failure, plus periodic repair cost times the frequency of repairs, plus inspection cost times the frequency of inspections.
c. Loss from failures = Cost of loss per failure times average failure frequency.

Then choose the one that brings the lowest costs.

Qualitative method

4. Decide on the style and frequency of maintenance by ranking the inspection characteristics of the facilities and equipment. Use the four criteria of necessity for inspection, effectiveness of inspection, need to disassemble to carry out an inspection, and cost-effectiveness.

5. *Necessity for inspection:* To determine the levels of need for inspection, examine the following seven points:
   a. The presence or absence of legal restrictions.
   b. The estimated suspension period.
   c. The impact on quality.
   d. The impact on safety.
   e. The impact on the environment.
   f. The impact on the capacity to respond to disasters.
   g. The cost of maintenance.

   After considering these seven points, group facilities and equipment into four levels of importance, A, B, C and D. The facilities and equipment with a great need for inspections are considered the principal facilities and equipment, and require detailed inspections and condition-based maintenance.

6. *Effectiveness of inspection:* Assess the effectiveness of inspections on the basis of facility and equipment deterioration characteristics e.g., facility and equipment life, progress of deterioration, and the nature of the deterioration.

7. *Need to disassemble:* Judge whether it is possible to inspect the degree of deterioration without disassembling the facilities and equipment and, based on this, classify them into the following three groups:

   High: It is possible to determine deterioration using normal measuring devices.
   Low: It is possible using diagnostic technology.
   None: It is impossible to inspect deterioration without disassembling.

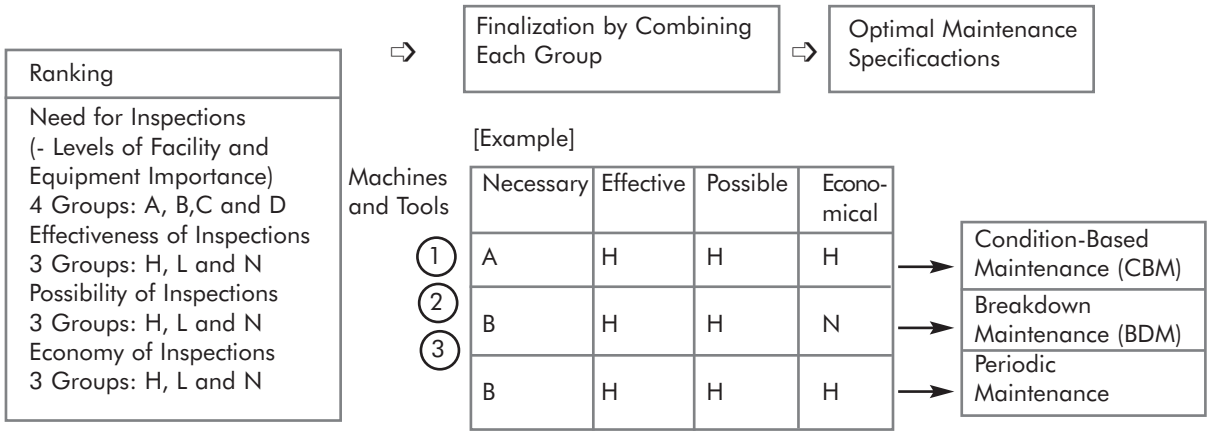
8. *Cost-effectiveness:* Assess the manpower needed for inspection, and classify facilities and equipment into three groups according to cost.

9. Finally, determine the optimal maintenance style on the basis of the four criteria described above. For example, use condition-based maintenance when:
   a. Facilities and equipment need to be inspected a lot.
   b. Inspection proves itself highly effective.
   c. There is a high possibility of inspecting deterioration without disassembling.

d. Inspection will be highly cost-effective.

However, if it is impossible to inspect deterioration without disassembly, periodic disassembly inspections are necessary. When periodic disassembly inspections fail to reveal the necessary information, there is no choice but to conduct breakdown maintenance.

Figure 16.10b Example of the logic behind finalisation of maintenance specifications



Discussion

The following questions ask you to reflect on your company's approach to determining maintenance specifications, and how the ideas in the text could help to improve this. Some of these ideas may not be relevant to you. Concentrate on those that are relevant. Keep notes of your conclusions – you will need them to prepare your action plan afterwards. Where appropriate ask yourself the RADAR questions.

Note: Always include in your discussion any figures referred to in the text, ***if*** you feel these are relevant to your company.

a. Parag. 1: Which styles of maintenance do you normally use? How do you decide which to use, and how frequently to use them?
b. Parag. 2: Why do you think condition-based maintenance is used for equipment and facilities where failures could cause large production losses? And why is breakdown maintenance used when maintenance costs are high?
c. Parag. 3: Try to apply the quantitative method to calculating maintenance costs in your company. How appropriate would it be?
d. Parags. 5, 6, 7 and 8: Discuss how relevant each of these criteria would be to your company, and how you would apply each of them to choosing the most suitable style and frequency of maintenance. Be as concrete and specific as you can.
e. Parag. 9: Decide which style of maintenance you would apply to some of your facilities and equipment.
f. Finally, apply the RADAR questions to these ideas in your company.

Action plan

Take the ideas you have found useful in the text, and in your discussion, and present them in a well-structured action plan for introducing improvements in your company.

16.11 Condition-based maintenance

1. Carry out condition-based maintenance to continuously monitor your more complex facilities and equipment, especially those where failure could lead to large production losses. Use diagnostic machines such as machine checkers and monitors to take continuous measurements. This will enable you to detect at a an early stage any signs of deterioration or any incidents that could lead to failures. Abnormalities and failures will be identified by warning signals or will be spotted during frequent inspections.

2. Keep inspection records: transcribe graphically the values that have been measured onto a chart so that the status of facility and equipment deterioration can be easily recognised. Draft maintenance plans on the basis of these monitoring activities. Record the results and inspect the data either continuously or periodically.

3. Diagnostic technology:
   a. Rotating machines that are often used in manufacturing require precision diagnosis using FFT analyzers.
   b. Vessels, tanks and piping require diagnostic technologies that can identify corrosion and cracks.
   c. Many kinds of thermal insulation devices require diagnosis to determine the degree of deterioration - thermocouples and radiation calorimeters and similar equipment are used for this purpose.
   d. Systems based on artificial intelligence are also now used.

Figure 16.11a Outline of diagnostic technologies used by gas manufacturer

ING Tanks	Vibration	Vibration analysis using artificial intelligence.
BOG Compressors	Abrasion	Sound analysis.
LNG Carburettors	Corrosion	Measurement of the thickness of metallicon films.
LNG Tanks	Leakage	Monitoring of leaks from internal and external tanks.
LNG Piping	Functional Decline	Diagnosis of cold insulation material deterioration.

Discussion

The following questions ask you to reflect on your company's condition-based maintenance system, and how the ideas in the text could help to improve this. Some of these ideas may not be relevant to you. Concentrate on those that are relevant. Keep notes of your conclusions – you will need them to prepare your action plan afterwards. Where appropriate ask yourself the RADAR questions.

Note: Always include in your discussion any figures referred to in the text, ***if*** you feel these are relevant to your company.

a. Parags. 1: Do you often have failures that could cause large production losses? If so, do you have a system for detecting indications of these before they emerge? Does it include any methods of the kind described in this paragraph?
b. Parag. 2: What benefit would it bring you to transcribe the measured values on to a chart?
c. Parag. 3: Which of these forms of diagnostic technology relate to your equipment? Draw up a chart like the one in the example to show the relationship of equipment, signs of decline and diagnostic technology for some of your equipment.
d. Apply the RADAR questions to these guidelines for using condition-based maintenance in your company.

Action plan

Take the ideas you have found useful in the text, and in your discussion, and present them in a well-structured action plan for introducing improvements in your company. You might like to follow the 6-Point Structure. Alternatively you may choose to prepare one action plan when you have discussed several texts.

16.12 Breakdown maintenance

1. However good your management may be, there will always be accidental failures. There are also some facilities and equipment that are so difficult and expensive to inspect that it is best to leave repairs until a failure actually occurs. When a failure does occur, repairs must be carried out immediately to minimize production losses, and also because sudden suspensions can have a major effect on other facilities and equipment. This is breakdown maintenance.

This is breakdown maintenance

2. Breakdown maintenance requires strict management, a constant state of preparedness, an efficient allocation of personnel, procurement of materials, and management of work progress. Follow this procedure:
   a. *Investigate causes and examine countermeasures.* When a failure emerges, investigate the causes and discuss countermeasures immediately. If necessary, disassemble the equipment to assess failed components and the extent of the failure.
   b. *Draft repair plans.* When causes are known and the machines, tools, and parts for repair or replacement have been determined, prepare a repair schedule based on the repairs that have to be done, and the time needed to do them.
   c. *Arrange personnel and material procurement.* Get the staff needed for repair work immediately. Make arrangements for procuring parts and materials as quickly as possible. Depending on how urgent the situation is, consider using goods in stock or goods that have been scheduled for other use.
   d. *Implement repairs and manage their progress.* Use a work process table to manage the progress of repairs.
   e. *Report repair results and keep records.* Once repairs have been completed, collect data on the results and write this up in reports.
   f. *Manage an inventory of repair parts and materials.* It is very difficult to maintain repair parts and materials at all times just to be prepared for sudden failures. However, repairs will be delayed if the right parts are not there, so parts and materials should be ordered from manufacturers in advance, and kept in stock. To decide which to keep in stock, examine the characteristics of facilities and parts, and past records.
   g. *Store repair records* to help with future decisions about appropriate maintenance methods.
   h. *Use PERT* (Programme Evaluation and Review Technique) to manage repairs. (See Text 16.6.)

Discussion

The following questions ask you to reflect on your company's breakdown maintenance, and how the ideas in the text could help to improve this. Some of these ideas may not be relevant to you. Concentrate on those that are relevant. Keep notes of your conclusions – you will need them to prepare your action plan afterwards. Where appropriate ask yourself the RADAR questions.

Note: Always include in your discussion any figures referred to in the text, ***if*** you feel these are relevant to your company.

a. Parag. 1: Do you often have accidental failures? Do you have facilities and equipment that are hard to inspect and where you must wait for a breakdown to occur before you know there is a problem? What kind of system do you have for dealing with failures? How efficient do you think it is? What, if any, are its shortcomings?
b. Parag. 2: Apply the RADAR questions to these guidelines for breakdown maintenance.

Action plan

Take the ideas you have found useful in the text, and in your discussion, and present them in a well-structured action plan for introducing improvements in your company. You might like to follow the 6-Point Structure. Alternatively you may choose to prepare one action plan when you have discussed several texts.

16.13 Recurrence prevention

Introduction

1. When you have removed the results of an abnormality or failure – usually by getting the machinery operating again – you need to investigate the causes and take steps to prevent it happening again. These are recurrence prevention measures. They are also known as corrective actions. The term corrective maintenance is used to refer to the total process of recurrence prevention, planned improvement of facility and equipment functions, extension of their life, and improvement of their reliability, maintainability, operational ease and safety.

Decide on recurrence prevention measures

2. To carry out recurrence prevention take the following actions:
   a. *Classify failures:* Classify failures into categories like the breaking of wires, connection damage, abrasion, and severe deterioration.
   b. *Identify causes and results:*
      i. Analyze the frequency of abnormalities: draw histograms and Pareto diagrams and conduct ABC analysis. (See the seven QC tools in Text 16.16.)
      ii. Analyze the factors behind the abnormalities, using statistical methods like cause and effect diagrams, scatter diagrams and stratification - especially the seven QC tools.
      iii. Investigate the causes by asking basic questions - the 5Ws and 1H questions: who, what, where, when, why and how.
      iv. If necessary, conduct detailed failure analysis: FTA (failure tree analysis) and FMEA (failure mode and effects analysis). (See parag. 4 below.)
   c. *Think of ideas for improvement:* Use brainstorming and other methods to generate a lot of different ideas. (See parag. 3 below.) Try to apply the four improvement principles: eliminate, consolidate, replace and simplify.
   d. *Assess the ideas for improvement and select the best:* Make these ideas as concrete as possible. Estimate how much investment each idea will require and how much improvement can be expected, using simulations and other methods. Select the best idea, keeping in mind ease of implementation and cost effectiveness.
   e. *Authorize and implement the ideas:* Revise the standards to include these ideas, and display them at manufacturing plants and work places. Train everyone who will be implementing the ideas.

Ways of generating ideas for improvement

3. There are several methods that you can use to come up with ideas for improvement:
   a. *Brainstorming:* Everyone puts forward whatever ideas they think of without stopping to evaluate them, and without anyone criticising them. When a lot of ideas have been freely and spontaneously generated in this way, they can then be discussed and assessed. This method is also used to investigate the causes shown in cause and effect diagrams.
   b. *Simulation:* Simulations are experiments that use models, e.g. wind-tunnel airplane performance tests. Simulation involves reproducing the results of abnormalities/failures on computers or on paper and then carrying out quantitative experiments. There are two

main methods: computer simulation and graphic simulation. For example, poor coordination between facility and equipment processing time and the arrival of goods produces stockpiles or idle facilities and equipment. Write this on a simulation chart in order to calculate the waiting time, how often it happens, and how often facilities and equipment are suspended as a result. Then change the facility and equipment capabilities and repeat the calculations in order to determine the optimal capabilities of the facilities and equipment.

c. *Economic Analysis:* Economic analysis considers plant and equipment investment on the basis of, for example, the number of years needed to recover invested capital. When invested capital can be recovered within two years, this particular plant and equipment investment should be considered a good investment.

Methods of failure analysis

4. Failure analysis is systematic research and study conducted to determine what corrective actions are needed. It is based on an examination of the mechanisms of facility and equipment failures, the failure emergence ratio, and their effects.
   a. Failure tree Analysis (FTA) is a technique used to analyze the root causes and ratios of failures by tracing back events and developing a tree-like figure.
   b. Failure mode Effective Analysis (FMEA) is a technique for analyzing the types of failures of constituent parts (failure-phenomena) and their effects on higher items (e.g. facilities, equipment machines, tools, parts, and systems). It identifies incomplete designs and latent defects. The effects of failure types are appraised using such criteria as (1) degree of influence, (2) failure frequency, and (3) failure detection and repair difficulty.

Discussion

The following questions ask you to reflect on the measures your company takes to prevent abnormalities or failures recurring, and how the ideas in the text could help to improve these. Some of these ideas may not be relevant to you. Concentrate on those that are relevant. Keep notes of your conclusions – you will need them to prepare your action plan afterwards. Where appropriate ask yourself the RADAR questions.

Note: Always include in your discussion any figures referred to in the text, ***if*** you feel these are relevant to your company.

a. Parag. 1: What steps does your company typically take to prevent abnormalities or failures recurring? How successful do you think these steps are? Where do you feel there is a need for improvement?
b. Parag. 2: Apply the RADAR questions to these recurrence prevention measures.
c. Parag. 3: Apply the RADAR questions to each of these methods for improving facilities and equipment.

Action plan

Take the ideas you have found useful in the text, and in your discussion, and present them in a well-structured action plan for introducing improvements in your company. You might like to follow the 6-Point Structure. Alternatively you may choose to prepare one action plan when you have discussed several texts.

16.14 Keep maintenance records

Introduction

1. Keep records of maintenance activities and analyze them. There are two main categories of records that you should keep: records of the results of your maintenance activities, and records of the appraisal of your maintenance activities:
   a. Records of maintenance results:
      i. Periodic reports, e.g. daily and monthly failure reports.
      ii. Analytic reports, e.g. maintenance results by manufacturing plants, facilities, and equipment, failure analysis tables and failure statistics by causes.
   b. Appraisal of maintenance activities:
      i. Appraisal of individual maintenance activities, e.g. failure duration per case and inspection cost per day.
      ii. Appraisal of the efficiency of maintenance activities, e.g. maintenance cost per production quantity, and loss from failures per production quantity.

Records of maintenance results

2. Record the totals of:
   a. Duration of failures and production losses.
   b. Maintenance man-days and labor cost.
   c. Cost of repair material and parts.
   d. Inspection equipment cost and others.

Figure 16.14a Failure Analysis Table

Machine and bearing tool name	**Large heating furnace**	**Failure case name**	**Burning and loss of the no. 1 pump of the walking oil pressure apparatus**
Defective apparatus	Pump	[Outline of the failure]	1. The no. 1 pump bearing was damaged due to defective installation of shafts and casings
Failed parts	Vane pump		
Failure phenomenon	Burning and loss	[Contents of action]	1. Improvement of centering accuracy (conduction of centering) 2. Replacement of coupling cushion rubber
Cause of the failure	Defective installation		
Action classification	Emergency action	[Cause of the failure]	1. Defective installation of shafts and casings
Action for recovery	Replacement	[Recurrence prevention]	1. Inspection of casing installation accuracy 2. Periodic inspection of the bearing 3. Management of vibration trends 4. Inspection of the bearing lubrication method

Figure 16.14b Failure Analysis list

Machine and tool name	Date of emergence	Suspension period	Failure result	Action classification	Cause of the failure	Failure case name

Figure 16.14c Facilities and equipment history ledger: records of work history, failure history and remodelling and revisions by facilities and equipment

Process	Facilities and equipment	Apparatus	Machine and tool	Work case name	Work period	Work objective

Figure 16.14d Work History Ledger

Process	Facilities and equipment	Apparatus	Machine and tool	Work case name	Date of starting	Work objective	Man days	Cost

Analysis of Maintenance Results

3. Graphic charts, including bar charts, broken-line charts and pie charts, are very useful for showing signs of improvement. They are part of the Seven QC Tools. (See Text 16.16.)

Figure 16.14e Numbers of failures by cause – bar graph

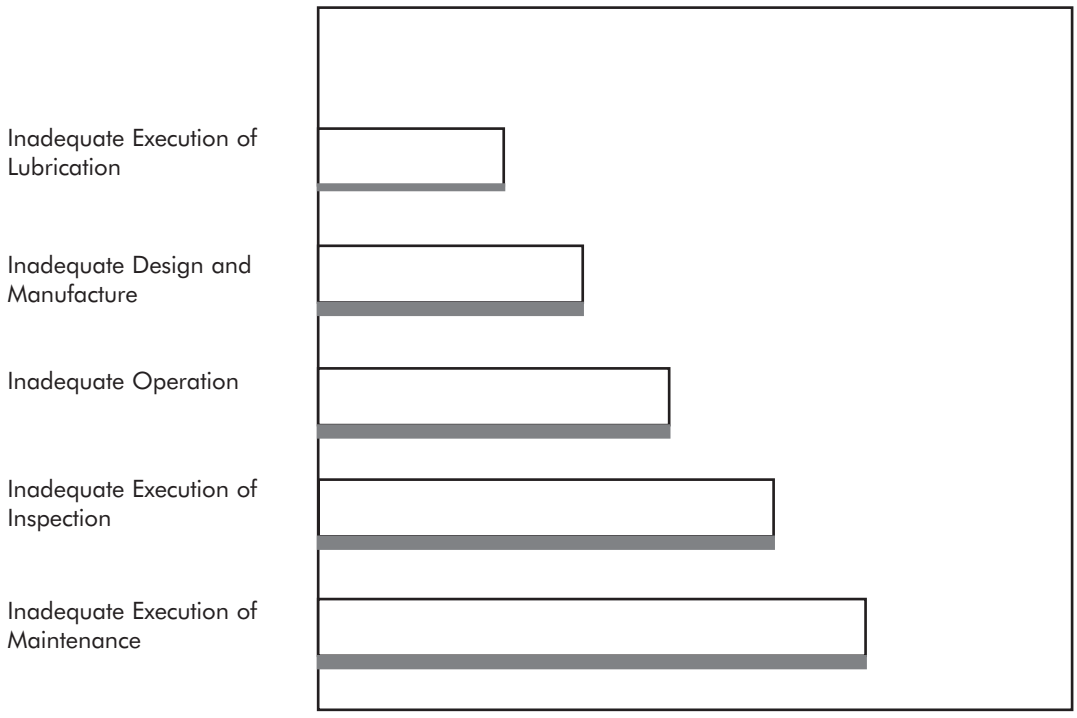
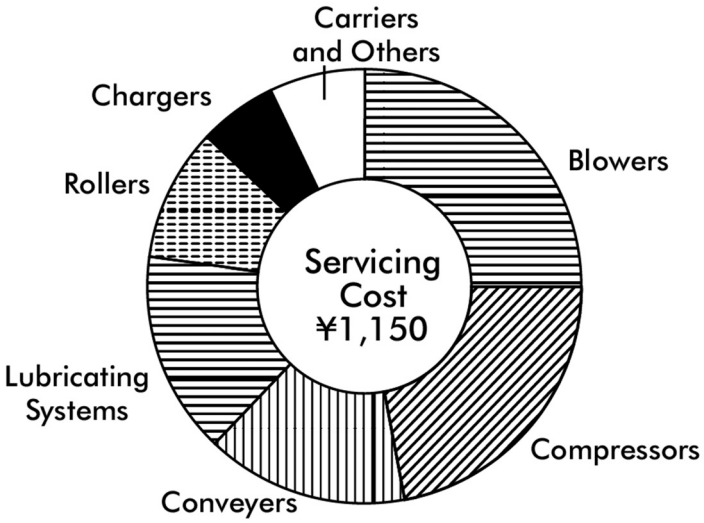


Figure 16.14f Servicing cost by facilities and equipment – pie chart



Appraisal of maintenance activities

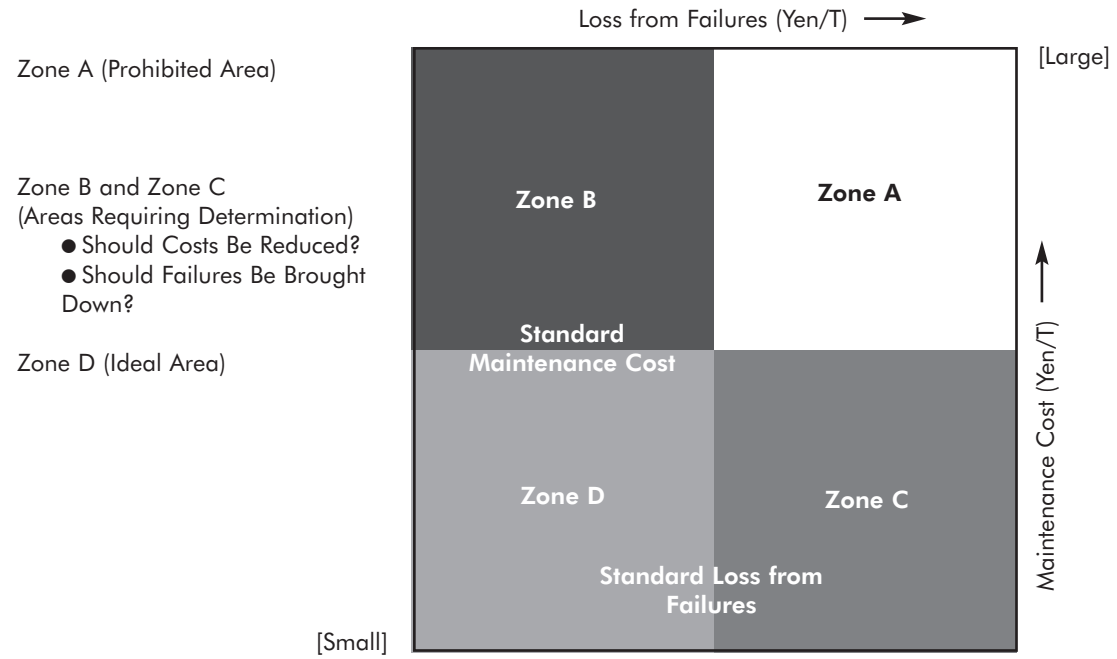
4. It is possible to assess maintenance activities by converting an efficiency index to the diagram below that shows the correlation between maintenance cost and loss from failures. This diagram shows that many figures fall within zones B and C. These zones make it hard to decide whether to reduce failures or keep down maintenance costs. Facilities and equipment in zone A require serious countermeasures. Ideally they should be relocated to zone D.

Figure 16.14g Maintenance activity efficiency index

	April 1989	May 1989	June 1989	July 1989
Inspection and Servicing Cost Repair Cost				
Actual Maintenance Cost				
Production Volume (Tons)				

	April 1989	May 1989	June 1989	July 1989
Suspension Period Number of Suspended Cases	8 10	14 15	19 9	24 21
Actual Production Loss	11584	21989	16339	25705

Figure 16.14h Diagram showing the correlation between maintenance cost and the loss from failures



Discussion

The following questions ask you to reflect on how your company keeps records of its maintenance results, and how the ideas in the text could help to improve these. Some of these ideas may not be relevant to you. Concentrate on those that are relevant. Keep notes of your conclusions – you will need them to prepare your ation plan afterwards. Where appropriate ask yourself the RADAR questions.

Note: Always include in your discussion any figures referred to in the text, ***if*** you feel these are relevant to your company.

a. Parag. 1: What kind of records does your company keep of maintenance results? How complete do you think these records are? Do you make good use of them? Which of them correspond to these categories?
b. Parag. 2 gives different examples of ways of recording results. Apply the RADAR questions to these. If you have enough information at hand, draft similar documents for your own company.
c. Parag. 3 gives two examples of graphic charts. Apply the RADAR questions to using these in your company.
d. Parag. 4: Do you often find it hard to decide whether to reduce failures or keep down maintenance costs? How do you usually decide this? Apply the RADAR questions to using the Maintenance Activity Efficiency Index to help make this decision. If you have enough information at hand, prepare a similar index for your own company.

Action plan

Take the ideas you have found useful in the text, and in your discussion, and present them in a well-structured action plan for introducing improvements in your company. You might like to follow the 6-Point Structure. Alternatively you may choose to prepare one action plan when you have discussed several texts.

16.15 Consider maintenance costs before purchasing new facilities and equipment

Introduction

1. Maintenance costs are a key factor to consider when you are buying facilities and equipment. Even if the purchase cost is low, facilities and equipment can end up being expensive if their maintenance and repair costs are high. Take into account their reliability – how likely they are to have failures, and their maintainability – how easy they are to maintain, and assess the total life-cycle costs. When you have made this assessment, examine the maintenance specifications and decide on the most suitable form of maintenance to use.

Life-cycle costs

2. Life-cycle costs are the entire costs incurred during the lifetime of the facility or equipment, from the start of operation to the point of scrapping. They include:
   a. Purchase costs.
   b. Operational costs, training costs, maintenance costs (inspections, tests, repairs, parts).
   c. Opportunity loss from failures (production suspension and loss of quality).

3. To asses the life-cycle costs you will need the following data:
   a. Performance and specifications of new facilities and equipment.
   b. Reliability data obtained in advance tests.
   c. Reliability data from similar or old facilities and equipment.
   d. Savings to be made from simplifying the maintenance of similar facilities and equipment.
   e. Duration of production suspension of similar facilities and equipment and the effects of this.

   Assess the life cycle costs and then decide on the specifications and maintenance methods that will optimize these costs.

Reliability and maintainability

4. *Reliability* is the quality that enables facilities and equipment to perform the required functions for a fixed period under given conditions. It is indicated by the FTA or FMEA methods (see Text 16.13.4.) based on the life-cycle and number of failures of the facilities and equipment:
   a. Mean time to failure (MTTF): the time for failures to develop in facilities and equipment that have not yet been repaired. This data is not considered.
   b. Mean Time between failures (MTBF): the length of time when repaired facilities and equipment are in operation between failures.

5. *Maintainability* is the quality that enables facility and equipment maintenance to be concluded within a prescribed period under given conditions. The maintenance period, the time required for maintenance (both preventive maintenance and breakdown maintenance), is one of the standards used to evaluate maintainability.
   a. *Repair time* is another phrase in common use. It means the same thing as breakdown maintenance time.
   b. *Mean Time to Repair (MTTR):* the time between the start of repairs and the resumption of function or operation. It includes time for preparation, investigation of failures, arranging and procuring parts, repairs, replacement tests, and cleaning.

6. High reliability and maintainability are especially important with principal facilities and equipment, particularly those whose production and quality are substantially affected by failures. Incorporating these concepts at the design stage is a big part of maintenance prevention.

7. *Availability*. The concept of availability is used as a standard for evaluating how well facilities and equipment functions are maintained. Availability means the amount of time that they are available to be used. It can relate to shortening the repair time, as well as to preventing failures and to maintainability. Availability is generally defined as: Number of failure intervals times (Failure interval + Repair time).

Examine the maintenance specifications

8. When you have assessed the life-cycle costs of new facilities and equipment, taking into account their reliability and maintainability, examine their maintenance specifications as concretely as possible, and decide on the maintenance style, frequency, and method that you will use. Your decision will be largely determined by maintenance cost and the loss of opportunities from failures, and will centre on:
   a. Detailed preventive maintenance for facilities and equipment that would have substantial losses from failures (example: condition-based maintenance).
   b. Rough maintenance and breakdown maintenance for facilities and equipment where maintenance costs are high.

(See Text 16.10.)

Keep records of facility and equipment operations and maintenance results

9. It is essential that you keep operational records and maintenance results for your facilities and equipment, since the analysis and appraisal of these is important for introducing and evaluating maintenance styles. The types of data that should be recorded and stored are:
   a. Operational period by facility, equipment, and line.
   b. Actual failures by facility, equipment, and line.
   c. Actual work by facilities, equipment, and line.
   d. Periodic maintenance results by facilities, equipment, and line (periodic inspection and periodic repairs).

(See also Text 16.14.)

Discussion

The following questions ask you to reflect on your company's approach to purchasing new facilities and equipment, and how the ideas in the text could help to improve this. Some of these ideas may not be relevant to you. Concentrate on those that are relevant. Keep notes of your conclusions – you will need them to prepare your action plan afterwards. Where appropriate ask yourself the RADAR questions.

Note: Always include in your discussion any figures referred to in the text, ***if*** you feel these are relevant to your company.

a. Parag.1: What preparation does your company make before purchasing new facilities and equipment? Do you think it could prepare itself better? Does it take probable maintenance costs into account? If so, how does it try to predict these? Has your company had any experiences of buying cheaper equipment that later became relatively more expensive because of maintenance costs?
b. Examine the definition of "Facility life-cycle costs". Is there anything you would add to it?
c. Parag. 3: Apply the RADAR questions to this method of assessing life cycle costs.
d. Parags. 4, 5 and 6: Examine these definitions of reliability and maintenance. Give some concrete examples of them from your own company.
e. Parag. 7. How would you apply the concept of availability to evaluating the maintenance of some of your equipment or facilities?
f. Parag. 8. Do you keep such records? If so, do you refer to them when you are deciding about new facilities or equipment? How useful is this?
g. Apply the RADAR questions to the ideas in this text.

Action plan

Take the ideas you have found useful in the text, and in your discussion, and present them in a well-structured action plan for introducing improvements in your company. You might like to follow the 6-Point Structure. Alternatively you may choose to prepare one action plan when you have discussed several texts.

16.16 Total preventive maintenance

Introduction

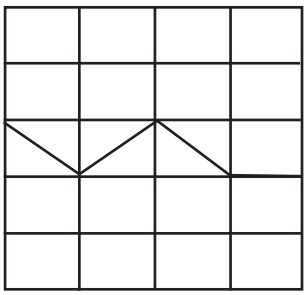
Total preventive maintenance (TPM) means that everyone takes part in maintenance activities. TPM is aimed at investigating and eliminating the causes of abnormalities and failures and preventing recurrence. It involves:

a. Establishing a comprehensive maintenance system that covers the entire lifespan of facilities and equipment.
b. Participation by design, operation, maintenance, and other corporate departments and sections.
c. Participation by every individual, from CEOs to frontline employees. This will lead to
   i. The achievement of goals that could not be attained by one person.
   ii. A sense of solidarity and teamwork.
d. Spontaneous small group activities (e.g. QC circle activities – see Unit 10): employees in the same work places form small groups to resolve familiar problems. The first step is that operators carry out spontaneous maintenance activities like making adjustments to equipment, and carrying out day-to-day inspections. Participants should maintain problem consciousness at all times and be creative in finding solutions to problems.
e. Making active use of statistical techniques to solve problems scientifically, e.g. the Seven QC Tools.

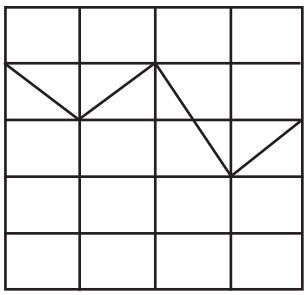
The Seven QC Tools

The Seven QC Tools are valuable statistical techniques. You will find more detailed descriptions of these in Unit 11 Statistics.

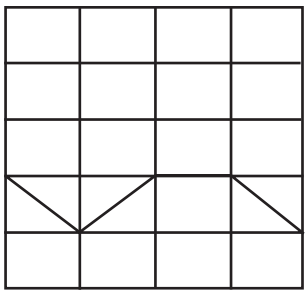
1. **Stratification.** Stratification refers to the division of a population (a data group) into several strata. Collecting stratified data and making comparisons among different strata will provide hints for improving maintenance activities.



Manufacturing Plants
(Total for Lines A and B)

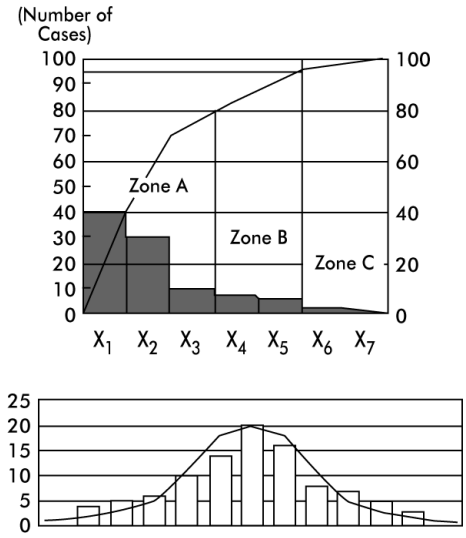


Line A



Line B

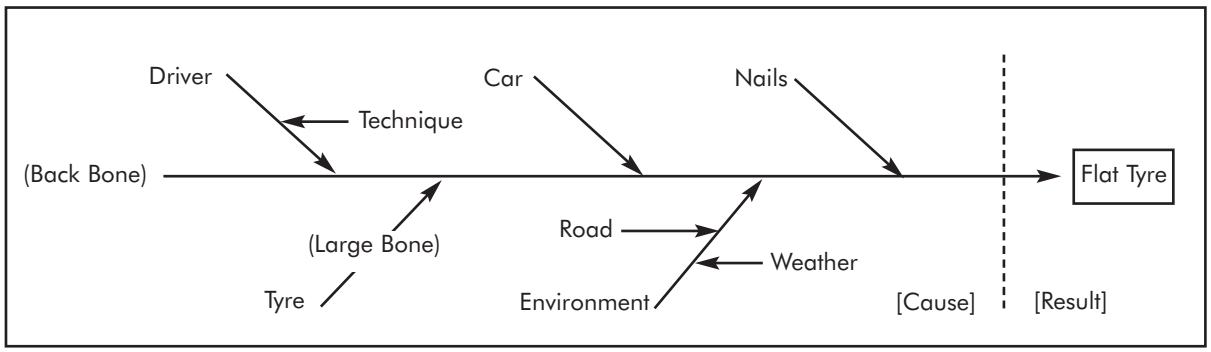
2. Pareto Diagrams. Pareto diagrams show stratified items by order of their emergence frequency. They also indicate the sum of accumulated data.



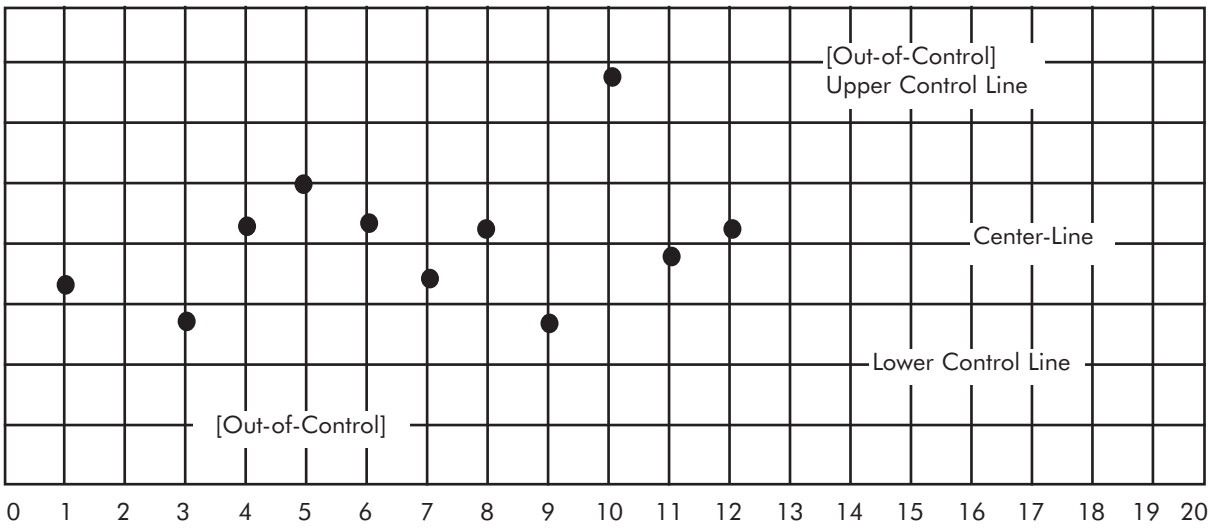
ABC analysis divides the accumulation curve of a Pareto diagram into three zones: zone A (80% of the total), zone B (80% to 95%), and zone C (95% to 100%). Zone A represents important management items.

3. **Histogram.** A histogram is a technique for showing graphically the distribution of numerical values:
   a. Normal distribution – equal distribution from the central point.
   b. Mean value – average value in a population.
   c. Deviation – deviation from the average value.

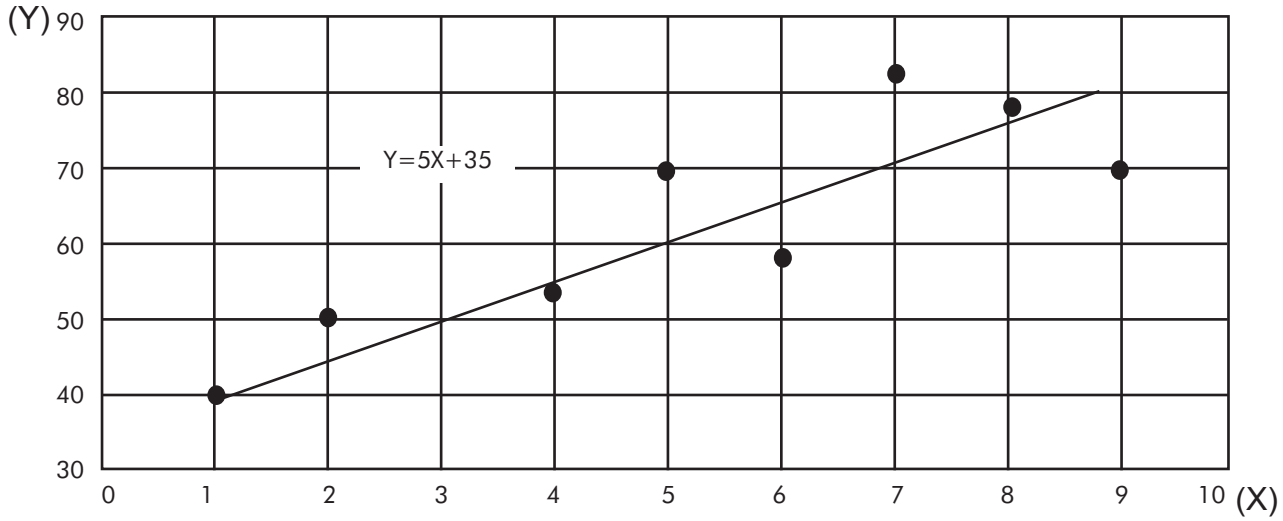
4. **Characteristic Diagrams.** Characteristic diagrams show the relationships between results and factors in a systematic manner. They are also known as fish bone diagrams.



5. **Control Chart.** Control charts are used to inspect facilities and equipment while they are in operation. They are also used to maintain stable conditions. (See Text 9.8 for more details on control charts.)



6. **Scatter Diagram.** Scatter diagrams are figures on which values are plotted to show the correlation between two variables:
   a. Correlation coefficient - standard showing the level of correlation: r = 0.7
   b. Regression line - formula for quantifying the correlation: Y=5X+35



Discussion

The following questions ask you to reflect on your company's overall approach to reducing the need for maintenance, and how the ideas in the text could help to bring improvements these. Some of these ideas may not be relevant to you. Concentrate on those that are relevant. Keep notes of your conclusions – you will need them to prepare your action plan afterwards. Where appropriate ask yourself the RADAR questions.

Note: Always include in your discussion any figures referred to in the text, ***if*** you feel these are relevant to your company.

a. To what extent are the employees and departments in your company involved in preventive maintenance?
b. Parag. 1: Apply the RADAR questions to these ideas for total preventive maintenance.
c. Parag. 2: Examine the description of the Seven QC Tools. Consider how you might apply these in your company.

Action plan

Take the ideas you have found useful in the text, and in your discussion, and present them in a well-structured action plan for introducing improvements in your company. You might like to follow the 6-Point Structure. Alternatively you may choose to prepare one action plan when you have discussed several texts.

Test

Answer these questions using **only** the information given in the text. For each question one, two or all three answers may be correct. Tick the answer or answers you think are correct for each question. Each question carries 3 points – you get one point for each correct answer that you tick, and one point for each wrong answer that you do not tick.

16.1 Keep the workplace neat and clean

1. The first step in maintaining facilities and equipment is to:
   - ☐ a. Carry out regular maintenance activities.
   - ☐ b. Keep the workplace neat and clean.
   - ☐ c. Keep the employees motivated.
2. The 3-S House-keeping campaign is based on the concept of:
   - ☐ a. Employees looking after their own facilities and equipment.
   - ☐ b. Having a special maintenance team to carry out regular checks.
   - ☐ c. Using inspection points.
3. To make the campaign as effective as possible:
   - ☐ a. Hang slogans on the walls.
   - ☐ b. Pay employees extra for carrying out maintenance checks on their machinery.
   - ☐ c. Give recognition to employees who follow these principles.

16.2 Follow the user manual

4. The user manual should include:
   - ☐ a. How to install and assemble facilities and equipment.
   - ☐ b. Methods for making adjustments.
   - ☐ c. Any abnormalities at the time of installation.

16.3 Carry out daily and periodic inspections

5. The daily inspection includes:
   - ☐ a. Inspection at the start of operation.
   - ☐ b. Refueling.
   - ☐ c. Inspection during operation.
6. In daily inspections, typical inspection items can include:
   - ☐ a. Damage to ground wires.
   - ☐ b. Stoppages caused by the absence of operators.
   - ☐ c. Objects that should not be there.
7. In daily inspections use a check sheet on which the inspection items and methods are written:
   - ☐ a. Before the inspection.
   - ☐ b. During the inspection.
   - ☐ c. After the inspection.

8. The choice of inspection items will be based primarily on the effect that the facilities and equipment have on:
   - ☐ a. Product cost.
   - ☐ b. Product quality.
   - ☐ c. Product life.
9. Normal daily inspections will be conducted by:
   - ☐ a. Members of the maintenance section.
   - ☐ b. Specialized inspectors.
   - ☐ c. Operators who know the equipment.
10. Details of the inspection should be entered on:
   - ☐ a. The check sheet.
   - ☐ b. The rules for processing abnormalities.
   - ☐ c. The manager's report.

16.4. Deal with abnormalities

11. Abnormalities can be classified into those that occur:
   - ☐ a. Regularly and periodically.
   - ☐ b. Repeatedly and chronically.
   - ☐ c. Rarely.
12. An abnormality report should include:
   - ☐ a. The type of abnormality.
   - ☐ b. The normal conditions of the facilities and equipment.
   - ☐ c. Possible causes of the abnormality.
13. To decide on permanent measures hold discussions with:
   - ☐ a. Managers, supervisors and operators.
   - ☐ b. Managers, supervisors and those in charge of maintenance.
   - ☐ c. Managers, supervisors, those in charge of maintenance, and technical staff.

16.5 Deal with failures

14. Failures can be classified under:
   - ☐ a. Period of emergence.
   - ☐ b. Cause.
   - ☐ c. Degree of loss of function.
15. When there are serious failures where recovery will take a long time:
   - ☐ a. Carry out repairs at once.
   - ☐ b. Replace parts on the spot.
   - ☐ c. Conduct precision inspection to determine the causes.
16. In processing failures the items to report are:
   - ☐ a. The causes of failure.
   - ☐ b. The cost of production-suspension periods.
   - ☐ c. The date of evaluating countermeasures.

16.6 Manage periodic repairs

17. The primary actions to take in managing periodic repairs are:
   - ☐ a. Draft and schedule repair plans.
   - ☐ b. Assign personnel and allocate materials.
   - ☐ c. Manage the progress of repairs.

18. Drafting repair plans includes:
    - ☐ a. Identifying job activities.
    - ☐ b. Preparing a job network.
    - ☐ c. Increasing the work schedule.

16.7 Manage the procurement of repair parts and materials

19. Some machines, tools or parts may have high priority for repair or replacement because of:
    - ☐ a. The failure rate.
    - ☐ b. The size of production loss in the event of a failure.
    - ☐ c. The cost of purchasing a new machine.
20. In the fixed period ordering method:
    - ☐ a. Fix the ordering interval in advance.
    - ☐ b. Order a fixed number of units whenever the inventory falls to a certain level.
    - ☐ c. Determine the order quantity each time according to the current inventory levels and the quantity required.

16.8. Prioritise maintenance of principal facilities and equipment

21. Decide on the levels of importance of different facilities and equipment with reference to:
    - ☐ a. The effect of a failure on the environment.
    - ☐ b. The frequency of failure.
    - ☐ c. The effect of a failure on safety.
22. The facilities and equipment in Rank A:
    - ☐ a. Usually only have a small number of failures and the costs are low.
    - ☐ b. Usually have a lot of failures but the costs are high.
    - ☐ c. Usually have only a small number of failures but the costs are high.
23. The maintenance measures to be taken for Rank A include:
    - ☐ a. Those in charge of operations carry out daily prioritized inspections.
    - ☐ b. Members of the maintenance section use diagnostic technology to examine facility and equipment conditions.
    - ☐ c. Operators carry out periodic repairs and maintenance work.

16.9 The different forms of maintenance

24. Equipment maintenance refers to activities aimed at:
    - ☐ a. Preventing equipment getting older.
    - ☐ b. Identifying and measuring deterioration.
    - ☐ c. Recovering after deterioration.
25. Maintenance prevention comes under the heading of:
    - ☐ a. Planned maintenance.
    - ☐ b. Productive maintenance.
    - ☐ c. Preventive maintenance.
26. Maintenance prevention means:
    - ☐ a. Preventing problems occurring.
    - ☐ b. Designing facilities and equipment to require less maintenance.
    - ☐ c. Constantly monitoring the conditions of facilities and equipment.

16.10 Decide what form of maintenance to use

27. Which of the following statements are correct?
    - ☐ a. Detailed, condition-based maintenance tends to be used when large production losses could result from failure.
    - ☐ b. Rough breakdown maintenance tends to be used when maintenance costs are low.
    - ☐ c. Periodic maintenance is used most commonly.
28. Use condition-based maintenance when:
    - ☐ a. Facilities and equipment do not need to be inspected frequently.
    - ☐ b. It is difficult to determine deterioration without disassembling.
    - ☐ c. Inspection will be highly cost-effective.

16.11 Condition-based maintenance

29. Condition-based maintenance systems monitor the status of facilities and equipment:
    - ☐ a. Continuously.
    - ☐ b. When their condition deteriorates.
    - ☐ c. At regular intervals.
30. Rotating machines require:
    - ☐ a. Precision diagnosis using FFT analyzers.
    - ☐ b. Radiation calorimeters and similar equipment.
    - ☐ c. Technologies that can identify corrosion.

16.12 Breakdown maintenance

31. The first step to be taken in breakdown maintenance is:
    - ☐ a. Draft repair plans.
    - ☐ b. Arrange personnel and material procurement.
    - ☐ c. Investigate the causes and examine countermeasures.
32. You should:
    - ☐ a. Order repair parts and materials as soon as a failure occurs.
    - ☐ b. Order them when you anticipate a failure might occur.
    - ☐ c. Keep them in stock.

16.13 Recurrence prevention

33. Recurrence prevention is also known as:
    - ☐ a. Corrective action.
    - ☐ b. Corrective maintenance.
    - ☐ c. Permanent maintenance.
34. To analyze the frequency of abnormalities use:
    - ☐ a. Cause and effect diagrams.
    - ☐ b. Scatter diagrams and stratification.
    - ☐ c. Histograms and Pareto charts.
35. Failure Tree Analysis:
    - ☐ a. Analyzes the routes, causes and ratios of failures.
    - ☐ b. Analyzes the failures types of constituent parts.
    - ☐ c. Identifies incomplete designs and latent defects.

16.14 Keep maintenance records

36. The categories of maintenance records include:
    - ☐ a. Analytic reports.
    - ☐ b. Appraisal of individual maintenance activities.
    - ☐ c. Appraisal of maintenance activity efficiency.
37. Which of the following can be used in the analysis of maintenance results to show signs of improvement:
    - ☐ a. Bar charts.
    - ☐ b. Pie charts.
    - ☐ c. Scatter diagrams.

16.15 Consider maintenance costs before purchasing new facilities and equipment

38. Facility life-cycle costs include:
    - ☐ a. Operational costs.
    - ☐ b. Training costs.
    - ☐ c. Production suspension costs.
39. Mean time to failure (MTTF) is:
    - ☐ a. The time for failures to develop in facilities and equipment that have not yet been repaired.
    - ☐ b. The time when repaired facilities and equipment are in operation between failures.
    - ☐ c. The time between repair start and functional recovery.
40. Mean Time to Repair (MTTR) is:
    - ☐ a. The time between breakdown and functional recovery.
    - ☐ b. The time between repair start and functional recovery.
    - ☐ c. The time between beginning and completion of repairs.

16.16 Total preventive maintenance

41. Total preventive maintenance involves:
    - ☐ a. Having absolutely no failures.
    - ☐ b. The CEO taking charge of maintenance.
    - ☐ c. Everyone in the company participating in maintenance.

Relationship with ISO

16.1 Cleanliness
Relationship with ISO 9001:2000:
6.3 Infrastructure
6.4 Work environment

16.2 Follow the User's Manual
Relationship with ISO 9001:2000:
7.5.1 Control of production and service provision
7.5.2 Validation of processes for production and service provision

16.3 Carry out daily and periodic inspections
Relationship with ISO 9001:2000:
7.5.1 Control of production and service provision
7.5.2 Validation of processes for production and service provision
8.5.2 Corrective action
8.5.3 Preventive action

16.4 Deal with abnormalities
Relationship with ISO 9001:2000:
7.5.1 Control of production and service provision
7.5.2 Validation of processes for production and service provision
8.5.2 Corrective action
8.5.3 Preventive action

16.5 Deal with failures
Relationship with ISO 9001:2000:
7.5.1 Control of production and service provision
7.5.2 Validation of processes for production and service provision
8.5.2 Corrective action
8.5.3 Preventive action

16.6 Manage periodic repairs
Relationship with ISO 9001:2000:
7.5.1 Control of production and service provision
7.5.2 Validation of processes for production and service provision
8.5.2 Corrective action
8.5.3 Preventive action

16.7 Manage the procurement of repair parts and materials
Relationship with ISO 9001:2000:
7.4.2 Purchasing information
7.5.1 Control of production and service provision
7.5.2 Validation of processes for production and service provision
8.2.3 Monitoring and measurement of processes

16.8 Prioritise maintenance of principal facilities and equipment
Relationship with ISO 9001:2000:
7.5.1 Control of production and service provision
7.5.2 Validation of processes for production and service provision

16.9 The different forms of maintenance
Relationship with ISO 9001:2000:
7.5.1 Control of production and service provision
7.5.2 Validation of processes for production and service provision
8.5.2 Corrective action
8.5.3 Preventive action

16.10 Decide what form of maintenance to use
Relationship with ISO 9001:2000:
7.5.1 Control of production and service provision
7.5.2 Validation of processes for production and service provision

16.11 Condition-based maintenance
Relationship with ISO 9001:2000:
4.2.4 Control of records
7.5.1 Control of production and service provision
7.5.2 Validation of processes for production and service provision
8.5.2 Corrective action
8.5.3 Preventive action

16.12 Breakdown maintenance
Relationship with ISO 9001:2000:
4.2.4 Control of records
7.5.1 Control of production and service provision
7.5.2 Validation of processes for production and service provision
8.2.3 Monitoring and measurement of processes
8.5.2 Corrective action
8.5.3 Preventive action

16.13 Recurrence-prevention
Relationship with ISO 9001:2000:
7.5.1 Control of production and service provision
7.5.2 Validation of processes for production and service provision
8.2.3 Monitoring and measurement of processes
8.5.1 Continual improvement

8.5.2 Corrective action
8.5.3 Preventive action

16.14 Keep maintenance records

Relationship with ISO 9001:2000:
4.2.4 Control of records
8.4 Analysis of data

16.15 Consider maintenance costs before purchasing new facilities and equipment

Relationship with ISO 9001:2000:
4.2.4 Control of records
7.5.1 Control of production and service provision
7.5.2 Validation of processes for production and service provision
8.2.3 Monitoring and measurement of processes
8.4 Analysis of data

16.16 Total preventive maintenance

Relationship with ISO 9001:2000:
7.5.1 Control of production and service provision
7.5.2 Validation of processes for production and service provision
8.2.3 Monitoring and measurement of processes
8.2.4 Monitoring and measurement of product
8.5.2 Corrective action
8.5.3 Preventive action

Unit 17

Measurement Control

Contents

Unit summary

The purpose of measurement control is to ensure that the right measuring equipment is used to measure, within an acceptable range of precision, the conditions in which your products are manufactured and their quality characteristics. This is essential if your products are to meet the required standards.

17.1 Purchase the right measuring equipment

The first step in making sure that your measurements are correct is to purchase the right measuring equipment.

17.2 Maintain your measuring equipment

When you have purchased the measuring equipment there are a number of steps that you need to take to make sure that it is properly looked after and used correctly.

17.3 Calibrate your measuring equipment

Calibrate all your measuring equipment at appropriate intervals. You may do this in-house or get an outside agency to do it:

a. Establish calibration procedures.
b. Mark the calibration expiry dates.
c. Issue calibration certificates.

17.4 Carry out measurement control

Measurement control is not just the concern of the quality assurance department. It should be carried out in all the departments that have anything to do with measuring, and also in your partner companies.

17.5 Review and improve your measuring equipment and methods

As well as the daily and periodic control checks of individual items of equipment, you need to carry out regular reviews of all your measuring equipment and measuring methods, and to seek ways of improving these.

Learning tools

The RADAR questions

As you read each text you will discuss how it could be applied in your company. The RADAR questions will help you to focus this discussion:

R - Are these ideas **relevant** to my company?
A - How would **I apply** each of them in my company?
D - What **difficulties** might I meet and how would I overcome them?
A - Are there any **additional** actions that I might take that are not mentioned in the text?
R - What **resources** would be needed, what would these cost, and how could they be acquired?

There will of course be some discussion points where not all of these questions will be applicable.

The 6-Point Structure

After you have discussed the ideas in the text, you write an action plan in which you present practical proposals for implementing the conclusions you have reached in your discussion. The 6-Point Structure will help you to write your action plan:

1. **Problems:** Problems you have in your company in the area you have just discussed.
2. **Proposals:** Your proposals for improvement.
   a. Be specific and concrete.
   b. Include an implementation plan, with a time schedule and minimum and optimal implementation targets.
   c. Refer to any forms, charts, tables etc. that you would use, and include samples in an appendix.
3. **Obstacles:** Obstacles to implementation in employee attitudes, company organization and culture etc., and how these could be overcome.
4. **Resources:**
   a. The resources required: funds, equipment, materials, man-hours, expertise etc.
   b. The resources available within the company.
   c. Any resources that would have to be found outside the company.
   d. Alternatives that could be used to cover any shortfall in resources.
5. **Assessment:** Ways of assessing the results of implementing these proposals.
6. **Benefits:** The benefits your proposals would bring.

17.1 Purchase the right measuring equipment

1. The purpose of measurement control is to ensure that the right measuring equipment is used to measure, within an acceptable range of precision, the conditions in which your products are manufactured and their quality characteristics (the specific features of a product that are inspected to evaluate if it is of the right quality). This is essential if your products are to meet the required standards. You must therefore be careful, first of all, to purchase the right equipment.

2. To make sure that you purchase the right equipment:
   a. Read professional books and catalogues.
   b. Select equipment that:
      i. Is appropriate for your manufacturing conditions and product quality characteristics.
      ii. Has the specifications that it is supposed to have.
      iii. Has the required precision.
      iv. Measures as easily as possible.
      v. Measures with a minimum of error.
      vi. Is cost-effective.
   c. Get a clear idea of the procedures and tools for using the equipment correctly.
   d. Get a clear idea of any special precautions that need to be taken:
      i. To avoid damaging the equipment, especially needles and other fine apparatus.
      ii. To keep the measuring error within the specified range.

3. After you have purchased the equipment, inspect it, and then register it in master tables recording the correct calibrations and using a standard format. Keep these master tables and use them at regular intervals to check and maintain the precision of the measuring equipment and measuring methods. (See figure 17.1a on page 6.)

Discussion

The following questions ask you to think about how the ideas in the text could be applied in your company. Some of the ideas may not be relevant to you. Concentrate on those that are relevant. Keep notes of your conclusions – you will need them to prepare your action plan afterwards. Where appropriate ask yourself the RADAR questions.

Note: Always include in your discussion any figures referred to in the text, ***if*** you feel these are relevant to your company.

a. What procedures does your company follow when it wants to purchase new measuring equipment? How successful are these? Where do they need to be improved?

b. Parag. 2 presents several actions to take when purchasing new equipment. Apply the RADAR questions to these.
c. Parag. 2: Apply the RADAR questions to these guidelines for inspecting and registering the new equipment.

Action plan

Take the ideas you have found useful in the text, and in your discussion, and present them in a well-structured plan for introducing improvements in your company. Alternatively, you may include these ideas in one action plan after you have discussed several texts. You might like to follow this 6-Point Structure.

Figure 17.1a Registration of measurement equipment

L/N	ITEM	DATA
1	1 I.D. No.	
2	2 Name	
3	3 Type	
4	Class	
5	Grade	
6	Manufacturer	
7	Model	
8	Mfg Serial No.	
9	Date (manufacture)	
10	Date (purchase)	
11	Unit(s)	
12	Precision	
13	Measurement item(s)	
14	Range of measurement	
15	Calibration interval	
16	Calibration due date	
17	Calibration by	(In-plant or at an outside lab.)
18	Procedure, Calibration Calibration	(Document I.D. No.)
19	Procedure, Measurement Measurement	(Document I.D. No.)
20	Location code of asset	
21	Asset No.	
22	Used at	(Location code)
23	Stored at	(Location code)

17.2 Maintain your measuring equipment

Introduction

1. When you have purchased the measuring equipment you have to make sure that it is properly looked after and used correctly:
   a. Establish procedures for calibrating, maintaining precision, storing and using the measuring equipment.
   b. Record the implementation of control procedures.
   c. Clarify responsibility and authority for measurement control.
   d. Establish procedures for changing the specifications of equipment.
   e. Establish master files.
   f. Give special attention to critical measuring equipment.
   g. Train operators to use the equipment.

Establish procedures for calibrating, maintaining precision, storing, and using measuring equipment

2. To establish these procedures:
   a. Decide on the calibration methods, and how to record the measurement results. (See Text 17.3.)
   b. Decide how to store the equipment in a way that will maintain its precision:
      i. Make sure that it is protected from dust, humidity, rust, and other harmful factors.
      ii. Make sure that it is wrapped up and stored carefully, even when used daily.
   c. Indicate the equipment's expiry date, using Arabic numerals.
   d. Prepare labels to attach to the equipment - labels will differ depending on the system of measuring.
   e. Set procedures for maintaining the precision and functioning of the equipment, and for inspecting, and repairing it.
   f. Establish procedures for dealing quickly with problems.
   g. Prepare manuals which will provide specifications for the purchase, installation, repair, maintenance, and disposal of measuring equipment.
   h. Make sure that everyone follows the rules and procedures for using the equipment, and is alert for any errors that may emerge either in the equipment or in the measurements.

Figure 17.2a gives examples of errors which can occur at the time of measurement (page 9)
Figure 17.2b gives examples of identification labels (page 10)
Figure 17.2c shows an illustration of storage places

Record the implementation of control procedures

3. Record and verify the implementation of each of the control procedures, take corrective action when necessary and record this action. Use recording methods which make it difficult to rewrite records.

Figure 17.2d. Check sheet for implementing control procedures for measuring equipment

Clarify responsibility and authority for measurement control

4. To clarify responsibility and authority for measurement control:
   a. Clarify the responsibility and authority of the department in charge of measurement control.
   b. Document the company's system of measurement control.
   c. Appoint someone to be responsible in each department, and clarify the scope of this person's authority.
   d. Require those in charge to control their own work, and train them to be able to do so.

Figure 17.2e Assignment of control task of measuring equipment

Establish procedures for changing the specifications of measuring equipment

5. You will need to change the specifications of measuring equipment when there are changes in manufacturing conditions, quality characteristics, and the frequency of use of the equipment. To select the right measurement precision after such changes, take account of the purpose, frequency, durability and reliability of the equipment. Then draft and implement the new control procedures.

   You can express the evaluation of the required characteristics of the equipment in scores which can then be used to determine how often the equipment should be inspected.

Figure 17.2f Required characteristics

Establish master files

6. Establish master files that document the purchase, calibration, repair and disposal of measuring equipment. These will provide records that make it easy to find the date of calibration and whether the equipment passed the calibration criteria.

7. Each unit of measuring equipment should have its individual file, marked with its identification number, and containing all relevant data including:
   a. Catalogue and specifications.
   b. Acceptance inspection certificate and calibration certificate.
   c. Reports on out-of-order items, repairs etc.

Figure 17.2g Folder for equipment ID

Give special attention to critical measuring equipment

8. Important measuring equipment that is used as in-house prototypes should be clearly designated and registered:
   a. Calibrate it regularly during its period of validity.
   b. Ensure that the expiry date and place of storage are clearly marked.
   c. Clearly identify it in the master tables (the master records of correct calibration).
   d. Control it to maintain a higher level of precision than other equipment.

Train your operators in using the measuring equipment

9. Measurement operators must understand the measurement objectives and be able to master the measurement skills. To ensure that this:
   a. Provide education and training to operators according to the importance and complexity of their jobs.
   b. Plan and implement individual training programmes.
   c. Include practice as well as lectures in the training programmes.
   d. Use control check data in your training programmes. (See 17.4.6.)
   e. Keep training records and re-train the operators when necessary.

10. It is a good idea to use the results of the analysis of the measurement data from the daily and periodic checks to improve the education and training of your measurement operators. Present it as problems for them to solve. Do follow-up checks on the effectiveness of this. It is important to look on this data as providing problems to be solved.

Figure 17.2h Employee training record
Figure 17.2i Countermeasures report format
Figure 17.2j Outline of a plan for education in measuring equipment

Figure 17.2a Errors in measurement

Errors due to parallax
When the sleeve scale and thimble scale of micrometers are not on the same plane, or when the main scale and vernier scale of vernier callipers are not on the same plane, if the scale lines are not read from the front, a reading error due to parallax occurs. (Parallax is where an object seems to be in different positions if viewed from different positions.)

Errors due to elastic deformation
When an object receives some force from a measuring device, it deforms elastically at the point of contact. Usually this is negligible, but sometimes one needs to keep this possibility in mind.

Errors due to thermal expansion
An object may receive thermal effects in two ways. One is heat generated by machining. The other is the temperature of the environment. The rise in temperature of the object being measured caused by machining affects the precision of machining. When a dimension is measured, the object should be conditioned at room temperature before the measurement is carried out.

Other errors
In addition to these types of errors, you should also take into account humidity, dust, atmospheric pressure, vibration (including vibration of the floor) light, and noise to ensure precise measurements.

Figure 17.2b Identification labels

Classification	Control method	Control department	Label
Measuring equipment maintained or calibrated by specialized department	To be inspected and calibrated according to a periodic inspection plan table	Measuring equipment: department which uses it Precision: specialised department	ID No: Expiry date: Year, month, day ABC Corp., XYZ factory
Measuring equipment to monitor operation of machine and equipment	To be inspected and maintained according to an equipment maintenance plan	User department or maintenance department	ID No: Expiry date: Year, month, day Periodic maintenance, precision inspection
Inspected by a user department	To be inspected periodically (once a year)	User department	ID No: Expiry date: Year, month, day. User department: Precision inspection XYZ factory section
	Daily inspection and periodic inspection	User department	ID No: Expiry date: Year, month, day User department: Function inspection XYZ factory section

Shape and colour of labels should be easily identifiable. Tag, paint, or tape measuring equipment which cannot be labelled.

Discussion

The following questions ask you to think about how the ideas in the text could be applied in your company. Some of the ideas may not be relevant to you. Concentrate on those that are relevant. Keep notes of your conclusions – you will need them to prepare your action plan afterwards. Where appropriate ask yourself the RADAR questions.

Note: Always include in your discussion any figures referred to in the text, ***if*** you feel these are relevant to your company.

a. Parag. 1: How adequate are your company's procedures for maintaining its measuring equipment?
   i. What are typical errors in using measuring equipment in your company? How serious are they? How do you deal with them? Have you experienced any of the errors described in the examples in Figure 17.2a ?
   ii. How effective is your system for storing measuring equipment? Where do you feel it may need to be improved?
b. Parag. 2: Apply the RADAR questions to these proposed procedures for calibrating, maintaining, storing and using measuring equipment.
c. Parag. 3: How effective is your system for recording the implementation of control procedures? Where does it need to be improved?

d. Parag. 3: Look at Figure 17.2d. How relevant would this check sheet be for your company? What changes would you make to it so that it would be suitable?
e. Parag. 4: Apply the RADAR questions to these recommendations. Could you adapt the table in Figure 17. 2e to suit your company?
f. What problems do you experience with measuring equipment when there are changes in the manufacturing conditions? How do you deal with them?
g. Parag. 4: Apply the RADAR questions to these recommendations for changing specifications.
h. Parag. 5: How do you educate and train your measurement operators? How do you think this could be improved?
i. Parags. 6 and 7: Apply the RADAR questions to these suggestions for maintaining master files.
j. Do you use any equipment as in-house prototypes? How do you maintain this or other critical equipment at a high level of precision?
k. Parag. 8: Apply the RADAR questions to these recommendations for looking after critical measuring equipment.
l. Parag. 9: Apply the RADAR questions to these training guidelines.
m. Parag. 10: Apply the RADAR questions to the idea of using control check data to train operators.

Action plan

Take the ideas you have found useful in the text, and in your discussion, and present them in a well-structured plan for introducing improvements in your company. You might like to use the 6-Point Structure. Alternatively, you may include these ideas in one action plan after you have discussed several texts.

17.3 Calibrate your measuring equipment

Introduction

1. Calibrate all your measuring equipment at appropriate intervals. You may do this in-house or get an outside agency to do it:
   a. Establish calibration procedures.
   b. Mark the calibration expiry dates.
   c. Issue calibration certificates.

Establish calibration procedures

2. First decide whether your measuring equipment will be calibrated in-house or by an outside calibration organization. Base this decision on what has to be calibrated, and the time, cost, and personnel needed to do it. When you are carrying out in-house calibration:
   a. Draft your calibration plans in advance.
   b. Decide on a date to calibrate the equipment, after consulting the related departments.
   c. Record the calibration results in calibration certificates and report them to the related departments.
   d. Consult the departments about what measures to take if deficiencies are found.
   e. Recalibrate the equipment when there are any changes in the procedures for calibrating it.

Figure 17.3a Calibration work instruction
Figure 17.3b Measuring equipment calibration instruction

Mark the calibration expiry dates

3. Clearly mark the calibration expiry date on each piece of equipment:
   a. Use labels that are easily identifiable by colour and shape, with different sizes for different sizes of equipment.
   b. Use hallmarking or permanent ink that will not be easily contaminated.
   c. Write in Arabic numerals.

Figure 17.3c Identification labels

Issue calibration certificates

4. Issue calibration certificates which show that the equipment has been calibrated to in-house, external, national or international standards. Certification should relate to the highest level of reference standards (official standards that other standards are based on). The calibration certificates should show:
   a. The calibrating department.
   b. The standards used.

c. The calibration date.
d. The person in charge.
e. What is certified.

5. The department in charge of calibration should not allow the calibration schedule to disturb the manufacturing departments. Give them prior notice in writing and carry out the calibration in a planned manner.

Figure 17.3d Traceability chart
Figure 17.3e History of calibration and repair

Discussion

The following questions ask you to think about how the ideas in the text could be applied in your company. Some of the ideas may not be relevant to you. Concentrate on those that are relevant. Keep notes of your conclusions – you will need them to prepare your action plan afterwards. Where appropriate ask yourself the RADAR questions.

Note: Always include in your discussion any figures referred to in the text, ***if*** you feel these are relevant to your company.

a. What calibration procedures does your company follow? Is the calibration done in-house or by an outside organisation? What are the shortcomings, if any, in your calibration procedures?
b. Parag. 2: Apply the RADAR questions to these guidelines for:
   i. Deciding whether to calibrate measuring equipment in-house.
   ii. Conducting in-house calibration.
   Include Figures 17.3a and 17.3b in your discussion and, if you feel it would be useful, draft similar calibration instructions for calibrating your own equipment.
c. Parag. 3 presents suggestions for marking the expiry date on each piece of equipment. Would these be an improvement on your present system? Decide what kind of system your company should have in future.
d. Parag. 4: Do you already use calibration certificates? What do they show? How would you change them after reading the suggestions in this paragraph? Include Figures 17.3d and 17.3e in your discussion and, if you feel it would be useful, draft similar charts for your own work.
e. Parag. 5: Do the people in your manufacturing departments ever complain that the calibration schedule disturbs their work? What could you do to make sure that you do not disturb them?
f. Does your company maintain master files? If so, what do they show? How useful are they?

Action plan

Take the ideas you have found useful in the text, and in your discussion, and present them in a well-structured plan for introducing improvements in your company. You might like to use the 6-Point Structure. Alternatively, you may include these ideas in one action plan after you have discussed several texts.

17.4 Carry out measurement control

Introduction

1. Measurement control is not just the concern of the quality assurance department. It should be carried out in all the departments that have anything to do with measuring, and in your partner companies.
   a. Carry out measurement control in all the related departments.
   b. Carry out measurement control in your partner companies.
   c. Carry out daily and periodic checks.
   d. Establish procedures for handling problems.

Carry out measurement control in all the related departments

2. All the departments that are involved in measurement should carry out measurement control, and not just the quality control department. This will require:
   a. Knowing the company-wide status of measurement control.
   b. Standardizing the procedures for using and calibrating the equipment in these departments, and training their personnel in these procedures.
   c. Controlling the measuring data, and the handling methods and precision control of the equipment.

Figure 17.4a Organisation of task assignment in the control of measuring equipment

Carry out measurement control in your partner companies

3. Your partner companies should also carry out measurement control. In fact their overall quality assurance system should be of a similar level to yours, since their level of quality often determines the quality of your products. The following steps should be taken:
   a. The department in charge of measurement in your company, in cooperation with your related departments, carry out measurement control in your partner companies.
   b. This department periodically audits the measurement control system in your partner companies.
   c. The related departments in your company provide guidance and assistance on measurement control when deficiencies emerge, or when requested to do so by these companies

Carry out daily and periodic control checks

4. Use daily and periodic checks to maintain the precision of your measuring equipment and to prevent the use of defective equipment. How often these checks are carried out depends on how often the equipment is used, and the reliability required of it. There are several times for checking: daily, before and after use, monthly or every three months.
   a. Periodic check: examine the functions of products or machine, look for deterioration of parts, and restore performance by adjusting the equipment, replacing parts, oiling, or other means.
   b. Daily check: examine all the activities that have to be carried out daily.

c. Procedures: Check the functions and the precision. Get a good understanding of the checking method, and the structure and function of the equipment, and read the manual.
d. Records: Use a format for check sheets that is easy to fill in. It is important to record that the check was carried out.

Figure 17.4b Check sheet: Daily check of micrometer

Establish procedures for handling problems

5. Establish procedures for dealing quickly and efficiently with any measurement problems that arise. Uniform procedures, based on the 5W1H principle (who did what where, when, why and how), will ensure that all operators will handle a problem in the same way. These procedures include:
   a. Get all the facts:
      i. The measuring equipment.
      ii. Identity number.
      iii. Time.
      iv. Place.
      v. Name of employee who discovered the problem.
      vi. The nature of the problem.
      vii. Deficiencies in the measuring equipment etc.
   b. Confirm who the operators should report to.
   c. Label the equipment.
   d. Analyse the problem (damage, wear and tear from usage, deterioration).
   e. Take countermeasures, both temporary and permanent.

   Establish standards for replacement procedures in advance to minimize the effects of replacement on measurement work.

Discussion

The following questions ask you to think about how the ideas in the text could be applied in your company. Some of the ideas may not be relevant to you. Concentrate on those that are relevant. Keep notes of your conclusions – you will need them to prepare your action plan afterwards. Where appropriate ask yourself the RADAR questions.

Note: Always include in your discussion any figures referred to in the text, ***if*** you feel these are relevant to your company.

a. Does your company conduct measurement control in all the departments that do inspections? If yes, how effectively does it do so?
b. Parag. 2: Apply the RADAR questions to these suggestions for implementing company-wide measurement control.
c. Parag. 3: Do you know how well your partner companies conduct measurement control? Do you have any worries about this?
d. Parag. 3: Apply the RADAR questions to these recommendations for ensuring that your partner companies carry out proper measurement control.

e. Parag. 4: Does your company conduct daily and periodic control checks of its measurement equipment? Do you feel that it conducts such checks often enough, and properly?
f. Parag. 4: Apply the RADAR questions to these procedures for conducting daily and periodic control checks.
g. Parag. 5: What kind of measurement problems arise in your company? Do you have an effective system for dealing with them quickly and effectively? What weaknesses are there in this system?
h. Parag. 5: Apply the RADAR questions to these procedures for handling problems.

Action plan

Take the ideas you have found useful in the text, and in your discussion, and present them in a well-structured plan for introducing improvements in your company. You might like to use the 6-Point Structure. Alternatively, you may include these ideas in one action plan after you have discussed several texts.

17.5 Review and improve your measuring equipment and methods

Introduction

1. As well as the daily and periodic control checks of individual items of equipment you need to carry out regular reviews of all your measuring equipment and measuring methods, and to seek ways of improving these. Only if you do this can you be sure of achieving your target level of quality and improving cost-effectiveness:
   a. Carry out periodic reviews.
   b. Develop new in-company methods and equipment.
   c. Use statistical techniques to control and improve quality.

Carry out reviews of your measuring equipment and method

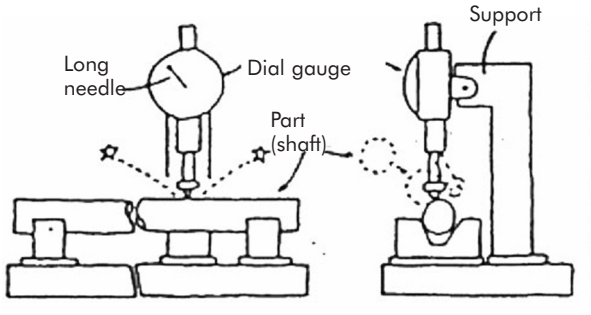
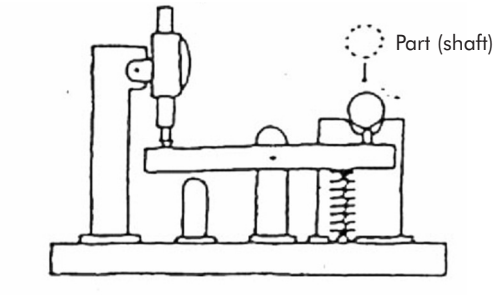
2. To review your measuring equipment and method:
   a. Review and improve:
      i. The measurement precision of drawings and specifications.
      ii. The precision of measuring equipment.
      iii. Measurement conditions.
   b. When the measurement values are abnormal, check the methods and equipment.
   c. Make the necessary improvements after studying other equipment with a higher level of precision and efficiency.
   d. Implement improvements to raise the efficiency of set-up and preparatory operations.

3. Your equipment and methods may be unsatisfactory for technical or procedural reasons:
   a. Technical:
      i. Inappropriate equipment has been selected.
      ii. The design or manufacture of the equipment is inappropriate.
      iii. The precision of the equipment has deteriorated.
   b. Procedural:
      i. Operators lack measurement skills.
      ii. The measurement operation standards are inappropriate.

   Note: Always look for ways of making more fundamental improvements rather than simply taking countermeasures when abnormalities occur.

Figure 17.5a Improvement of detection method
Figure 17.5b Improvement of the use of a dial guage (page 18)

Figure 17.5b Improvement of the use of a dial gauge

Present situation	Improvement
A dial gauge is used to inspect a shaft swing. It breaks often and found frequently defective at periodic inspection.	The method of use of dial gauge has been improved to inspect a shaft swing. Breakage and defective precision has been improved.
Method before improvement	Method after improvement
	
The method before improvement set a shaft laterally. It strikes a spindle and tends to bend it.	In the method after improvement,a shaft is placed from above. So, a spindle cannot be bent. This method will be applied to similar processes to maintain precision of measuring equipment.

[Source: "Measurement control for Management and Managers, 4th ed." (in Japanese), edited by Instrumentation Control Association, Manufacturing Process Measurement, Japanese Standards Association, P 169 (1987)]

Develop new in-company measuring methods and equipment

4. Look for ways to develop new measuring methods and equipment within the company, in particular to deal with:
   a. Problems in the present technology: low precision, high dispersion, high maintenance costs, time-consuming training requirements.
   b. Problems in operations: lack of skills, time-consuming set-up, dangerous handling.

Use statistical techniques to control and improve quality

5. Use statistical techniques to control and improve quality. These will give a better grasp of the issues related to measurement and a better understanding of the problems. They will help to show whether a problem in the relationship between measurement precision and dispersion is caused by the equipment or the method. If the problem is with the measuring equipment, replace it; if it is with the measuring method, revise the method and the operation standard for the method.

Discussion

The following questions ask you to think about how the ideas in the text could be applied in your company. Some of the ideas may not be relevant to you. Concentrate on those that are relevant. Keep notes of your conclusions – you will need them to prepare your action plan afterwards. Where appropriate ask yourself the RADAR questions.

Note: Always include in your discussion any figures referred to in the text, ***if*** you feel these are relevant to your company.

a. How often does your company review its measuring equipment and methods? What does it include in this review? What weaknesses, if any, are there in the way this is done?
b. Parags. 2 and 3: Apply the RADAR questions to these guidelines.
c. Parag. 3: Examine the example given in Figure 17.5b of improving the use of a dial gauge. What can you learn from this that could be applied in your company?
d. Parag. 4: Has your company developed new measuring techniques and equipment? How useful have these been?
e. Parag. 5: Does your company use statistical techniques to control and improve quality? If so, how effective has it been in doing so? How could it do so more effectively in future? What resources would you need in order to do so?

Action plan

Take the ideas you have found useful in the text, and in your discussion, and present them in a well-structured plan for introducing improvements in your company. You might like to use the 6-Point Structure. Alternatively, you may include these ideas in one action plan after you have discussed several texts.

Test

Answer these questions using **only** the information given in the text. For each question one, two or all three answers may be correct. Tick the answer or answers you think are correct for each question. Each question carries 3 points – you get one point for each correct answer that you tick, and one point for each wrong answer that you do not tick.

17.1 Purchase the right measuring equipment

1. The first step when you are going to purchase new equipment is to:
   - ☐ a. Select equipment that has the required precision.
   - ☐ b. Read professional books and catalogues.
   - ☐ c. Get a clear idea of the procedures for using the equipment correctly.
2. The first thing to do after purchasing the equipment is to:
   - ☐ a. Register it.
   - ☐ b. Keep precision records.
   - ☐ c. Inspect it.

17.2 Maintain your measuring equipment

3. Procedures for maintaining measuring equipment include:
   - ☐ a. Determine the calibration methods.
   - ☐ b. Store the equipment where only the person in charge of management control can access it.
   - ☐ c. Make sure that everyone is alert for errors that may occur at the time of measurement.
4. Procedures for maintaining measuring equipment also include:
   - ☐ a. Make sure that everyone follows the rules and procedures.
   - ☐ b. Indicate the expiry date in Roman numerals.
   - ☐ c. Establish procedures for dealing quickly with problems.
5. Prepare manuals which will provide specifications for the ... of measuring equipment.
   - ☐ a. Purchase.
   - ☐ b. Disposal.
   - ☐ c. Exchange.
6. Store calibrated measuring equipment where:
   - ☐ a. Its precision will be maintained.
   - ☐ b. It will be difficult for anyone to get at it.
   - ☐ c. It will be easy to access.
7. To record the implementation of control procedures use recording methods which:
   - ☐ a. Make it difficult to rewrite records.
   - ☐ b. Make it easy to rewrite records.
   - ☐ c. Make it impossible to rewrite records.

8. To clarify the responsibility and authority of the measurement control department:
   - ☐ a. Document the company's system of measurement control.
   - ☐ b. Appoint someone to be responsible in each department.
   - ☐ c. Ensure that the work of those in charge is carefully controlled by senior managers.
9. Establish procedures for changing the specifications of measuring equipment when there are changes in:
   - ☐ a. Manufacturing conditions.
   - ☐ b. Quality characteristics.
   - ☐ c. The frequency of use of the equipment.
10. The master file for each piece of equipment should include:
   - ☐ a. The catalogue.
   - ☐ b. The acceptance inspection certificate.
   - ☐ c. The purchase receipt.
11. With measuring equipment that is used as in-house prototypes:
   - ☐ a. Designate it clearly and register it.
   - ☐ b. Calibrate it only at the beginning and end of its period of validity.
   - ☐ c. Clearly identify it in the master tables.
12. To ensure that measurement operators are able to carry out measurements to the specified precision:
   - ☐ a. Provide education and training according to the complexity of their jobs.
   - ☐ b. Have training that is completely practical.
   - ☐ c. Keep training records and retrain the operators when necessary.
13. When the measurement data is analysed it can be used to:
   - ☐ a. Do follow ups on measurement operators.
   - ☐ b. Improve the education and training of measurement operators.
   - ☐ c. Provide them with sample problems to solve.

17.3 Calibrate your measuring equipment

14. When conducting in-house calibration:
   - ☐ a. Draft calibration plans in advance.
   - ☐ b. Decide on the calibration date before consulting the related departments.
   - ☐ c. Instruct the related departments about what measures to take if deficiencies are found.
15. Clearly mark the calibration expiry date on each piece of equipment:
   - ☐ a. In Arabic numerals.
   - ☐ b. In ink that can be easily erased and rewritten.
   - ☐ c. On labels that only those in charge can identify.
16. Calibration certificates should show:
   - ☐ a. The name of the calibrating department.
   - ☐ b. The standards used.
   - ☐ c. The labels used.

17.4 Carry out measurement control

17. Carrying out measurement control in all the related departments requires:
   - ☐ a. Controlling the measuring data, the handling methods, and the precision control of the equipment.

- ☐ b. Standardizing the procedures for using and calibrating the equipment in these departments.
- ☐ c. Knowing the company-wide status of measurement control.

18. To ensure that partner companies carry out a similar level of measurement control to the parent company:
    - ☐ a. The department in charge of measurement in the parent company should carry out measurement control in the partner companies.
    - ☐ b. The department in charge of measurement in the partner company should periodically audit the measurement control system in the partner companies.
    - ☐ c. The related departments in the parent company should provide guidance and assistance on measurement control when deficiencies arise.
19. How often periodic checks are carried out depends on:
    - ☐ a. How old the equipment is.
    - ☐ b. How often the equipment is used.
    - ☐ c. How reliable the equipment is required to be.
20. Procedures for handling problems include:
    - ☐ a. Get all the facts.
    - ☐ b. Decide on the action to be taken against the employee who caused the problem.
    - ☐ c. Confirm who the operators should report to.

17.5 Review and improve your measuring equipment and methods

21. In carrying out reviews of measuring equipment and methods:
    - ☐ a. Make necessary improvements after studying other equipment with the same level of precision and efficiency.
    - ☐ b. Implement improvements to raise the efficiency of set-up and preparatory operations.
    - ☐ c. Review the measurement precision of drawings and specifications.
22. Unsatisfactory measuring methods may be the result of:
    - ☐ a. Selecting inappropriate equipment.
    - ☐ b. Deterioration in the precision of the equipment.
    - ☐ c. Using equipment of a higher level of precision.
23. New measuring techniques and equipment may be developed within the company to deal with:
    - ☐ a. Problems caused by operators.
    - ☐ b. Problems in the present technology.
    - ☐ c. Problems in operations.
24. Statistical techniques help to:
    - ☐ a. Give a better grasp of the issues related to measurement.
    - ☐ b. Give a better understanding of the problems.
    - ☐ c. Show whether certain problems are caused by the method or the equipment.

Relationship with ISO

17.1 Purchase the right measuring equipment

Relationship with ISO 9001:2000

7.6 Control of monitoring and measuring devices
7.4.1 Purchasing process
7.4.2 Purchasing information

17.2 Maintain your measuring equipment

Relationship with ISO 9001:2000

7.6 Control of monitoring and measuring devices
4.2.3 Control of documents
4.2.4 Control of records
5.5.1 Responsibility and authority
6.2.1 Competence, awareness and training

17.3 Calibrate your measuring equipment

Relationship with ISO 9001:2000

7.6 Control of monitoring and measuring devices
4.2.4 Control of records

17.4 Carry out measurement control

Relationship with ISO 9001:2000

7.6 Control of monitoring and measuring devices
7.5.3 Identification and traceability

17.5 Review and improve your measuring equipment and methods

Relationship with ISO 9001:2000

7.6 Control of monitoring and measuring devices
8.4 Analysis of data
8.5.1 Continual improvement

Unit 18

External Suppliers

Contents

Unit summary

The quality of the products that you are selling on the market will often be determined by other companies - your external suppliers. The raw materials and parts that you receive from your external suppliers will have a major impact on the quality and competitiveness of your products.

18.1 Taking on new external suppliers

Approach the choice of external suppliers with great care:

a. Follow sound procedures in selecting your external suppliers.
b. Give preference to suppliers with a good business record.
c. Carry out an in-depth investigation of potential suppliers. (See 18.2.)
d. Draw up a business contract.
e. Know when to change your external suppliers.

18.2 Carry out an in-depth investigation of potential external suppliers

Before finally selecting an external supplier, carry out an in-depth investigation to make sure that they can deliver goods to the agreed quality on time, and can respond to any changes that you may require:

a. Check the potential supplier's management systems.
b. Assess their production capability.
c. Use quantitative assessment methods to assess their quality capability.

18.3 Inspect supplies on delivery

It is essential that you inspect supplies when they are delivered to see if they meet your requirements:

a. Establish standards for incoming inspection.
b. Prepare an inspection evaluation form for delivered items.

18.4 Assist your external suppliers to maintain and improve quality

Wherever possible you should assist your external suppliers to maintain and improve quality:

a. Encourage your suppliers to put someone in charge of quality control.
b. Encourage them to use small group activities.
c. Exchange information with your suppliers.
d. Encourage them to undertake their own improvements.

18.5 Monitor quality levels in your external suppliers

There are several ways that your company can monitor your suppliers' level of quality:

a. Evaluate your external suppliers and agree on an improvement plan.
b. Keep a record of technical instructions you give your suppliers.
c. Use the standards and a QC process chart to check your suppliers' work.
d. Evaluate the records of goods delivered.

18.6 Maintain a good long-term relationship with your external suppliers

It is important to have a good long-term relationship with your external suppliers. You should:

a. Establish a long-term strategy for maintaining this relationship.
b. Clarify the roles of your support departments.

Learning tools

The RADAR questions

As you read each text you will discuss how it could be applied in your company. The RADAR questions will help you to focus this discussion:

R - Are these ideas **relevant** to my company?
A - How would I **apply** each of them in my company?
D - What **difficulties** might I meet and how would I overcome them?
A - Are there any **additional** actions that I might take that are not mentioned in the text?
R - What **resources** would be needed, what would these cost, and how could they be acquired?

There will of course be some discussion points where not all of these questions will be applicable.

The 6-Point Structure

After you have discussed the ideas in the text, you write an action plan in which you present practical proposals for implementing the conclusions you have reached in your discussion. The 6-Point Structure will help you to write your action plan:

1. **Problems:** Problems you have in your company in the area you have just discussed.
2. **Proposals:** Your proposals for improvement.
   a. Be specific and concrete.
   b. Include an implementation plan, with a time schedule and minimum and optimal implementation targets.
   c. Refer to any forms, charts, tables etc. that you would use, and include samples in an appendix.
3. **Obstacles:** Obstacles to implementation in employee attitudes, company organization and culture etc., and how these could be overcome.
4. **Resources:**
   a. The resources required: funds, equipment, materials, man-hours, expertise etc.
   b. The resources available within the company.
   c. Any resources that would have to be found outside the company.
   d. Alternatives that could be used to cover any shortfall in resources.
5. **Assessment:** Ways of assessing the results of implementing these proposals.
6. **Benefits:** The benefits your proposals would bring.

18.1 Taking on new external suppliers

Introduction

1. The quality of your products will often be determined by other companies – your external suppliers. The raw materials and parts that you receive from them will have a major impact on the quality and competitiveness of your products. You should approach the choice of an external supplier with great care:
   a. Follow sound procedures in selecting your external suppliers.
   b. Give preference to suppliers with a good business record.
   c. Carry out an in-depth investigation of potential suppliers. (See Text 18.2.)
   d. Draw up a business contract.
   e. Know when to change your external suppliers.

Follow sound procedures in selecting your external suppliers

2. The basic procedures for selecting the right external supplier are:
   a. If appropriate, hire an external consultant to assist you.
   b. Collect information about potential external suppliers, both domestic and foreign, from the internet, television, newspapers, speciality publications, etc.
   c. Talk to other departments in your company, especially the sales department.
   d. Use the analysis of information gathered in your company's business activities.
   e. Use cost accounting to decide on your target purchase price. Include the cost of material and parts, labor, and overheads, and a profit estimate.
   (See Figure 18.1a on page 7.)
   f. Keep in mind the factors influencing market price and aim for a competitive price. You may have to consider:
      i. Industrial property rights.
      ii. Compulsory rules and regulations.
      iii. Stable supply capability.
      iv. Exchange rate fluctuations etc.
   g. Ask candidate companies to submit written documents that describe their operations.
   h. Ask representatives of these companies to present and explain these documents in person.
   i. Ask them to submit a written bid to the desired specifications. If necessary, ask them to provide a cost breakdown for the bid.
   j. Ask them to produce a prototype to these specifications and check its quality, to make sure that the company is capable of delivering what it claims.
   k. Carry out an in-depth investigation of your preferred company. (See Text 18.2.)

Figure 18.1a Simple cost accounting

Selling price of finished product	Labor costs	Material costs	Overheads	Profit	Price of goods purchased from external supplier	Target purchasing price
100	20	30	20	10	Part A – 15 Part B – 5	Set lower than the price in the first column

Figure 18.1b 5-level method for evaluating new external suppliers

Items to be evaluated	Company A	Company B	Company C	Company D
Cost	2	2	**4**	1
Design	2	3	**3**	2
Performance	3	5	**4**	2
Service	3	3	**4**	3
Ability to develop	3	3	**4**	2

Result of analysis: Company C was selected

Give preference to suppliers with a good business record

3. It is always good to take suppliers who already have a good business record. This is especially so when purchasing:
   a. Special items and important items.
   b. Items whose defects are likely to be undetected at final inspection, especially parts that are processed or melted into finished goods.
   c. Items that can change in quality over time.
   d. Items for which a quality record must be maintained during the production process.
   e. Items where your supplier has advanced technology, and the product is extremely reliable.

   This will usually mean using the same suppliers, since you already know their capacity and their ability to meet deadlines. However when quality, supply and deadlines are stable in the market, it is alright to select different suppliers on the basis of price.

Draw up a business contract

4. When you have selected your external supplier, draw up and sign a contract with them. This will help to ensure that your relationship with them runs smoothly. The contract should include:
   a. Names, date, term etc.
   b. Specifications.
   c. Price (including necessary molds and dies).
   d. Payment conditions.

e. Deadlines.
f. Quantity (lot structure, planned quantity).
g. Procedure for dealing with defective goods.
h. Conditions for making changes (when there are changes in your product specifications etc.).
i. Checks or audits of your supplier's quality assurance system.
j. Instructions for work that requires a license.

Figure 18.1c Main contract items

Main Contract Items	Main Contract Points
Specifications (documents)	Clarify the engineering requirements.
Price	Clarify quantity, packaging, shipping conditions, etc., to determine the price.
Quantity	Determine the delivery quantity in both normal and emergency conditions.
Deadline	Determine the normal deadline and the deadline for emergencies.
Procedure for dealing with defective goods	Determine the procedure for making contact with the person in charge and countermeasures to be taken when product defects occur.
Conditions for making changes	Determine the response that will be taken when there are changes in the details of the contract.
Checking the quality assurance system	Determine the procedures for conducting audits and submitting data, etc.

Know when to change your supplier

5. Sometimes you may decide to work with new suppliers because of changes in your company policy, or changes in the market. Changes in policy can include:
   a. A decision to enter a new field of business.
   b. A response to new technology and new materials.
   c. A response to changes in the present suppliers, e.g. a decrease in their technological skills or an increase in cost.

   Changes in the market environment may include:
   a. New competitor products.
   b. Changes in customer needs.
   c. Changes in laws and regulations.
   d. Increased price competition.

Discussion

The following questions ask you to think about how the ideas in the text could be applied in your company. Some of these ideas may not be relevant to you. Concentrate on those that are relevant. Keep notes of your conclusions – you will need them to prepare your action plan afterwards. Where appropriate ask yourself the RADAR questions.

Note: Always include in your discussion any figures referred to in the text, ***if*** you feel these are relevant to your company.

a. Parag. 2: What procedures do you use for selecting external suppliers? How effective are they? Where do you feel there are weaknesses in your system?
b. Parag. 2: Does your company have any problems keeping its prices competitive because of what it has to pay for its supplies? How would you normally determine the purchase price?
c. Parag. 2 presents basic procedures for selecting external suppliers. Apply the RADAR questions to these.
d. Figure 18.1b shows a method for evaluating potential new suppliers. Apply the RADAR questions to the possibility of using this method in your company.
e. Parag. 3: Do you normally give priority to suppliers who already have a good business record? Or is price more important? Do any of the supplies that you purchase fit into any of these categories? If so, and if your priority has always been the price of supplies, would you now consider reviewing your choice of supplier?
f. Parag. 4 lists points to include in the contract. Apply the RADAR questions to these points. Include the example in Figure 18.1c in your discussion, and, if possible, suggest examples of your own.
g. Parag. 5a: Has your company made any changes in its policies in the last few years? Have any of these changes required you to change your external suppliers? If you did not change your supplier, do you now think it would have been a good idea to change them?
h. Parag. 5b: Have there been any changes in your market environment? Did you change suppliers as a result? If not, would it have been a good idea to do so?

Action plan

Take the ideas you have found useful in the text, and in your discussion, and present them in a well-structured plan for your company. Alternatively you may choose to prepare one action plan when you have discussed and completed 18.2. You might like to follow the 6-Point Structure.

18.2 Carry out an in-depth investigation of potential external suppliers

Introduction

1. Before finally selecting an external supplier, carry out an in-depth investigation to make sure that they can deliver goods to the agreed quality on time, and can respond to any changes that you may require:
   a. Check your potential supplier's management systems.
   b. Assess their production capability.
   c. Use quantitative assessment methods to assess their quality capability. (You should also carry out an in-depth investigation of your present suppliers, if you have not already done so.)

Check your potential supplier's management systems

2. Check that they can:
   a. Respond immediately to any changes that you may make in your product specifications or design.
   b. Respond to quality audit requests.
   c. Provide the necessary job training.
   d. Continuously increase their technological know-how as they supply more and more orders.

Assess your potential supplier's production capability

3. Assess their:
   a. Production resources: their equipment, personnel, warehouse space and layout, processing methods etc.
   b. Inspection and control systems:
      i. Their system for inspecting their own incoming supplies.
      ii. Their lot control and inventory control.
      iii. Their testing equipment and their management of it.
      iv. Their control of their reliability equipment*.
      v. Their finished goods inspection.
   c. Capability to handle abnormalities:
      i. To detect abnormalities.
      ii. To respond immediately to abnormalities and to report their occurrence.
      iii. To identify and record the cause of abnormalities.
      iv. To decide on countermeasures, and check the results of the countermeasures.
   d. Engineering response capability:
      i. To analyse the causes of defects and to take the necessary countermeasures.
      ii. To respond to requests for changes to specifications.
      iii. To adapt to new materials, equipment and technology.

(*Reliability equipment shows the probability of an item performing a required function under given conditions and in a given period of time.)

Figure 18.2a Criteria for evaluating external suppliers

Items	Evaluation by	a	b	c
1. How well are bonus penalty deadlines met?	Bonus penalty monthly production	+2% or more 30 points	Other than a or c 20 points	-20% or less 10 points
2. Inspection passage rate	Monthly inspection report	98% or more 30 points	98% or more 20 points	Other than a or b 10 points
3. Dependability	6 months fixed (manager for supplier)	80% or more 20 points	Other than a, c 10 points	40% or less 0 point
4. Cooperation	(person responsible for supplier)	Fair 20 points	Normal 10 points	Poor 0 point

Bonus Penalty System:
Outline

Delivered on time	% of Total Production Amount	5% bonus
Delivered up to 2 days late	% of Total Production Amount	1% penalty
Delivered 3 days late or later	% of Total Production Amount	5% penalty

The payment of a bonus, however, is based on the condition that the passage rate at inspection is 95% or higher. Delivery time is evaluated based on the date indicated by the inspection stamp.

Use quantitative assessment methods to assess the supplier's quality capability

4. Quantitative assessment methods are a very effective way of checking that their production system is capable of providing quality goods. (This is where assessment is based on items or features that can be counted.)
   a. Check their organizational chart showing the relationship between various individuals, equipment, and the transport system, etc.
   b. Generate a QC process chart showing how their production process is controlled.
   c. Be aware of their process capability (Cp) index for important quality characteristics.
   d. Clarify who is in charge of handling quality issues and changes in the production process.
   e. Analyze the daily log of production activity and use it in the Kaizen (continuous improvement) process.

Figure 18.2b A QC process chart for blower assembly

Discussion

The following questions ask you to think about how the ideas in the text could be applied in your company. Some of the ideas may not be relevant to you. Concentrate on those that are relevant. Keep notes of your conclusions – you will need them to prepare your action plan afterwards. Where appropriate ask yourself the RADAR questions.

Note: Always include in your discussion any figures referred to in the text, ***if*** you feel these are relevant to your company.

a. Parag. 2 suggests points to check in a supplier's management systems. Apply the RADAR questions to using these checkpoints in relation to one of your suppliers, past, present or potential.
b. Parag. 3. Apply the RADAR questions to using these check points on one of your suppliers.
c. Parag. 4 gives quantitative assessment methods that can be used to check the supplier's quality capability. Apply the RADAR questions to using these methods.

Action plan

Either include the ideas you have just discussed in a combined action plan for 18.1 and 18.2, or prepare a new action plan based only on the ideas you have just discussed in this text on improving the way your company investigates new or current external suppliers. You might like to follow the 6-Point Structure.

18.3 Inspect supplies on delivery

Introduction

1. It is essential that you inspect supplies when they are delivered to see if they meet your requirements. To do this effectively you need to:
   a. Establish standards for incoming inspection.
   b. Prepare an inspection evaluation form for delivered items.

Establish standards for the procedures to be used in this inspection

2. To establish these standards:
   a. The department in charge produces a draft plan for standards for incoming inspection.
   b. Related internal departments meet to discuss the plan and make any necessary changes.
   c. A meeting is held with your external supplier to discuss this plan.
   d. Final standards are submitted to those in charge for approval.
   e. The results of the incoming inspections are monitored and, if necessary, the standards are revised.

Figure 18.3a Standards for incoming inspection (page 15)

Prepare an inspection evaluation form for delivered items

3. Prepare an inspection evaluation form to record the inspection of incoming goods. This form should include:
   a. The inspector's name and license.
   b. The name of the person in charge.
   c. The date of inspection.
   d. The inspection data: compliance with the required specifications, lot size, selection method for inspection, and evaluation results.
   e. The inspection method (accuracy, inspection devices, and calibration data etc.)

   This information should be entered in the form at the time of delivery. If any nonconformities are found, contact your supplier. Keep the records on file so that any changes in quality while the items are in storage (e.g. rust) can be traced.

Discussion

The following questions ask you to think about how the ideas in the text could be applied in your company. Some of the ideas may not be relevant to you. Concentrate on those that are relevant. Keep notes of your conclusions – you will need them to prepare your action plan afterwards. Where appropriate ask yourself the RADAR questions.

Note: Always include in your discussion any figures referred to in the text, ***if*** you feel these are relevant to your company.

a. What kind of inspection does your company carry out on incoming supplies? How effective is it? How could it be made more effective?
b. Parag. 2 describes how to establish standards for the procedures to be followed in incoming inspections. Apply the RADAR questions to these guidelines.
c. Prepare a draft standard for one of the inspections that you have to carry out. Look also at the sample standard in Figure 18.3a and decide if it would be a suitable model for your company - perhaps with some changes.
d. Parag. 3 suggests points to include in an Inspection Evaluation Form for Delivered Items, and procedures for using this form. Apply the RADAR questions.

Action plan

Draw up an action plan for improving the way your company inspects incoming supplies, based on the discussions you have just had. Alternatively you many include this in an action plan that covers the ideas in several texts. You may like to use the 6-Point Structure.

Figure 18.3a Standards for incoming inspection

Standard No.1905
Date received: Incoming Lot No. Inspected Date:
Item Name: Switch Inspector:
Part No. Inspection Location:
Series No. Approved Diagram No.

Inspection Items		**Inspections Standards**	**Evaluation**
Appearance		No scratches, dents, deformities, or discoloration	OK,NG
Size	Length	50 mm :t 2	OK,NG
	Height	25 mm :t 1	OK,NG
	Width	25 mm :t 1	OK,NG
Weight		90 g:t 5	OK,NG
Terminal	Size	JIS-90001	OK,NG
	Fitting conditions	Terminal is firmly secured	OK,NG
	Direction	90 degrees	OK,NG
Spring tension	Functionality	Smooth operation	OK,NG
	Operation noise	No abnormal noise	OK,NG
	Play, rattle	No excessive play or rattle	OK,NG
	Fitting conditions	Mounted in the correct position	OK,NG
Distance between conjunctions	Interval	15 mm +/- 0.5	OK,NG
	Parallelism	0.5 mm	
Dust cover	Gasket fitting condition	No protrusions	OK,NG
	Screw tightness	Not too tight	OK,NG
	Condition at point of contact	No rattle at contact position	OK,NG
Electrical conductivity test	On-off operation	Lever operation is smooth	OK,NG
	Conductivity	Stable current is maintained	OK,NG
	Generation of heat	No excessive heat	OK,NG

Overall evaluation; OK, Fail, Special evaluation (with the following conditions:)

18.4 Assist your external suppliers to maintain and improve quality

Introduction

1. Wherever possible you should assist your external suppliers to maintain and improve quality:
   a. Encourage your suppliers to put someone in charge of quality control.
   b. Encourage your suppliers to use small group activities.
   c. Exchange information with your suppliers.
   d. Encourage them to undertake their own improvements.

Encourage your suppliers to put someone in charge of quality control

2. Someone in each supplier company should be put in charge of quality control. This should be someone in a position of authority who can quickly grasp any quality problem that may arise, and act immediately to deal with it. Follow this procedure:
   a. Your supplier voluntarily puts someone in charge of quality control, and informs you of their name, position, emergency contact number, etc.
   b. You communicate directly with this person about quality issues.
   c. You contact this person in an emergency and ask them to deal with the matter at once.
   d. When the matter is resolved this person reports the results of the measures taken both to you and to any of your internal departments that are involved.
   e. Have a list of the names of the people to be contacted in an emergency and how to get in touch with them.
   f. Give practical support to the person in charge of quality.

Figure 18.4a Abnormality Countermeasures Request Form

Encourage your suppliers to use small group activities, including QC circles

3. Encourage your supplier to use small groups, such as QC circles, to target specific areas for improvement. Your supplier should:
   a. Get all its departments to participate.
   b. Establish an administrative organization for the entire company and register the QC circle name, the number of members, the theme, etc.
   c. Keep a record of the frequency with which activities are carried out, the number of problems solved, and the number of presentations etc., by each circle.
   d. Get the board of directors to attend and evaluate the presentation of results. They should evaluate each presentation in detail, and always include both positive and negative comments.
   e. Award prizes for specific successful themes.

Figure 18.4b QC Activity Report from external suppliers

(See Unit 10 for detailed guidelines on introducing QC circles.)

Exchange information with your suppliers

4. It will benefit both you and your supplier to exchange information. This can include information about:
   a. Changes in the allocation of work.
   b. Changes in the allocation of responsibility.
   c. Technological development.
   d. Cost reductions.
   e. Analysis of defects.
   f. Analysis of the complaint resolution system.
   g. Improvements to the production methods.
   h. Job training programs.

   Exchange information regularly, keep a detailed record, and review any implementation that is based on this exchange. Be careful that vital know-how is not leaked to third parties.

Figure 18.4c Meeting to resolve a problem

Encourage your external suppliers to undertake their own improvements

5. Encourage your external suppliers to undertake their own improvements so that they can produce high quality goods independently of your company. Encourage them specifically to:
   a. Become more aware of their current situation, problems etc.
   b. Make decisions about practical improvement plans, the methods for implementing these plans, and who will deal with any problems that arise.
   c. Carry out their own evaluation of the implementation results.
   d. Continually create and implement new plans.

   Give your suppliers very positive support in doing this, and analyse and assess the results of the evaluations that they carry out.

6. The success of an external supplier in becoming more independent will be seen in the number of prizes they receive, their issuance of public shares, and their receipt of an order from a public body.

Figure 18.4d Audit of supplier company

Discussion

The following questions ask you to think about how the ideas in the text could be applied in your company. Some of the ideas may not be relevant to you. Concentrate on those that are relevant. Keep notes of your conclusions – you will need them to prepare your action plan afterwards. Where appropriate ask yourself the RADAR questions.

Note: Always include in your discussion any figures referred to in the text, if you feel these are relevant to your company.

a. Parag. 1: How does your company support your external suppliers in maintaining quality? In what ways could you give more support?
b. Parag. 2 presents procedures for your supplier company to put someone in charge of quality control. Apply the RADAR questions.
c. Parag. 3: How practical would it be for you to encourage your suppliers to use small group activities, such as QC circle activities? How useful do you think they would be in achieving improvements in specific areas. If you think they could be useful, investigate them in more detail in Unit 10.
d. Parag. 4: Does your company exchange information with your suppliers? If so, is this useful? If you do not, do you think it would be a good idea to do so?
e. Parag. 4 suggests various categories of information that could be exchanged, and procedures for exchanging information. Apply the RADAR questions.
f. Parag. 5: Would it be appropriate for you to encourage your external suppliers to undertake their own improvement activities? Apply the RADAR questions to these guidelines.

Action plan

Draw up an action plan for improving the way your company supports its external suppliers in improving quality, based on the discussions you have just had. Alternatively you may choose to prepare one action plan when you have discussed several texts. You might like to follow the 6-Point Structure.

18.5 Monitor quality levels in your external suppliers

Introduction

1. There are several ways that your company can monitor your suppliers' level of quality.
   a. Evaluate your external suppliers, and agree on an improvement plan.
   b. Keep a record of any technical instructions you give them.
   c. Use the standards and QC process chart to check their work.
   d. Evaluate the records of goods delivered.

Evaluate your external suppliers

2. Use the Supplier Evaluation Form to carry out an evaluation of your external supplier:
   a. As far as possible, use hard data, dividing items into categories of quality, production control, deadlines, etc.
   b. Agree with your supplier on an improvement plan to deal with any weak points that are found.
   c. Work with your supplier in carrying out the improvement plan; provide instructions on site.
   d. Check the results of the improvement plan and see if it can be further improved.
   e. Do all of this in a fair and courteous manner.

Figure 18.5a Supplier Evaluation Form

Item No.	Item	Evaluation A B C D E *	Detailed contents
1	Has a qualtiy assurance system been established?		
2	Has a method been clearly established for handling defective goods?		
3	Is a clear identification mark used when defective goods occur?		
4	Are customer claims being handled immediately?		
5	Is there an effective system in place to prevent recurring defects?		
6	Is there sufficient inspection prior to shipment?		
7	Is there a system to protect goods during transportation?		
8	Are the goods being protected from deterioration?		
9	Do the goods satisfy the customer's engineering requirements?		
10	Are the total needs of the customer being immediately satisfied?		

* A: 100-90 points, B: 89- 70 points, C: 69-50 points, D: 49-30 points, E: 29-20 points

Keep a record of any technical instructions you give your suppliers

3. Keep a record of any technical instructions for corrective action that you give your suppliers, so that you can be sure that these are carried out effectively. This record should include:
    a. Location and date of the instruction.
    b. Names of the instructor and the trainees.
    c. Analysis of the current situation with a plan for improvement.
    d. Items included.
    e. Future schedule.
    f. Expected result.

Figure 18.5b Quality Audit Record

Use the operation standards and QC process chart to check your supplier's work

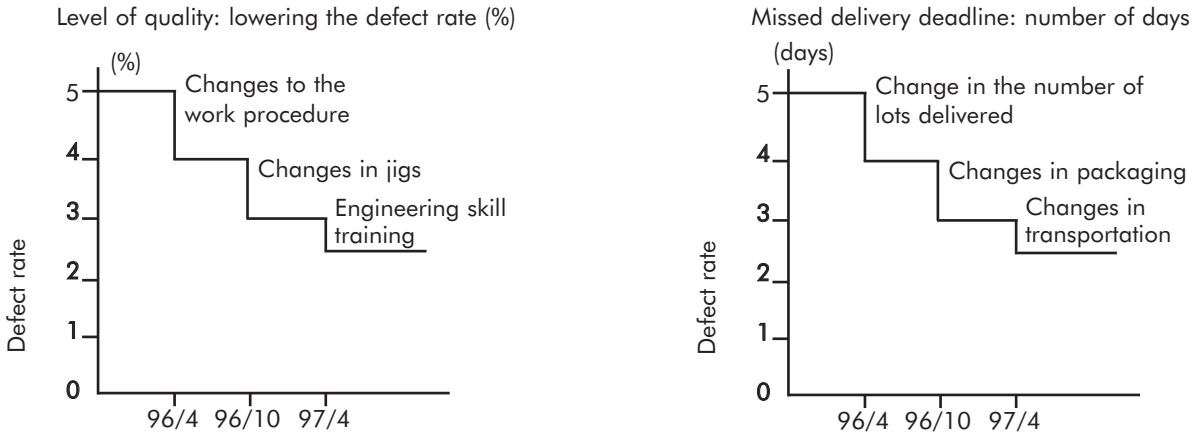
4. Use the operation standards and QC process chart to confirm that your supplier is carrying out each process correctly and maintaining the production flow. Use the appropriate standard for each individual employee and the quality verification points (predetermined points where quality can be verified). The procedure is as follows:
    a. Confirm the most recent operation standards and the QC process chart.
    b. Confirm that each process and each piece of work is being carried out as specified in the most recent version.
    c. Match the actual work to the standards and the chart, and find the reasons for any differences.
    d. Take corrective action where appropriate. This could involve revising the standards.
    e. Give instructions for a more effective (i.e. a more simplified) approach.
    f. Create a Kaizen improvement schedule and check that it is being carried out.
    g. Confirm that the production process is in accordance with the flow in the QC process chart.

Figure 18.5c Paint finishing process check procedure

Evaluate the record of goods delivered

5. Regularly evaluate the records of goods delivered:
    a. Evaluate each delivery with reference to the contents of the Record of Inspection of Delivered Goods (the number of returns, re-workings etc.)
    b. Regularly evaluate the level of quality, (acceptance rate by lot, defect rate by lot), the rate of late delivery (number of days late by lot), and the quantity delivered (by lot and total).
    c. Evaluate your supplier's handling of complaints:
        i. The number of days required to resolve complaints.
        ii. The details of complaints.
        iii. The procedure for resolving complaints.
        iv. Actions taken to prevent similar complaints being made again.

Figure 18.5d Regular evaluation of quality, quantity, and deadlines at the external supplier



Discussion

The following questions ask you to think about how the ideas in the text could be applied in your company. Some of the ideas may not be relevant to you. Concentrate on those that are relevant. Keep notes of your conclusions – you will need them to prepare your action plan afterwards. Where appropriate ask yourself the RADAR questions.

Note: Always include in your discussion any figures referred to in the text, ***if*** you feel these are relevant to your company.

a. Parag. 1: What does your company do to monitor your suppliers' level of quality? How effective is this? What more could you do?
b. Parag. 2: The Supplier Evaluation Form can be used to evaluate quality in your supplier company. Would this form be suitable for your company to use with your external suppliers? Apply the RADAR questions to the idea of using this form.
c. Parag. 2 also suggests steps to take to correct a supplier's weak points. Would these be suitable for your suppliers? Apply the RADAR questions to these suggestions.
d. Parag. 3: How important do you think it is to keep a record of any technical instructions you give to your supplier? Are there any other items you would add to those in the list? Look at Figure 18.5b, the sample Quality Audit Record. Recall any instructions you have needed to give a supplier and consider if this would be a good way of recording them.
e. Parag. 4: Apply the RADAR questions to putting these guidelines into practice with one of your suppliers.
f. Parag. 5 suggests three areas to evaluate in the records of goods delivered. Apply the RADAR questions to these.

Action plan

Draw up an action plan for improving the way your company supports quality in its external suppliers, based on the discussions you have just had. Alternatively you may choose to prepare one action plan when for your discussions of several texts. You might like to follow the 6-Point Structure.

18.6 Maintain a good long-term relationship with your external suppliers

Introduction

1. It is important to have a good long-term relationship with your external suppliers. You should:
   a. Establish a long-term strategy for managing your suppliers.
   b. Clarify the roles of your support departments.

Establish a long-term strategy for managing your suppliers

2. Establish a long-term strategy for managing your suppliers. The primary objectives of this strategy are to:
   a. Maintain and improve quality in your suppliers.
   b. Ensure that the correct production volume is achieved.
   c. Shorten deadlines.
   d. Utilize the specific technology of your supplier (plating, special processing etc.).
   e. Reduce production costs.

3. This strategy should include:
   a. A plan for personnel development.
   b. Technical instructions.
   c. A quality audit.

   Good management of your external suppliers will help both you and them to grow and prosper together.

Figure 18.6a Utilizing external suppliers (page 24)

Clarify the roles of your support departments

4. Decide which department in your company is responsible for managing your external suppliers, and which other departments should provide support. Define their roles, functions and responsibilities. The typical roles of the different support departments are:
   a. Procurement department: Reduce cost, and control inputs and outflows of purchased raw materials and parts.
   b. Manufacturing Department: Transfer management technology for more efficient production to your suppliers, e.g. techniques, know-how, management methods, etc.
   c. Engineering and Design Department: support the supplier when there are changes to specifications and improvements in technology.
   d. Quality Assurance Department: inspect the lot structure, provide inspection procedures (for inspecting appearance, for creating boundary samples, and for giving training in QC methods).

Remember that if your external supplier is to have the correct know-how it is essential that they receive proper instruction.

Figure 18.6b Department roles in supporting external suppliers (page 24)

Discussion

The following questions ask you to think about how the ideas in the text could be applied in your company. Some of the ideas may not be relevant to you. Concentrate on those that are relevant. Keep notes of your conclusions – you will need them to prepare your action plan afterwards. Where appropriate ask yourself the RADAR questions.

Note: Always include in your discussion any figures referred to in the text, ***if*** you feel these are relevant to your company.

a. Parag. 1: Does your company have a long-term strategy for managing its suppliers? If it does, what kind of strategy is it? How could it be improved? If not, what benefits would come from having one?
b. Parag. 2 suggests five primary objectives of this strategy. Do all of these apply to your company? Are there any others that you would add?
c. Parag. 3: Are there any other points, in addition to these three, that your strategy should include?
d. Parag. 4: Which departments or individuals in your company are responsible for managing and supporting your external suppliers? What are their responsibilities?
e. Parag. 4 suggests roles for different departments in supporting external suppliers. Apply the RADAR questions to these suggested roles. Include Figure 18.6b in your discussion.

Action plan

Draw up an action plan for improving your company's long-term management of its suppliers, based on the discussions you have just had. Alternatively you may choose to prepare one action plan when for your discussions of several texts. You might like to follow the 6-Point Structure.

Figure 18.6a Utilising your external suppliers

Significant Points	**Utilise the specific technology of your external supplier in long term strategic management and planning.**
Maintain and improve quality.	Gain improvements in quality by using production control technology which your external suppliers have specialised for your product.
Increase your production volume.	Reduce investment in personnel and equipment by taking advantage of the production capability of your external suppliers.
Shorten deadlines.	Aim to shorten internal lead times and reduce your inventory by taking advantage of the faster production capabilities of your external supplier.
Get the benefits of your supplier's technology.	Aggressively take advantage of your supplier's specialised technology such as specially patented processes.
Reduce production costs.	Aim for reduced cost of finished goods by taking advantage of lower prices at your external supplier.

Figure 18.6b Example of different department roles in dealing with a defective fitting-bolt thread in delivered goods

Related departments	**Roles, division of work, and responsibilities of the related departments.**
QA department	Using incoming inspection data, judge defects and request that the manufacturer's responsible department take countermeasures. At the same time, inform the procurement department. Request the cooperation of related internal departments in resolving the problem.
Procurement department	To minimise any internal confusion at the production department, if there are supply delays, revise the purchasing plan of components.
Manufacturing department	After receiving a request from the QA department in relation to the defect, investigate the process which resulted in the defect at your external supplier and determine the causes. (It was determined that the problem was caused by the thread cutter being worn out. Advise to revise the standards for replacing the cutter.)
Design department	Change material of bolt to new material which is good for cutting.

Test

Answer these questions using only the information given in the text. For each question one, two or all three answers may be correct. Tick the answer or answers you think are correct for each question. Each question carries 3 points – you get one point for each correct answer that you tick, and one point for each wrong answer that you do not tick.

18.1 Taking on new external suppliers

1. The competitive quality of a company's products often depends on the ... of materials and parts it gets from external suppliers.
   - ☐ a. Proportion.
   - ☐ b. Quality.
   - ☐ c. Source.
2. The basic procedures for selecting the right external supplier include:
   - ☐ a. Ask candidate companies to submit written documents that describe their operations.
   - ☐ b. Ask representatives of the companies to present and explain these documents in person.
   - ☐ c. Carry out an independent investigation of other companies that these companies sell supplies to.
3. When setting a purchase price a company may typically have to consider the following points:
   - ☐ a. Compulsory rules and regulations.
   - ☐ b. Exchange rate fluctuations.
   - ☐ c. The cost of property.
4. It is especially important to take suppliers who already have a good business record when:
   - ☐ a. Purchasing items that can change in quality over time.
   - ☐ b. Your priority is price.
   - ☐ c. Purchasing items for which a quality record must be maintained during the production process.
5. The business contract should include:
   - ☐ a. Procedures for dealing with defective goods.
   - ☐ b. Payment conditions.
   - ☐ c. Conditions for making changes e.g. when there are changes in the specifications.
6. A company may choose new suppliers because:
   - ☐ a. It has decided to enter a new field of business.
   - ☐ b. There have been new developments in technology and materials.
   - ☐ c. It has taken on new staff.
7. Changes in the market that can lead a company to choose new suppliers include:
   - ☐ a. A drop in profits.
   - ☐ b. New competitor products.
   - ☐ c. Changes in laws and regulations.

18.2 Carry out an in-depth investigation of possible external suppliers

8. Carry out an in-depth investigation of possible external suppliers to make sure that they can
   - ☐ a. Deliver goods of the highest possible quality.
   - ☐ b. Deliver goods on time.
   - ☐ c. Respond to any changes that you may require.
9. Check that the supplier:
   - ☐ a. Can provide the necessary job training.
   - ☐ b. Can respond to quality audit requests.
   - ☐ c. Can transport goods to your factory.
10. An investigation of the supplier's production capability will include their:
   - ☐ a. Equipment.
   - ☐ b. Salary incentives.
   - ☐ c. Processing methods.
11. An investigation of how they handle abnormalities will include their capability to:
   - ☐ a. Detect abnormalities.
   - ☐ b. Respond immediately to abnormalities.
   - ☐ c. Stop all abnormalities arising.
12. An investigation of their engineering response capability will include their ability to:
   - ☐ a. Develop new materials, equipment and technology.
   - ☐ b. Analyze the causes of defects and take the necessary countermeasures.
   - ☐ c. Respond to requests for changes to the original specifications.
13. Quantitative assessment methods for checking that a supplier company's production system is capable of providing quality goods include:
   - ☐ a. Generate a QC process chart showing how their production process is controlled.
   - ☐ b. Clarify who is in charge of making pricing decisions.
   - ☐ c. Be aware of their production capability (Cp) index for important quality characteristics.

18.3 Inspect supplies on delivery

14. Establishing standards for incoming inspections includes:
   - ☐ a. The department in charge in the supplier company produces a draft plan for standards for incoming inspection.
   - ☐ b. Internal departments in the purchasing company meet to discuss the plan and make changes.
   - ☐ c. The results of the incoming inspections are monitored and, if necessary, the standards are revised.
15. An Inspection Evaluation Form for Delivered Items should include:
   - ☐ a. The name of the relevant manager in your supplier company.
   - ☐ b. The inspection data.
   - ☐ c. The inspector's license.
16. If there is any nonconformity, contact:
   - ☐ a. The inspector.
   - ☐ b. The general manager.
   - ☐ c. Your supplier.

18.4 Assist your suppliers to maintain and improve quality

17. The procedure for putting someone in charge of quality control in your suppliers includes:
    - ☐ a. Your company orders your supplier to put a person in charge of quality control.
    - ☐ b. Your company communicates directly with this person about quality issues.
    - ☐ c. Your company contacts this person when there is an emergency.
18. Exchanging information with external suppliers can include:
    - ☐ a. Changes in the allocation of responsibility.
    - ☐ b. Analysis of the complaint resolution system.
    - ☐ c. Changes in currency exchange rates.
19. Suppliers should be encouraged to:
    - ☐ a. Become more aware of their current situation.
    - ☐ b. Make their own decisions about practical improvement plans.
    - ☐ c. Carry out a self-evaluation of the results of the implementation of these plans.
20. The success of an external supplier in becoming more independent will be seen in:
    - ☐ a. The number of prizes they receive.
    - ☐ b. Their issuance of public shares.
    - ☐ c. Their receipt of an order from a private company.

18.5 Monitor quality levels in your external suppliers

21. After carrying out an evaluation of your supplier you should:
    - ☐ a. Develop an improvement plan and then present it to your supplier.
    - ☐ b. Carry out the improvement plan together with your supplier.
    - ☐ c. Check the results of the improvement plan and see if it can be further improved.
22. The record of technical instructions for corrective actions given to your supplier should include:
    - ☐ a. The names of the instructor and trainees.
    - ☐ b. Analysis of the current situation with a plan for improvement.
    - ☐ c. All the training materials used.
23. Using operation standards and a QC process chart to confirm that your supplier is carrying out each process correctly and maintaining the production flow correctly includes:
    - ☐ a. Confirm the most recent work standards and the QC process chart.
    - ☐ b. Confirm that each process is being carried out as specified in the original versions of these.
    - ☐ c. Match the actual work to the work standards and find the reasons for any differences.
24. Evaluating the records of goods delivered includes:
    - ☐ a. Evaluate each delivery with reference to the contents of the QC process chart.
    - ☐ b. Regularly evaluate the level of quality, rate of late delivery and the quantity delivered.
    - ☐ c. Evaluate your supplier's handling of complaints.

18.6 Maintain a good long-term relationship with your external suppliers

25. The primary objectives of a long term strategy for managing suppliers include:
    - ☐ a. Maintain and improve quality in your suppliers.
    - ☐ b. Ensure the correct production volume is achieved.
    - ☐ c. Utilize the specific technology of your supplier.
26. This long term strategy should include:
    - ☐ a. A plan for personnel development.
    - ☐ b. Financial instructions.
    - ☐ c. A quality audit.
27. Identify the roles of the different departments in supporting external suppliers:

Department	Role
a. Procurement b. Manufacturing c. Engineering and Design d. Quality Assurance	1. Transfer management technology for efficient production 2. Support your supplier when there are changes to specifications and the improvement of specific techniques 3. Inspect the lot structure, provide inspection procedures 4. Reduce cost and control inputs and outflows of purchased raw materials and parts

☐ a. a1, b4, c2, d3 ☐ b. a4, b1, c2, d3 ☐ c. a4, b2, c1, d3

Relationship with ISO

18.1 Taking on new external suppliers
Relationship with ISO 9001:2000
7.4.1 Purchasing process

18.2 Carry out an in-depth investigation of possible external suppliers
Relationship with ISO 9001:2000
7.4.1 Purchasing process
7.4.2 Purchasing information
7.5 Production and service provision

18.3 Inspect supplies on delivery
Relationship with ISO 9001:2000
7.4.3 Verification of purchased product
8.2.4 Monitoring and measurement of product
4.2.4 Control of records

18.4 Support your external suppliers in maintaining and improving quality
Relationship with ISO 9001:2000
7.4. Purchasing
6.2.2 Competence, awareness and training
6.2.4 Work environment
8.5.1 Continual improvement
7.4.1 Purchasing process
7.4.2 Purchasing information
8.5.1 Continual improvement

18.5 Monitor quality levels in your external suppliers
Relationship with ISO 9001:2000
7.4.1 Purchasing process
6.2.2 Competence, awareness and training
4.2.4 Control of records
7.5 Production and service provision

18.6 Maintain a good long-term relationship with your suppliers
Relationship with ISO 9001:2000
7.4. Purchasing
6.2.2 Competence, awareness and training

Unit 19

After-sales Service

Contents

Unit summary

Your responsibility for your products does not end when you sell them. The success of your company depends, above all, on whether your customers are satisfied with your products. No matter how good your quality and inspection systems are, some defective products can always get through to your customers. This is why it is essential to have a good after-sales service. View it positively – it can make a good impression on the customer and lead to more orders and increased sales.

19.1 The role of the CEO in after-sales service

The CEO should take an active interest in the after-sales service, since it has an important quality assurance function.

19.2 Prepare a product guarantee certificate

The product guarantee certificate is an essential document for both preventing and dealing with after-sales problems. Give it careful thought. Decide on your guarantee conditions and document them so that claims can be dealt with quickly before they develop into a dispute.

19.3 Deal with customer claims

You need to have an organisational structure and procedures in place when customers present claims about failed products. This will allow you to deal quickly and efficiently with the claim: to receive the claim; to analyse the failed product; to take corrective measures and recurrence prevention measures; and to keep a record of all essential data. And remember that you can often turn claim processing into opportunities for attracting new customers.

19.4 Analyse failed products and take recurrence prevention measures

Your analysis of failed products should be thorough, and should be followed by measures to prevent the recurrence of such a failure. These measures should include, if necessary, changes in design and materials.

19.5 Control service parts and spare parts

Good control of service parts and spare parts means:

a. Having the parts ready when they are needed.
b. Avoiding a surplus of parts that could deteriorate, especially when production of a particular product comes to an end.
c. Having the right quantity of sales material such as catalogues.

19.6 Control the initial distribution of products

A key after-sales quality assurance procedure is to control the initial distribution of new or modified products. This means to decide in advance on certain control items on these products and then to check these items at certain times to make sure that they continue to be correct.

19.7 Train your service engineers

Your aim in training your service engineers is that they will be able to provide correct servicing that meets your customers needs, and in the shortest possible time. The training should develop both their technical knowledge and skills, and their customer relations skills. You will also need to have a good service manual, since engineers cannot be expected to learn all the servicing operations.

19.8 Make good use of field information

Make good use of the field information collected by your after-sales department. This information on the quality, technology and sales of your products, and on your competitors, will help your company to develop and promote new products.

Learning tools

The RADAR questions

As you read each text you will discuss how it could be applied in your company. The RADAR questions will help you to focus this discussion:

R - Are these ideas **relevant** to my company?
A - How would **I apply** each of them in my company?
D - What **difficulties** might I meet and how would I overcome them?
A - Are there any **additional** actions that I might take that are not mentioned in the text?
R - What **resources** would be needed, what would these cost, and how could they be acquired?

There will of course be some discussion points where not all of these questions will be applicable.

The 6-Point Structure

After you have discussed the ideas in the text, you write an action plan in which you present practical proposals for implementing the conclusions you have reached in your discussion. The 6-Point Structure will help you to write your action plan:

1. **Problems:** Problems you have in your company in the area you have just discussed.
2. **Proposals:** Your proposals for improvement.
   a. Be specific and concrete.
   b. Include an implementation plan, with a time schedule and minimum and optimal implementation targets.
   c. Refer to any forms, charts, tables etc. that you would use, and include samples in an appendix.
3. **Obstacles:** Obstacles to implementation in employee attitudes, company organization and culture etc., and how these could be overcome.
4. **Resources:**
   a. The resources required: funds, equipment, materials, man-hours, expertise etc.
   b. The resources available within the company.
   c. Any resources that would have to be found outside the company.
   d. Alternatives that could be used to cover any shortfall in resources.
5. **Assessment:** Ways of assessing the results of implementing these proposals.
6. **Benefits:** The benefits your proposals would bring.

19.1 The role of the CEO in after-sales service

The CEO should take an active interest in the after-sales service, since it has an important quality assurance function. He or she should:

a. Check the after-sales feedback on products that have been sold, and periodically give instructions to the manufacturing department based on this feedback. This feedback will be drawn from periodic after-sales inspections, the repair/parts service and visits to the customer.
b. Follow up the progress of improvements and countermeasures.
c. Whenever there are claims because of product failures, ask the department responsible to provide an explanation of the technical problem, and the cost of any corrective action needed to meet the claims.
d. Have a good understanding, based on the investigation of after-sales failures, of the main current problems, their causes, and possible countermeasures.
e. Facilitate the establishment and implementation of improvement plans for current problems.
f. Participate actively in the overall improvement of the after-sales service, and the establishment of an annual improvement scheme.
g. Implement regular checking and follow-up procedures.

Discussion

The following questions ask you to think about how the ideas in the text could be applied in your company. Some of the ideas may not be relevant to you. Concentrate on those that are relevant. Keep notes of your conclusions – you will need them to prepare your action plan afterwards. Where appropriate ask yourself the RADAR questions.

Note: Always include in your discussion any figures referred to in the text, ***if*** you feel these are relevant to your company.

a. Does your CEO take an active interest in after-sales service is? How important do you think it is that he or she does so?
b. Parag. 4 presents seven actions that a CEO should take in relation to after-sales service. Apply the RADAR questions to these.

Action plan

Take the ideas you have found useful in the text, and in your discussion, and present them in a well-structured plan for introducing improvements in your company. Alternatively, you may include these ideas in one action plan after you have discussed several texts. You might like to follow the 6-Point Structure.

19.2 Prepare a product guarantee certificate

The product guarantee certificate is an essential document for both preventing and dealing with after-sales problems. Give it careful thought. Decide on your guarantee conditions and document them so that claims can be dealt with quickly before they develop into a dispute. The standard guarantee certificate includes:

a. The date of issuing the certificate.
b. The items to be guaranteed.
c. The guarantee conditions in detail, including the scope and period of the guarantee.
d. Items which do not come under the guarantee such as:
    i. The customer has abused the product.
    ii. The customer has deliberately caused the product to breakdown.
    iii. Consumables.

Make an official agreement with your customers about the content of the guarantee certificate or fix the certificate to the product. Write the certificate in clear, easy language that the customer can easily understand.

Figure 19.2a Sample extract from a certificate

1. During the guarantee period, if a unit fails because of imperfect quality, this unit will be repaired or reworked free of charge.
2. The guarantee period is 5 years after initial installation for the freezer unit (compressor, condenser, radiator and piping unit) and 1 year for other cabinets including attached electrical parts.
3. The cases below cannot be accepted for free-of-charge repair or rework even during the guarantee period:
    a. Failure due to misuse by user.
    b. Failure due to inadequate modification.
    c. Failure or damage due to disaster or the like.
    d. Failure due to installation on a vehicle, marine vessel or the like.
    e. Where the guarantee certificate does not show any selling dealer's stamp or name.
    f. Where a guarantee certificate is not presented.
4. This guarantee certificate is valid only in Japan.

Discussion

The following questions ask you to think about how the ideas in the text could be applied in your company. Some of the ideas may not be relevant to you. Concentrate on those that are relevant. Keep notes of your conclusions – you will need them to prepare your action plan afterwards. Where appropriate ask yourself the RADAR questions.

Note: Always include in your discussion any figures referred to in the text, ***if*** you feel these are relevant to your company.

a. Does your company write down the guarantee conditions in advance? Does this prevent disputes arising?
b. This text presents several suggestions for the product guarantee certificate. What are the main points that you would include in certificates for one or two of your products?

Action plan

Take the ideas you have found useful in the text, and in your discussion, and present them in a well-structured action plan for introducing improvements in your company. Alternatively, you may include these ideas in one action plan after you have discussed several texts. You might like to follow the 6-Point Structure.

19.3 Deal with customer claims

1. You need to have an organisational structure and procedures in place when customers present claims about failed products. This will allow you to deal quickly and efficiently with the claim: to receive the claim; to analyse the failed product; to take corrective measures and recurrence prevention measures; and to keep a record of all essential data. And remember that you can often turn claim processing into opportunities for attracting new customers.

   (A claim is where a customer seeks compensation, repair or replacement of a defective product that has a warranty, and likewise with a service; a complaint is where they express dissatisfaction and may or may not make a demand for compensation.)

2. Take the following actions:
   a. Set up an organisational structure:
      i. Assign a person to be in charge of claims and include a written job description in the standards.
      ii. Decide on the procedures to be used for a) quick corrective actions and b) distributing the recorded claim information to all the relevant people.
      iii. Clarify who is responsible for replying to the customer about the processing of the claim.
      iv. Simplify liaison between departments.
      v. Prepare a claim handling rule – a document which clearly describes the procedures, listed below, for processing claims, and for repairing defective goods.
   b. Standardize a flow chart showing the procedures for processing claims. These procedures should include:
      i. Record the receipt of a claim.
      ii. Maintain up-to-date information on the status of reported claims.
      iii. Record the analysis of failed items.
      iv. Record the corrective and recurrence prevention measures taken in each process and the names of those responsible. (Corrective measures are taken to deal with the specific product and customer; recurrence prevention measures are taken to prevent similar problems arising with other products.)
      v. Record the history of the manufacturing and storage of the product.
   c. Prepare a form for reporting the processing of claims:
      i. Standardize the format of the report with spaces for the contents of claims, the analysis of results, and the actions to be taken.
      ii. Include columns that distinguish between corrective measures and recurrence prevention measures.
      iii. Include in the report the names of the responsible department and the person responsible for giving approval.

iv. Ensure that the final written report of the claim covers causes, contents and countermeasures.

d. Maintain a ledger of reported claims covering:
   i. Receiving claims.
   ii. Checking the progress of claims.
   iii. Reporting each process.

   This will enable the person in charge to reply accurately to any inquiries from customers about the status of their claim, and when it will be completely processed.
e. Standardize the criteria for accepting returned failed units for each kind of product.
f. Standardize phased procedures for claim processing, such as reworking, repair, providing an explanation, assessment, and rejection.
g. Control temporary measures and permanent measures separately.
h. Assign a person to be responsible for judging the progress of claim processing.

3. Present these procedures clearly:
   a. Make sure the standardized flow chart is easy to understand.
   b. Make it clear who is in charge of each process and the time-limit for responding to the claim, and who is responsible.
   c. Specify clearly the activities and data that are to be entered in the record forms.
   d. Establish a communication method that will allow everyone to receive the final results of the processing of a claim.

4. Get a clear picture of your claim processing rate:
   a. Control and monitor the flow chart activities for processing claims - both the activities that are in progress, and those that are closed.
   b. Use graphs and other tools to get a clear picture of the period required for claim processing and to control it.
   c. Reduce the processing period by distinguishing the time taken to respond to a claim, and the time taken to carry out the service. (i.e. response time and service time.)
   d. Monitor how unexpected events are dealt with, and standardise a system for dealing with these.
   e. Hold regular quality meetings to follow-up on the progress of the service activities and to see what can be improved.
   f. Prepare and implement an improvement scheme and follow it up.

5. Ensure that employees are courteous to customers who bring claims. Whoever takes a claim call from a customer should:
   a. Listen carefully and take accurate notes in a fixed format, and then repeat their notes to the customer and get their confirmation.
   b. Send the customer a written statement of the date that they will receive a reply. If the job is not completed by that date, write an intermediate report and send the customer a new date for replying.

Figure 19.3a Basic activities and control items for services
Figure 19.3b Functions and control items for after sales services
Figure 19.3c Claim handling receipt sheet

Figure 19.3d QA system service chart (service dept.)
Figure 19.3e QA system
Figure 19.3f Total QA system
Figure 19.3g Service control system

Discussion

The following questions ask you to think about how the ideas in the text could be applied in your company. Some of the ideas may not be relevant to you. Concentrate on those that are relevant. Keep notes of your conclusions – you will need them to prepare your action plan afterwards. Where appropriate ask yourself the RADAR questions.

Note: Always include in your discussion any figures referred to in the text, ***if*** you feel these are relevant to your company.

a. Parag. 1. How efficient is your handling of customer claims? Where do you think it needs improvement?
b. Parag. 1. How can a good processing of customer claims lead to increased sales?
c. Parags. 2 and 3. Apply the RADAR questions to these guidelines.
d. Parag. 4. Do you have a clear picture of your claim processing rate? How would you benefit from having one?
e. Parag. 4. Apply the RADAR questions to these guidelines.
f. Parag. 5. How courteous and efficient are your employees in taking claims from customer? How would these suggestions help? Can you add any further suggestions?

Action plan

Take the ideas you have found useful in the text, and in your discussion, and present them in a well-structured action plan for introducing improvements in your company. You might like to follow the 6-Point Structure. Alternatively, you may include these ideas in one action plan for the complete unit.

19.4 Analyse failed products and take recurrence prevention measures

You need to have a system that allows you to carry out a thorough analysis of a failed product returned by a customer, and to take measures to prevent the recurrence of such a failure (including, if necessary, changes in design and materials). Take the following steps:

a. Standardize a system that will feed the claim information back to the original manufacturing department.
b. Establish a communication route between the service department and the manufacturing department.
c. Establish failure analysis procedures for analysing returned failed units.
d. Decide the department and person responsible for, and the person in charge of, conducting the failure analysis, and for reviewing and drafting recurrence prevention measures. Decide also who is to be responsible for making the final decision, and what points in this decision are to be recorded.
e. Set up a system for recording the failure analysis.
f. Send the results of the analysis to the service department, as feedback for them.
g. Treat the time limit of delivery as what differentiates temporary measures and permanent measures.
h. Standardize the criteria for evaluating the effect of recurrence prevention measures.
i. Decide who is to be responsible for confirming the effects of the recurrence prevention measures and taking any necessary follow-up action, such as review of the claim criteria.
j. Record and control the effect of the recurrence-prevention measures.
k. Communicate the final conclusion of the recurrence prevention measures to the department that is dealing with the claim and to the person in charge; then decide who is to be responsible for the follow-up.
l. Standardize the registration of all records and their distribution to all those concerned.
m. Maintain these records in the standard format, and use them for planning future activities.

Discussion

The following questions ask you to think about how the ideas in the text could be applied in your company. Some of the ideas may not be relevant to you. Concentrate on those that are relevant. Keep notes of your conclusions – you will need them to prepare your action plan afterwards. Where appropriate ask yourself the RADAR questions.

Note: Always include in your discussion any figures referred to in the text, ***if*** you feel these are relevant to your company.

a. What procedures do you already have for analysing failed products and taking recurrence prevention measures? How effective are they? How do you think they might be improved? How important do you think each of these is?
b. Apply the RADAR questions to the guidelines in this text.

Action plan

Take the ideas you have found useful in the text, and in your discussion, and present them in a well-structured action plan for introducing improvements in your company. You might like to use the 6-Point Structure. Alternatively, you may include these ideas in one action plan for the complete unit.

19.5 Control service parts and spare parts

1. Good control of service parts and spare parts means:
   a. Having the parts ready when they are needed.
   b. Avoiding a surplus of parts that could deteriorate, especially when production of a particular product comes to an end.
   c. Having the right quantity of sales material – catalogues etc.

2. Service parts are those that replace old parts after fixed periods of time as recommended in the service manual. Spare parts are used as the need arises. To control both service parts and spare parts, take the following actions:
   a. Set up an inventory system:
      i. Establish a standard method of inventory control.
      ii. Standardize the system for marking the parts.
      iii. Decide on standard periods for having parts in the inventory.
      iv. Monitor fluctuations in sales and stock volumes, preferably with graphs.
   b. Establish a supply control system for service parts:
      i. Decide how many service parts you should keep in the inventory with reference to the reliability of the parts - how long can they be expected to last before they have to be replaced again.
      ii. Set up procedures that will ensure that you place orders at the right time.
      iii. Constantly monitor fluctuations in the service parts inventory by each part number.
      iv. Have a system for making the best use of customer information in placing orders for service parts.
      v. Set up standard procedures for requesting improvements when service parts fail.
   c. Establish control criteria for maintaining the right inventory quantity of spare parts.
      i. Standardize the procedures for the supply of spare parts.
      ii. Enter the incoming, outgoing and remaining quantities in the ledger for each part.
      iii. Decide on the person and department that will be responsible for the supply and inventory control of spare parts.
      iv. Revise the operation standard as necessary, and inform those who should know.

Figure 19.5a Flowchart for repairing, receiving and delivering parts

Discussion

The following questions ask you to think about how the ideas in the text could be applied in your company. Some of the ideas may not be relevant to you. Concentrate on those that are relevant. Keep notes of your conclusions – you will need them to prepare your action plan afterwards. Where appropriate ask yourself the RADAR questions.

Note: Always include in your discussion any figures referred to in the text, ***if*** you feel these are relevant to your company.

a. In your company, are service and spare parts always available when they are needed? If not, what problems does this bring?
b. Do you have different systems and procedures for service parts and spare parts?
c. Parag. 2 presents guidelines for maintaining control of service parts and spare parts. Apply the RADAR questions to these. Decide to what extent you would use different systems and procedures for service parts and spare parts.

Action plan

Take the ideas you have found useful in the text, and in your discussion, and present them in a well-structured action plan for introducing improvements in your company. You might like to use the 6-Point Structure. Alternatively, you may include these ideas in one action plan for the complete unit.

19.6 Control the initial distribution of products

A key after-sales quality assurance procedure is to control the initial distribution of new or modified products. This means to decide in advance on certain control items on these products and then to check these items at certain times to make sure that they continue to be correct. Check them with reference to the control information that the manufacturing department prepared for the product. If you maintain control in this way you will be able to identify problems at an early stage, and take corrective action quickly.

a. Take the following preliminary actions:
    i. Appoint a person responsible for deciding when control should be applied and when released.
    ii. Decide which department will be responsible for control.
    iii. Decide on control items.
    iv. Decide what data is to be collected.
    v. Set up a procedure for processing product failures.
    vi. Draft a scheme of after-sales service to find out how the product is being used by the customer.
b. Continually review the control items against the control data by using field information on product failures and errors.
c. Visit important customers, whether or not problems have arisen.
d. Hold communications at an early stage with those involved in quality issues, followed by discussions chaired by the person responsible.
e. Provide thorough training on the new product for the personnel involved. (This will be a function of the service department.)
f. When a customer makes a claim, find out exactly how they are operating the product, as well as what their claim is based on.

Figure 19.6a Claim process chart
Figure 19.6b System for recurrence prevention of customer complaints
Figure 19.6c Claim process report – Format 1
Figure 19.6d Claim process report – Format 2
Figure 19.6e Claim process report – Format 3

Discussion

The following questions ask you to think about how the ideas in the text could be applied in your company. Some of the ideas may not be relevant to you. Concentrate on those that are relevant. Keep notes of your conclusions – you will need them to prepare your action plan afterwards. Where appropriate ask yourself the RADAR questions.

Note: Always include in your discussion any figures referred to in the text, ***if*** you feel these are relevant to your company.

a. Does your company control the initial distribution of new or modified parts? If yes, what do you regard as the strengths and weaknesses of your system? What benefits does it bring? If not, what problems do you have that such a system might solve?
b. Apply the RADAR question to these guidelines for controlling the initial distribution of new or modified products.
c. How would a good control system improve your after-sales service?

Action plan

Take the ideas you have found useful in the text, and in your discussion, and present them in a well-structured action plan for introducing improvements in your company. You might like to use the 6-Point Structure. Alternatively, you may include these ideas in one action plan for the complete unit.

19.7 Train your service engineers

1. Your aim in training your service engineers is that they will be able to provide servicing that meets your customers needs, and in the shortest possible time. The training should be systematic and ongoing, and should develop both their technical knowledge and skills, and their customer relations skills. The latter are essential in any sales-related activities. You will also need to have a good service manual, since engineers cannot be expected to learn all the servicing operations.

2. To provide appropriate training:
   a. Evaluate the job performance level of the service engineers, e.g. their average repair time.
   b. Set up a training programme to raise their job performance level to meet gaps shown in this evaluation. Include customer services education.
   c. Provide a qualification programme that will lead them to the appropriate qualifications.
   d. Keep a record of each engineer's skills level.
   e. Provide education appropriate to each engineer's job and experience.
   f. Have an instructor to conduct on-site education and training.
   g. Give special attention to the training of new employees, and to training for new products.
   h. Motivate the engineers by:
      i. Setting up an annual scheme to give awards based on the evaluation.
      ii. Use in-house service contests and external competitions such as the international vocational training competition, and encourage engineers to participate positively in these.

3. You should also provide after-sales service training to your service companies and dealers:
   a. Focus training on each product and decide whether the training should be general or specific.
   b. Draft and implement a training programme when new employees are recruited to these companies.
   c. Measure the effect of the training programme and take the results into account in the next programme.

Figure 19.7a Training system for all employees
Figure 19.7b Qualification system for service personnel
Figure 19.7c Control tools for skills

4. Prepare a good customer service manual. After-sales service varies depending on the type of product, the function of the product and the kind of servicing that has to be

done. No service person can possibly know all the servicing operations. The customer service manual is the standard document for providing technical support for after-sales service whenever a claim is presented. Note the following:

a. The customer service manual sets out all the important procedures from receipt of the customer's service request to completion of the service including setting a delivery date.
b. It consists of the service guidebook, the technical manual, the troubleshooting manual, the maintenance criteria, and the standard maintenance manual.
c. It should have illustrations so that it is easy to understand.
d. Standardize the issuing, revision and distribution of the manual.
e. Review it periodically for inaccuracies or inadequacies.
f. Managers of the responsible departments should periodically check that manual study sessions are being held, and that they include a focus on customer services.

Figure 19.7d Service engineer's attitude

Discussion

The following questions ask you to think about how the ideas in the text could be applied in your company. Some of the ideas may not be relevant to you. Concentrate on those that are relevant. Keep notes of your conclusions – you will need them to prepare your action plan afterwards. Where appropriate ask yourself the RADAR questions.

Note: Always include in your discussion any figures referred to in the text, ***if*** you feel these are relevant to your company.

a. What training do you already provide for your service engineers? Do you think it is adequate? How could it be improved?
b. How important do you think it is for service engineers to be trained in customer relations skills?
c. Parag. 2: Apply the RADAR questions to these guidelines for the training of service engineers.
d. Parag. 4 shows how complex after-sales service can be. How complex is it in your company? Do you have a customer service manual? If yes, how useful is it? In what ways could it be improved? If not, do you feel you need one? What benefits would it bring?
e. Parag. 4: Apply the RADAR questions to these guidelines.

Action plan

Take the ideas you have found useful in the text, and in your discussion, and present them in a well-structured action plan for introducing improvements in your company. You might like to use the 6-Point Structure. Alternatively, you may include these ideas in one action plan for the complete unit.

19.8 Make good use of field information

Make good use of the field information collected by your after-sales department. This information on the quality, technology and sales of your own products, and the products of your competitors, will help your company to develop and promote new products. There are several actions that you can take:

a. Standardize a system to exchange information on quality between the after-sales department and the manufacturing department.
b. Find out the defective and non-defective rates of your products, analyse the causes and implement countermeasures.
c. Find out the rate at which failure claims are resolved.
d. Gather and analyze after-sales service information about competitors and then prepare suitable counter-actions:
    i. Specify which department is responsible for gathering, analyzing and responding to competitor data.
    ii. Compare your competitor data with data about your own products and services to help you analyze your own weak points and strengths.
    iii. Get all those concerned to draft and implement an improvement scheme based on this analysis, and check the effects of the improvement measures.
    iv. Use your competitor data to develop new own-brand products
e. Carry out periodic customer satisfaction surveys to evaluate the reliability of your after-sales service and how satisfied customers are with it:
    i. Use a questionnaire on the quality of service and a customer follow-up sheet.
    ii. Prepare a service reliability index such as "Mean Time Between Service Calls" (MTBSC). Example: CS guideline.
    iii. Establish customer service guidelines.
f. Use the information you get at exhibitions to anticipate customer and market trends and apply this in service activities, and in the development of new products.

Figure 19.8a CS guideline
Figure 19.8b Harmonate CS expansion
Figure 19.8c Claim processing procedure (page 21)

Discussion

The following questions ask you to think about how the ideas in the text could be applied in your company. Some of the ideas may not be relevant to you. Concentrate on those that are relevant. Keep notes of your conclusions – you will need them to prepare your action plan afterwards. Where appropriate ask yourself the RADAR questions.

Note: Always include in your discussion any figures referred to in the text, ***if*** you feel these are relevant to your company.

a. Do you find that much information comes into your company from the fieldwork of

Figure 19.8c Claim processing procedure

	Procedures	Customer	Sales Dept.	QA	Design Dept.	Manuf. Dept.
1	Claim occurrence.	*	◇	◇		
2	Verification of claim and recording.			*		
3	Communication of claim.			*	◇	◇
4	Research of claim.			*	*	*
5	Action conference (first aid, actual action).	◇	◇	*		
6	Action conference (research of cause, research method).				*	*
7	Research of cause and duplication test.			*	*	*
8	Action review (rework, repair, concession, deletion).			*	*	*
9	Determination of processing for claim product.	◇	◇	*		
10	Review and standardization of corrective action and preventive action.			*	*	*
11	Research report.	◇	◇	*		
12	Implementation of corrective action and preventive action.				*	*
13	Action and approval.	*	◇	*		
14	Verification of effect of corrective action.			*	*	*

* Person or section in charge.
◇ Where to contact.

the after-sales department? Is it or could it be useful? What use does your company make of this information? How could it make better use of it? How could it get more and better information?

b. What steps do you already take to evaluate service reliability and customer satisfaction? How could this be improved?
c. Apply the RADAR questions to the guidelines in this text.

Action plan

Take the ideas you have found useful in the text, and in your discussion, and present them in a well-structured action plan for introducing improvements in your company. You might like to use the 6-Point Structure. Alternatively, you may include these ideas in one action plan for the complete unit.

Test

Answer these questions using only the information given in the text. For each question one, two or all three answers may be correct. Tick the answer or answers you think are correct for each question. Each question carries 3 points – you get one point for each correct answer that you tick, and one point for each wrong answer that you do not tick.

19.1 The role of the CEO in after-sales service

1. The CEO should periodically give instructions to the ... department based on after-sales field feedback.
   - ☐ a. Sales.
   - ☐ b. Manufacturing.
   - ☐ c. Marketing.
2. The CEO should participate actively in the:
   - ☐ a. Improvement of the after-sales service.
   - ☐ b. Introduction of countermeasures.
   - ☐ c. Establishment of an annual improvement scheme.

19.2 Prepare a product guarantee certificate

3. Items which do not come under the guarantee include:
   - ☐ a. Failure caused by a design fault.
   - ☐ b. Consumables.
   - ☐ c. Failure caused by customer abuse.

19.3 Deal with customer claims

4. To set up an effective organizational structure you should:
   - ☐ a. Decide in advance on the points to be considered when claims are received, and format a standard claims document to include these.
   - ☐ b. Simplify liaison between departments.
   - ☐ c. Decide on the procedures to be used for distributing the recorded claim information to all the relevant people.
5. To set up claim handling procedures:
   - ☐ a. Standardize the criteria for accepting returned failed units for each kind of product.
   - ☐ b. Standardize phased procedures for claim processing.
   - ☐ c. Control the temporary and permanent measures separately.
6. The procedures for processing claims should include:
   - ☐ a. Record the history of the manufacturing and storage of the product.
   - ☐ b. Record the recurrence prevention measures taken.
   - ☐ c. Record similar claims.
7. To report the processing of claims:
   - ☐ a. Distinguish between corrective and recurrence prevention measures.
   - ☐ b. Include costs.

- ☐ c. Standardize the format of the report with spaces for contents of claims, the analysis of results and the actions to be taken.

8. To present claims procedures clearly:
   - ☐ a. Standardize an overall flow chart of claim processing that is easy to understand.
   - ☐ b. Make it clear who is in charge of each process.
   - ☐ c. Establish a communication method that will allow everyone to receive the final results.
9. To get a clear picture of the claim processing rate:
   - ☐ a. Control the activities for processing, both the activities that are in progress, and those that are closed.
   - ☐ b. Reduce the processing period by distinguishing the time taken to respond to a claim and the time taken to report it to the manufacturing department.
   - ☐ c. Hold regular quality meetings to follow-up on the progress of the service activities and to see what can be improved.
10. When customers make claims by telephone the personnel taking the call should:
   - ☐ a. Listen carefully and write up notes after the call is over.
   - ☐ b. Write notes at the time and thank the customer for calling.
   - ☐ c. Write notes at the time and repeat them to the customer.

19.4 Analyse failed products and take recurrence prevention measures

11. To have a system to analyze returned failed units:
   - ☐ a. Establish failure analysis procedures for analyzing returned failed units.
   - ☐ b. Establish a communication route between the service department and the manufacturing department.
   - ☐ c. Standardize a system that will feed the claim information back to the original manufacturing department.
12. To effectively implement recurrence prevention measures:
   - ☐ a. Standardize the criteria for evaluating the effect of recurrence prevention measures.
   - ☐ b. Establish an information communication route between the service department and the marketing department.
   - ☐ c. Treat the time since purchase as what differentiates temporary and permanent measures.

19.5 Control service parts and spare parts

13. To monitor the inventory of spare parts:
   - ☐ a. Standardize a system for making the parts.
   - ☐ b. Decide on standard periods for having parts in the inventory.
   - ☐ c. Monitor fluctuations in sales and stock volumes.
14. To establish a supply control system of service parts:
   - ☐ a. Decide how many service parts you should keep in the inventory with reference to the reliability of the parts.
   - ☐ b. Set up standard procedures for requesting improvements when service parts fail.
   - ☐ c. Monitor fluctuation in the service parts inventory by lot number.
15. To establish control criteria for maintaining an adequate inventory of spare parts:
   - ☐ a. Enter the incoming, outgoing and remaining quantities in the ledger for each part.

- ☐ b. Standardize the procedures for the supply of spare parts.
- ☐ c. Decide on the person and department to be responsible for the supply and inventory control of spare parts.

19.6 Control the initial distribution of new or modified products

16. To control the initial distribution of new or modified products, check if important control items correspond to control data that was prepared for the product by:
    - ☐ a. The after-sales department.
    - ☐ b. The sales department.
    - ☐ c. The manufacturing department.
17. The preliminary actions for controlling the initial distribution of products should include:
    - ☐ a. Decide on control items.
    - ☐ b. Decide what data is to be collected.
    - ☐ c. Find out exactly how customers are using the product.

19.7 Train your service engineers

18. A training programme to evaluate and improve the skills of service engineers should include:
    - ☐ a. Run an annual examination programme.
    - ☐ b. Evaluate their job performance.
    - ☐ c. Provide education appropriate to each engineer's job experience.
19. Give special attention to:
    - ☐ a. The training of new employees.
    - ☐ b. Training for new products.
    - ☐ c. Training customer services staff.
20. To provide after-sales service training to the service company and dealer:
    - ☐ a. Focus training on each company.
    - ☐ b. Draft and implement a training programme when new employees are recruited.
    - ☐ c. Measure the effect of the training programme and take the results into account in the next programme.
21. After-sales service varies depending on:
    - ☐ a. The age of the product.
    - ☐ b. The type of product.
    - ☐ c. The function of the product.
22. A customer services manual should include:
    - ☐ a. The service guidebook.
    - ☐ b. The maintenance criteria.
    - ☐ c. The sales manual.
23. Which of the following should be standardized?
    - ☐ a. The revision of the manual.
    - ☐ b. The distribution of the manual.
    - ☐ c. The study of the manual.

19.8 Make good use of field information

24. A company can use the field information on ... to develop and promote new products.
    - ☐ a. Competitors.
    - ☐ b. Production.
    - ☐ c. Quality.
25. To make good use of the information obtained by your after-sales department:
    - ☐ a. Use the information you get at exhibitions to anticipate customer and market trends and apply this in service activities, and in the development of new products.
    - ☐ b. Standardize a system to exchange information on quality between the after-sales department and the finance department.
    - ☐ c. Find out the rate at which failure claims are resolved.
26. Gathering and analyzing after-sales information about competitors and preparing suitable counter-action includes:
    - ☐ a. Using after-sales information about competitors to analyze one's own weak points and strengths.
    - ☐ b. Using data about competitors to develop new own-brand products.
    - ☐ c. Specifying which department is responsible for gathering and analyzing this information.
27. To carry out periodic customer satisfaction surveys:
    - ☐ a. Use a questionnaire on the quality of service and a customer follow-up sheet.
    - ☐ b. Prepare a sales index.
    - ☐ c. Establish customer service guidelines.

Relationship with ISO

19.1 The role of the CEO in after-sales service

Relationship with ISO 9001:2000

5.1 Management commitment

5.6 Management review

19.2 Prepare a product guarantee certificate

Relationship with ISO 9001:2000

7.2.2 Review of requirements related to the product

7.2.3 Customer communication

7.5.1 Control of production and service provision

19.3 Deal with customer claims

Relationship with ISO 9001:2000

8.3 Control of nonconforming product

7.2. Customer communication

8.2.2 Customer satisfaction

8.5.2 Corrective action

8.5.3 Preventive action

19.4 Analyse failed products and take recurrence prevention measures

Relationship with ISO 9001:2000

8.4 Analysis of data

8.5.3 Preventive action

19.5 Control service parts and spare parts

Relationship with ISO 9001:2000

7.4 Purchasing

7.5.5 Preservation of product

8.2.1 Customer satisfaction

8.3 Control of nonconforming product

8.4 Analysis of data

8.5 Improvement

19.6 Control the initial distribution of products

Relationship with ISO 9001:2000

8.2.1 Customer satisfaction

8.3 Control of nonconforming product

8.4 Analysis of data

8.5 Improvement

19.7 Train your service engineers

Relationship with ISO 9001:2000

6.2.2 Competence, awareness and training

7.5.1 Control of production and service provision

19.8 Make good use of field information

Relationship with ISO 9001:2000

7.2.3 Customer communication

8.2.2 Customer satisfaction

8.4 Analysis of data

Unit 20

Product Design and Development

Contents

Unit summary

Product design and development is the process of creating a new product to be sold by a business to its customers. It involves identifying a market need, creating a product to meet this need, and testing and improving this product until it is ready for production. It consists of a series of activities: research, analysis, design, engineering, and building prototypes, and then testing, modifying, and re-testing until the design is perfect. Design and development is usually carried out by a project team, with members from both outside and inside the company. This unit presents detailed procedures for managing the process of product design and development.

20.1 Set up the primary requirements for new-product design and development

To design and develop new products your company will need to:

a. Have a good understanding on the part of the CEO of what design and development involves.
b. Prepare written rules and procedures for managing design and development.
c. Prepare a new-product development project sheet.
d. Establish a standard for testing new products.
e. Calculate the costs of development.

20.2 Plan for the design and development of the new product

To plan for the design and development of a new product:

a. Set up a unit to carry out the design work.
b. Establish design standards that will cover all the design requirements.
c. Make clear the responsibility and authority of the designers.
d. Find out how many problems related to design and development arise each year.
e. Plan how corrective action should be taken when such problems arise.
f. Establish procedures for changing the design standards when the need arises.

20.3 Implement the new design

To implement the design of a new product your company will need to:

a. Establish procedures for starting production of the new product.
b. Prepare a flowchart with the quality characteristics of the manufacturing processes.
c. Control the design and development budget.
d. Regulate the design and development process.

20.4 Prepare for the development of the new product

To prepare for the development of the new product:

a. Set up a new-product development system and establish standards.
b. Establish evaluation standards and criteria for reviewing the design and testing the product.

c. Design parts that meet common standards.
d. Check the process capability: make sure that the production process has the capability to produce products with the required quality characteristics.
e. Carry out design reviews based on customer claims.

20.5 Take a long-term perspective on design and development

The design and development of a new product is normally a big investment. To bring a good return on this investment the new product must hold its position in the market well into the future. You therefore need to take a long-term perspective. This text highlights several actions that are especially important in taking a long-term approach. Some have already been presented in this unit but they are emphasized again here. You should:

a. Ensure that you have a long-term development system.
b. Control the progress, quality and cost of design and development planning.
c. Make a continuous effort to reduce quality problems.
d. Base each phase of product planning on market research.
e. Take environmental trends into account.

Learning tools

As you read each text you will discuss how it could be applied in your company. The RADAR questions will help you to focus this discussion:

R - Are these ideas **relevant** to my company?
A - How would **I apply** each of them in my company?
D - What **difficulties** might I meet and how would I overcome them?
A - Are there any **additional** actions that I might take that are not mentioned in the text?
R - What **resources** would be needed, what would these cost, and how could they be acquired?

There will of course be some discussion points where not all of these questions will be applicable.

The 6-Point Structure

After you have discussed the ideas in the text, you write an action plan in which you present practical proposals for implementing the conclusions you have reached in your discussion. The 6-Point Structure will help you to write your action plan:

1. **Problems:** Problems you have in your company in the area you have just discussed.
2. **Proposals:** Your proposals for improvement.
   a. Be specific and concrete.
   b. Include an implementation plan, with a time schedule and minimum and optimal implementation targets.
   c. Refer to any forms, charts, tables etc. that you would use, and include samples in an appendix.
3. **Obstacles:** Obstacles to implementation in employee attitudes, company organization and culture etc., and how these could be overcome.
4. **Resources:**
   a. The resources required: funds, equipment, materials, man-hours, expertise etc.
   b. The resources available within the company.
   c. Any resources that would have to be found outside the company.
   d. Alternatives that could be used to cover any shortfall in resources.
5. **Assessment:** Ways of assessing the results of implementing these proposals.
6. **Benefits:** The benefits your proposals would bring.

20.1 Product design and development: the primary requirements

Introduction

1. To design and develop new products your company will need to:
   a. Have a good understanding on the part of the CEO of what design and development involves.
   b. Prepare written rules and procedures for managing design and development.
   c. Prepare a new-product development project sheet.
   d. Establish a standard for testing new products.
   e. Calculate the costs of development.

The CEO's understanding of design and development

2. The CEO should understand what is involved in product design and development, especially what it requires in manpower, capital, equipment and time. He has full responsibility for providing the minimum resources that are needed. He should also participate actively in planning right from the beginning, and should have an understanding of the basic research.

3. He should be aware that successful product development requires:
   a. Sufficient time and expenditure on market research.
   b. Well-qualified design and development personnel.
   c. A substantial programme of education and training.
   d. An annual review of the level of investment in, and the cost-effectiveness of, the new-product development project.
   e. That development personnel participate in market research to get a good understanding of what the market needs.
   f. A recognition that basic research does not bring immediate benefits - it must be seen as part of a long-term plan.

Figure 20.1a New-product development project

Prepare written rules and procedures for managing design and development

4. Different departments and staff must be able to work together in the design and development of new products. This will require written rules and procedures. These should include the work procedures, the conceptual criteria governing the design, and a checklist of anticipated results.
   a. Prepare manuals for basic design, design calculation, design control points and methodology.

b. Establish a drawing standard, and a system of drawing control.
c. Establish standards for procurement and a range of standards for parts and materials.
d. Check that the rules and procedures are consistent with national safety and environment standards.

5. You should plan to use standardized parts in order to:
   a. Reduce the total number of components.
   b. Ensure that specific parts will perform identical function at all times no matter which design personnel are working with them.

Figure 20.1b Control of new design product

Prepare a new-product development project sheet

6. Formulate the medium-term and long-term plans in a new-product development project sheet, in accordance with the procedures specified in the new-product development standards. The project sheet should include:
   a. The purpose of the development project.
   b. The name/model of the new product, its purpose, its selling points, its working title, and the related safety and environmental issues.
   c. The state of the market: a forecast of demand, and information about what the competitors are doing.
   d. A complete description of the new product: its specifications, shape, and performance.
   e. The development engineering that has to be carried out, the intellectual property situation, the technology that will be used, and the reference standards and laws. (Reference standards are the official standards that other standards are based on.)
   f. The evaluation items that have to be checked at each stage of development.
   g. The target quality level, the target cost and the development schedule.
   h. Approval by management.

Figure 20.1c New-product development project sheet

Establish a standard for testing new products

7. The new product will have to be tested to make sure that it complies with the product development project sheet. This testing will include the basic design and the intermediate prototype. You will therefore need to have a new-product testing standard to specify the testing procedures. This standard should:
   a. Ensure that the design parameters fully comply with the project sheet.
   b. Clearly define the criteria for what is acceptable and what is not acceptable.
   c. Make clear the major design characteristics (operation, storage and handling) that will ensure that the product functions safely and properly.
   d. Specify the inspection steps to be taken to verify the design, and the review of inspection items by experts, including non-design personnel.
   e. Specify that corrective action be taken for any abnormalities or non-conforming products found in the verification results.
   f. Specify the inspection equipment to be used.

Figure 20.1d New-product review standard and inspection report

Calculate the cost of development

8. The cost of development must be worked out carefully and in detail. To do this calculate the time and cost of:
   a. The economic aspects:
      i. Preparing the original plan.
      ii. Training participants.
      iii. Changing over from the previous product type.
      iv. Research.
      v. Labor.
   b. The technical aspects:
      i. Improving the company's own level of technology.
      ii. Improving the process capability.
      iii. Responding to external conditions.
      iv. Anticipating predictable technological progress.
   c. The administration aspects:
      i. Organizing a system for product development.
      ii. Establishing standards.
      iii. Organizing education and training for engineers.
      iv. Clarifying responsibility and authority.
      v. Improving the administrative capability of the secretariat.

   Be sure to implement cost control and budget allocation, and be prepared to make immediate adjustments to the cost if there is any change in the overall situation.

Figure 20.1e Development cost calculation check sheet

Discussion

The following questions ask you to think about your company's approach to the design and development of new products, and how the ideas in the text could help to bring improvements. Some of the ideas may not be relevant to you. Concentrate on what is relevant. Keep notes of your conclusions – you will need them to prepare your action plan afterwards. Where appropriate ask yourself the RADAR questions.

Note: Always include in your discussion any figures referred to in the text, ***if*** you feel these are relevant to your company.

a. Parag. 2: Does the CEO in your company already take an active involvement in product development? If so, how does he contribute to its success? If not, how could he participate more actively, and what benefits would you expect this to bring?
b. Parag. 3 presents the important requirements of product development. Are these also important in your company? Are there any others you would add to the list?
c. Parag. 4 describes the rules and procedures for managing design and development. Apply the RADAR questions to these.
d. Parag. 5: Does your company always use standardised parts? Do you agree that they bring, or should bring, the benefits mentioned here?

e. Parag. 6 specifies what a project sheet should include. Look also at Figure 20.1c. Take a new product that your company is developing, or might possibly develop, and discuss what you would include in a draft project sheet for this product.
f. Parag. 7 describes what a new-product testing standard should determine. Apply the RADAR questions to establishing a testing standard for the product you have discussed in the previous question.
g. Parag. 8 describes what to include in calculating the cost of development. How many of these points would also apply in your company? Are there any others you would add? How would you go about making these calculations?

Action plan

Take the ideas you have found useful in the text, and in your discussion, and present them in a well-structured action plan for introducing improvements in your company. You might like to follow the 6-Point Structure.

20.2 Plan for the design and development of the new product

Introduction

1. To plan for the design and development of a new-product:
   a. Set up a unit to carry out the design work.
   b. Establish design standards that will cover all the design requirements.
   c. Make clear the responsibility and authority of the designers.
   d. Find out how many problems related to design and development arise each year.
   e. Plan how corrective action should be taken when problems arise.
   f. Establish procedures for changing the design standards.

Set up a unit to carry out the design work

2. Set up a unit to ensure that the design work is carried out as planned:
   a. Set up the unit.
   b. Decide who will hold the key positions in this unit.
   c. Decide how roles should be assigned and work shared: assignments should be made by the person in charge, and should be based on ability.
   d. Require the person in charge of the unit to check the state of progress periodically.
   e. Train design personnel to raise their skills to the necessary level.

3. Keep the following points in mind:
   a. Design staff are fully responsible for the follow-up on design work.
   b. If the work cannot be carried out as planned, they should find out why before deciding what action to take.
   c. They should be prepared to respond immediately to any design changes requested by the customer and properly authorized.

Figure 20.2a. Chart for role and share of design work (air conditioning equipment design dept.)

Establish design standards

4. Establish design standards covering all the design requirements. These standards will enable you to:
   a. Reduce any inconsistency in the requirements in the design drawings held by the different departments.
   b. Take recurrence prevention measures if and when any customer complaints arise.

5. To establish these design standards:
   a. Specify which departments should be involved, both in-house and in affiliated companies.

b. Classify the technical standards and technical documents, and their titles, contents and characteristics.
c. Specify the relationship of any reference standards contained in external standards (including international, national, and corporate standards) to your in-house standards.
d. Identify all the procedures that are to be followed from establishing the standards to issuing them, and then to reviewing them.
e. Fix the standard format.
f. Specify the numbering system of the standards.
g. Specify the procedures for classifying the standards.

6. In preparing these standards you should take into account the opinions not only of design personnel but also of personnel from other sections: production, sales, after sales service, etc. Finally, the standards should be:
   a. Approved by the senior design manager or his immediate deputy.
   b. Reviewed periodically and upgraded if necessary.
   c. Kept in their latest version in all the departments that are involved.

Figure 20.2b. Constitutive elements for design standards and procedures for allocating those elements
Figure 20.2c Table standard system

Make clear the responsibility and authority of the designers

7. Prepare planning sheets which clearly define the responsibility and authority of the design and development personnel, and of any other participants in the project. These sheets should be approved by the appropriate people in the design and development department, and copies sent to the various workshops. The staff assigned to design and development should, of course, have suitable qualifications, whether national, in-house, or other.

Figure 20.2d. Design system and qualified personnel list

Find out how many problems related to design and development arise each year

8. The design and development department should maintain data, on an annual basis, on the problems for which it is responsible. Such problems may emerge in complaints from customers, or they may be defects found in the manufacturing process or in the materials or parts supplied by sub-contractors. To get a clear annual picture of these problems, both inside and outside the company, take the following actions:
   a. For customer complaints, get the number of major complaints and calculate the cost of countermeasures.
   b. For manufacturing defects, get:
      i. The total percentage of defects: the total rate of defective and reworked units in relation to the volume of products shipped.
      ii. The line-direct rate: the rate of units shipped without being reworked in relation to the volume going through the manufacturing lines.

c. For subcontracted items, get the percentage of defects: the rejection rate per inspection lot, and the extent that they are behind with deliveries.
d. Find out the number of defects among supplied service parts.
e. Find out the number of design changes made to correct design defects during the first flow of products after the commencement of mass-production.
f. Analyze each problem by item and classify it.

9. In taking these actions:
   a. Classify in-house problems and customer complaints separately by product and by model.
   b. Clarify who is responsible for collecting information on problems, and make sure that they send the different departments the information they need.
   c. Clarify who is responsible for checking problems.
   d. Monitor how efficiently the procedures for dealing with problems are working.

Figure 20.2e Pareto diagram

Plan for corrective action when problems arise

10. The design and development department should of course be informed at once of any problems that emerge, so that they can make appropriate design changes. Put procedures in place to:
    a. Establish the cause of the problem.
    b. Carry out both temporary and permanent countermeasures.
    c. Make changes to design specifications and drawings.

    Always carry out complete quality checks after changes to specifications and drawings.

Figure 20.2f Quality information feedback system

Establish procedures for changing the design standards

11. Whenever changes are made in the design of a product, the design standards will have to be changed. Put procedures in place for changing these standards. You should:
    a. Establish and document procedures:
       i. For changing design standards, drawings and specifications.
       ii. For issuing a design change notice.
       iii. For keeping a record of the changes.
       iv. For ensuring that old drawings are collected before the new ones are distributed.
    b. Have the procedures approved by authorized personnel before they are implemented.

Figure 20.2g Procedures for establishment and review
Figure 20.2h Design change notice

Discussion

The following questions ask you to think about how the ideas in the text could be applied in your company. Some of the ideas may not be relevant to you. Concentrate on those that are relevant. Keep notes of your conclusions – you will need them to prepare your action plan afterwards. Where appropriate ask yourself the RADAR questions.

Note: Always include in your discussion any figures referred to in the text, ***if*** you feel these are relevant to your company.

a. Does your company already plan new-product design and development? If it does, where do you feel there are shortcomings, and how might these be improved?
b. Parag. 1 lists six main actions that should be taken in planning the development of new products. Which of these actions does your company already take?
c. Parags. 2 and 3: Apply the RADAR questions to these guidelines..
d. Parag. 4 gives two reasons for having design standards. Would each of these also be true of your company? Can you give one or two examples of things that have gone wrong, or could go wrong in these areas, if there were no design standards?
e. Parag. 5 lists the procedures for establishing design standards. Apply the RADAR questions to these.
f. Parag 6 mentions three actions to take in preparing design standards. Apply the RADAR questions to these.
g. Parag. 7: What problems can arise if the responsibility and authority of the designers are not clearly defined and documented?
h. Parag. 8: Can you give some examples of problems that have arisen in the development of new products in your company?
i. Parag. 8 suggests a number of actions to take to get a good grasp of such problems. Apply the RADAR questions to these.
j. Parag. 9 suggests several further actions to take in relation to such problems. Again apply the RADAR questions.
k. Parag. 10: Apply the RADAR questions to the suggestions in this paragraph.
l. Parag. 11 presents the procedures for changing the design standards. Give one or two examples of when your company has had to change the design standards. Then apply the RADAR questions to these proposed procedures.

Action plan

Take the ideas you have found useful in the text, and in your discussion, and present them in a well-structured plan for introducing improvements in your company. You might like to use the 6-Point Structure.

20.3 Implement the new design

Introduction

1. To implement the design of a new product your company will need to:
   a. Establish procedures for starting production of the new product.
   b. Prepare a flowchart with the quality characteristics of the manufacturing processes.
   c. Control the design and development budget.
   d. Regulate the design and development processes.

Establish procedures for starting production

2. To make sure that production conversion gets off to a smooth start, set up procedures for starting production, in cooperation with related departments:
   a. Check that the design and development phase is completed.
   b. Carry out a trial production run, remove any problems and improve the design of the production site.
   c. Decide on the standard of quality required for production.
   d. Decide on the quality characteristics required for each manufacturing process and specify these in a standard for the operating procedure. (The quality characteristics are key features of a product that can be examined to evaluate if it has the right level of quality.)
   e. Enter the required quality characteristics in the records.
   f. Specify the roles of the related departments in the operating procedure standard.
   g. Get the related departments to carry out a production conversion review.
   h. Be sure to explain everything fully to the related departments and operators before starting production.
   i. Check the procedures and schedule for production conversion.

Figure 20.3a Design review report

Prepare a flowchart showing the quality characteristics of the manufacturing processes

3. To enable personnel from related departments to check the quality characteristics of the manufacturing processes, prepare a flow chart of these processes. This flow chart should:
   a. Specify the quality characteristics required in these processes.
   b. Specify how the quality characteristics are to be checked.
   c. Keep records of the quality characteristics.

4. Take the following steps:
   a. Review the system for checking and recording quality characteristics - and see if the recording can be done automatically.
   b. Review the statistical quality records used to determine the acceptability of lots.
   c. Clarify the procedure for identifying quality characteristics.
   d. If possible have an automatic system for checking the quality characteristics.

Figure 20.3b Quality assurance process drawing

Control the design and development budget

5. To control the budget for design and development:
    a. Make a list of the items required for design and development.
    b. Estimate the cost of each item.
    c. Draw up a budget application form. The person in charge of budgeting should check previous records for similar products before submitting the application.
    d. Explain the contents of the budget to related personnel, and then ask them to follow it strictly.
    e. Periodically check expenditure against the budget.
    f. If there is a big cost over-run, the person in charge should hold an emergency meeting with all the members of the department, to decide on an appropriate course of action.
    g. If the cost over-run is caused by specification changes required by the customer, negotiate with the customer through the sales department.
    h. Keep expenditure not provided for in the budget as low as possible.

Figure 20.3c Budget application form

Regulate the design and development processes

6. To regulate the design and development processes:
    a. Get a good understanding of what the market needs.
    b. Review these needs from both medium and long-term perspectives.
    c. Get a good idea of what technology will be required.
    d. Prepare a development project sheet.
    e. Acquire the necessary resources (employees, materials and cost).
    f. Systematize the development processes.
    g. Clarify who has responsibility and authority.

Figure 20.3d Standard for each individual product development step

Discussion

The following questions ask you to think about how the ideas in the text could be applied in your company. Some of the ideas may not be relevant to you. Concentrate on those that are relevant. Keep notes of your conclusions – you will need them to prepare your action plan afterwards. Where appropriate ask yourself the RADAR questions.

Note: Always include in your discussion any figures referred to in the text, ***if*** you feel these are relevant to your company.

a. What is your company's experience of implementing the design of a new product? Where do you see the main shortcomings, if any, in your company's way of doing this?
b. Parag 1 lists four primary actions that a company will need to take to implement the design. Which of these actions does your company already take?

c. Parag. 2: Does your company already have procedures for starting production? What are the shortcomings, if any, of your procedures?
d. Parag. 2 describes the procedures for starting production. Apply the RADAR questions to these.
e. Parag. 3: What problems can arise if the quality characteristics of the production process are not documented? What are the benefits of documenting them?
f. Parag. 3 describes what to include in a flow chart of the manufacturing processes. Apply the RADAR questions in relation to a new product that you have started work on, or may start work on.
g. Parag. 4 suggests some additional steps to take. Again apply the RADAR questions to these.
h. Parag. 5: How successful is your company in controlling its design and development budget ? What shortcomings are there, if any?
i. Parag. 5 presents a list of actions to take to control the budget. Apply the RADAR questions to these?
j. Parag. 6: Apply the RADAR questions to these suggestions for regulating the design and development processes.

Action plan

Take the ideas you have found useful in the text, and in your discussion, and present them in a well-structured action plan for introducing improvements in your company. You might like to use the 6-Point Structure.

20.4 Prepare for the development of the new product

Introduction

1. To prepare for the development of the new product:
   a. Set up a new-product development system and establish standards.
   b. Establish evaluation standards and criteria for reviewing the design and testing the product.
   c. Design parts that meet common standards.
   d. Check the process capability: make sure that the production process has the capability to produce products with the required quality characteristics.
   e. Carry out design reviews based on customer claims.

Set up a new-product development system

2. To set up a new-product development system and establish standards:
   a. Draw up a product development mid-term plan.
   b. Draw up an engineering development mid-term plan.
   c. Draw up a development plan for the technology and equipment your company will require.
   d. Get a good understanding of market needs.
   e. Plan product development for the current term.
   f. Verify the product concept and the technology capacity required to design and develop it.
   g. Prepare a new-product development project schedule.
   h. Hold a product planning conference.
   i. Carry out trial manufacture and development.
   j. Check the results of this trial.
   k. Review the design.
   l. Prepare a final project report to be approved by the project manager.
   m. Hold a check and review meeting with the related sections.

   Review this system periodically, and get the opinions of those involved in it.

Figure 20.4a New-product development system

Establish evaluation standards and criteria for design review and product testing

3. To establish evaluation standards and criteria for reviewing the design and testing the product:
   a. Decide on the design review procedures.
   b. Decide on the test procedures for certification.
   c. Decide on the prototype-testing standard.
   d. Clarify the evaluation criteria.

Experts from other departments should participate in design review if necessary. The purpose of this review is, of course, to ensure that the product meets the user's requirements.

Figure 20.4b New-product evaluation criteria

Design parts that meet common standards

4. To design parts that meet common standards:
   a. Design bolts and nuts in accordance with the standard products.
   b. Use standard parts made by a specialized manufacturer.
   c. Specify your own approved parts in accordance with the design objectives, in-house standards and process procedures.
   d. List and register standard parts and use items from these lists as required.

Figure 20.4c Parts standardization procedures.

Check the process capability

5. Make sure that the production process can produce products with the required quality characteristics (the quality features that are of particular importance to customers). This is known as the process capability (Cp, Cpk). To check it:
   a. Determine the scope of the process (type, lot, process, characteristic).
   b. Decide on the equipment to be used to measure it, the unit of measurement, and the person who will do the measuring.
   c. Review the measurement results systematically.
   d. Calculate the process capability index.
   e. Judge whether the process conditions are acceptable or not.
   f. Take immediate corrective action if an abnormality occurs.
   g. Upgrade technicians' skills when the processes are stabilized.
   h. Specify the appropriate statistical techniques.

(See Unit 11.1 for a more detailed description of carrying out a process capability study.)

Figure 20.4d Process capability research records.

Carry out design reviews

6. Carry out design reviews at appropriate intervals, based on customer claims:
   a. Collect information on customer claims.
   b. Research the possible causes of these claims.
   c. Take both corrective and preventive action for each cause.
   d. Check that the corrective action decided on in the design review is adequate; carry out a follow-up check for each product.
   e. Carry out a design review from product planning through to product design as required.
   f. Be thorough in considering the outcomes of the customer claims, their causes, and corrective and preventive actions.

g. Train specialists to make sure that the design review is carried out correctly.
h. Have specialists from other departments participate in the design review.
i. Always be sure to carry out customer claim research for products that are being introduced for the first time.

Figure 20.4e Quality assurance system chart

Discussion

The following questions ask you to reflect on your company's approach to preparing a new product development system, and how the ideas in the text could be applied in your company. Some of the ideas may not be relevant to you. Concentrate on those that are relevant. Keep notes of your conclusions – you will need them to prepare your action plan afterwards. Where appropriate ask yourself the RADAR questions.

Note: Always include in your discussion any figures referred to in the text, ***if*** you feel these are relevant to your company.

a. Does your company already have a new product development system? In what ways does it nee to be improved?
b. Parag 1 lists five primary actions to be taken to prepare for the development of the new product. Which of these actions does your company already take?
c. Parag. 2 presents a number of actions to take to organize the new-product development system. Apply the RADAR questions to these.
d. Why is it important to have evaluation criteria for design review and product testing?
e. Parag. 3 presents a procedure for establishing evaluation criteria. Apply the RADAR questions.
f. Why is it important to design parts that meet common standards? To what extent does your company do this? Could it do this to a greater extent?
g. Parag. 4: Apply the RADAR questions to these guidelines.
h. Give one or two examples of important quality characteristics in new products that your company has developed, or might develop.
i. Parag. 5 suggests actions to take to make sure that the production process can deliver products with the required quality characteristics. Apply the RADAR questions.
j. Does your company carry out design reviews often enough? How important do you think this is?
k. Parag. 6 describes what needs to be done to carry out design reviews. Apply the RADAR questions.

Action plan

Take the ideas you have found useful in the text, and in your discussion, and present them in a well-structured action plan for introducing improvements in your company. You might like to use the 6-Point Structure.

20.5 Take a long-term perspective on design and development

Introduction

1. The design and development of a new product is normally a big investment. To bring a good return on this investment the new product must hold its position in the market well into the future. You therefore need to take a long-term perspective. This text highlights several actions that are especially important in taking a long-term approach. Some have already been presented in this unit but they are emphasized again here. You should:
   a. Ensure that you have a long-term development system.
   b. Control the progress, quality and cost of design and development planning.
   c. Make a continuous effort to reduce quality problems.
   d. Base each phase of product planning on market research.
   e. Take environmental trends into account.

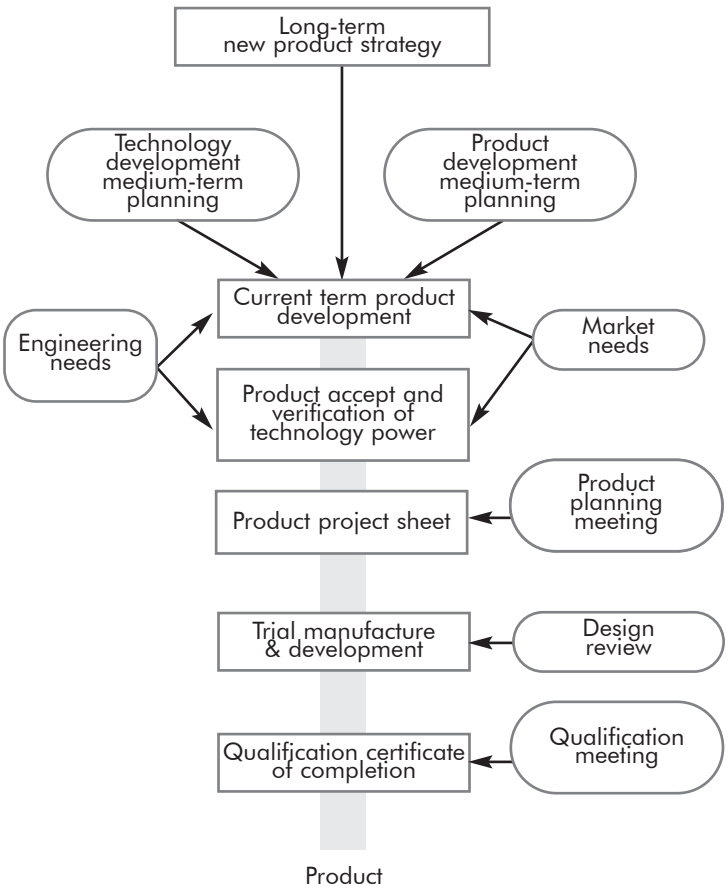
Ensure that you have a long-term development system

2. To ensure that you have a long-term development system, the following actions are especially important:
   a. Gain a good understanding of market needs.
   b. Check what high-level technology your company needs.
   c. Ensure that there are adequate resources of employees, materials, and money.
   d. Determine a long-term development policy. (This is a CEO function.)
   e. Establish two forms of planning: planning that can be completed in the short-term and planning that can respond flexibly to changes in the business situation of the company.
   f. Make sure to have planning approved by the technical management.
   g. Involve team members from outside the company.
   h. Reserve the necessary funds in a long-term budget.

Control the progress of design and development planning

3. A long-term perspective also requires that you control the progress, quality and cost of design and development planning.
   a. Clarify the development policy (including investment intentions) in the medium-term business plan.
   b. Prepare a plan to collect market information.
   c. Prepare a detailed schedule for quality and cost control at each design and development phase, and be sure to control quality and cost from the beginning of development planning.
   d. Record the results and planning at each design and development phase and be sure to follow up on these.

Figure 20.5a Product development procedures



e. If there is any change in design planning, have related personnel hold an action meeting and share information about the changes.
f. If design and development are changed, verify the reliability of the products.
g. Ensure that there is regular communication between the design and development personnel and those in charge of related departments so that everyone is kept up to date.

Figure 20.5b Table for design and development progress control

Make a continuous effort to reduce quality problems

4. Quality-related problems will keep arising. To reduce them requires a continuous effort:
   a. Get a good understanding of critical items that affect quality.
   b. Hold regular quality verification meetings, and decide on the targets for reducing quality problems.
   c. Investigate the possible causes of each problem, and take recurrence-prevention measures.
   d. Wherever appropriate use statistical methods to identify problems.
   e. Establish a communication system for managing claims.
   f. Keep employees informed of the cost of quality problems so that they will become more sensitive to them.
   g. Communicate regularly with major customers about quality issues.

Base product planning on market research

5. If your new product is to establish itself successfully as a market leader, in both domestic and world markets, its development must be based on thorough market research. The table in Figure 20.5c shows how closely new-product development should be related to the market.

Figure 20.5c Product planning and market research

New product concept	Create ideas.	Gather all the information you can from both inside and outside the company: information about consumers, competitive products and sales dealers.
	Evaluate and select ideas.	Evaluate and select ideas: take into account the development period, development cost, price and production profit with reference to the target market, and the competitive edge you want to achieve.
	Decide on a product concept.	Make a comparative evaluation of consumers' response, and decide on the scale of production, and the sales method.
Strategy review	Review the marketing strategy.	Decide on the marketing target, and how to proceed marketing.
	Carry out a business review.	Carry out a review of profitability (cost-volume-profit) based on the product concept.
Product development	Decide on the product specifications.	Decide on the specifications of the product, and then repeat the trial manufacture and decide on the detailed specifications. Review detailed specifications for engineering and production points of view.
	Do a field test.	Carry out a field test, including the quality and shipping conditions.
	Set up production facilities.	Set up production facilities that correspond to market demand, keeping the capital investment in mind.
Market Introduction	Introduce the new product on the market.	Carry out a market trial, and prepare instruction manuals and sales promotion materials.

Take environmental issues into account in designing a new product

6. In taking a long-term perspective it is essential that you allow for trends in environmental protection (e.g. pollution control, energy efficiency) without reducing performance:
   a. Use less resources and materials, use recycled materials and design the product to have a long lifetime.
   b. Develop a design that does not consume excessive energy.
   c. Improve both the recovery and the recycling of products that are no longer in use.
   d. Provide for the easy dismantling of products that are no longer in use, and for their easy final disposal without causing any pollution.

Figure 20.5d Check sheet for environmental matching design

Discussion

The following questions ask you to reflect on your company's approach to long-term design and development, and how the ideas in the text could help to bring improvements. Some of the ideas may not be relevant to you. Concentrate on those that are relevant. Keep notes of your conclusions – you will need them to prepare your action plan afterwards. Where appropriate ask yourself the RADAR questions.

Note: Always include in your discussion any figures referred to in the text, ***if*** you feel these are relevant to your company.

a. Do you think that your company take a sufficiently long-term approach to design and development?
b. Parag 1 lists five primary actions that a company should take to form a longer-term perspective. Which of these actions does your company already take?
c. Parag. 2 describes how to organize a long-term development system. Apply the RADAR questions.
d. Parag. 3:How successful is your company in controlling the progress, quality and cost of design and development planning? What, if any, are the main shortcomings?
e. Parag. 3 suggests ways of controlling these. Apply the RADAR questions.
f. Parag. 4: What priority does your company give to reducing quality problems? How successful is it?
g. Parag. 4 presents ways to reduce quality problems. Apply the RADAR questions.
h. Parag. 5: To what extent does your company base its product planning on market research? How important is this?
i. Parag. 5 outlines the steps of product planning based on market research. Which of these steps does your company already take? Should your company take all of them? Are there any other steps you would add to this list?
j. To what extent does your company take environmental issues into account in designing a new product? What more could it do? What risk is there of reducing performance by giving attention to environmental issues?
k. Parag. 6 suggests several ways to take trends in environmental protection into consideration in designing a new product. Apply the RADAR questions to these.

Action plan

Take the ideas you have found useful in the text, and in your discussion, and present them in a well-structured action plan for introducing improvements in your company. You might like to use the 6-Point Structure. Alternatively you may wish to incorporate them in one of your earlier action plans.

Test

Answer these questions using only the information given in the text. For each question one, two or all three answers may be correct. Tick the answer or answers you think are correct for each question. Each question carries 3 points – you get one point for each correct answer that you tick, and one point for each wrong answer that you do not tick.

20.1 Set up the primary requirements for new-product design and development

1. The CEO has full authority for providing ... needed for product development.
   - ☐ a. All the resources.
   - ☐ b. The minimum resources.
   - ☐ c. The optimum resources.
2. The CEO should be aware that successful product development requires that development personnel participate in ...
   - ☐ a. Financial planning.
   - ☐ b. Purchase of technical equipment.
   - ☐ c. Market research.
3. The rules and procedures for managing design and development should be documented in order to:
   - ☐ a. Reduce the costs of materials.
   - ☐ b. Ensure that the different departments and staff can work effectively together.
   - ☐ c. Improve the drawing methods.
4. The new-product development project sheet should include:
   - ☐ a. A complete description of the new product.
   - ☐ b. An estimate of sales volume.
   - ☐ c. The target quality level.
5. The new product testing standard should:
   - ☐ a. Ensure that the design parameters fully comply with the product-testing standard.
   - ☐ b. Clearly define the criteria for what is acceptable.
   - ☐ c. Make clear the design characteristics that ensure that the product is safe.
6. To work out the cost of development, calculate the time and cost of:
   - ☐ a. Changing over from the previous product type.
   - ☐ b. Improving the process capability.
   - ☐ c. Preparing a brochure for the sales team.

20.2 Plan for the design and development of the new product

7. The assignment of roles for the design work should be based on:
   - ☐ a. The seniority of each person.
   - ☐ b. The qualifications of each person.
   - ☐ c. The ability of each person.

8. The follow-up design work is the responsibility of:
   - ☐ a. The design staff.
   - ☐ b. The production staff.
   - ☐ c. The customer services staff.
9. Design standards should be established in order to:
   - ☐ a. Allow recurrence prevention measures to be taken when there are customer complaints.
   - ☐ b. Encourage designers to be creative in producing new designs.
   - ☐ c. Reduce any inconsistency in the requirements specified in the design drawings held by the different departments.
10. The design standards should be approved by:
   - ☐ a. The CEO.
   - ☐ b. The senior design manager.
   - ☐ c. The senior production manager.
11. The sheets specifying the responsibility and authority of the design and development personnel should be approved by:
   - ☐ a. The CEO.
   - ☐ b. The senior design manager.
   - ☐ c. The appropriate people in the design and development department.
12. To find the number of manufacturing defects each year, get the total rate of defective and reworked units in relation to:
   - ☐ a. The volume of products shipped.
   - ☐ b. The number of products manufactured.
   - ☐ c. The number of products inspected.
13. To ensure that corrective action is taken as soon as problems arise:
   - ☐ a. Pass the information on quickly to the customer services department so that they can act to prevent recurrence of the problem.
   - ☐ b. Implement and confirm design changes.
   - ☐ c. Establish the cause of the problem.
14. The procedures for changing the design standards, drawings and specifications include:
   - ☐ a. Have the changes approved by the authorized personnel before they are implemented.
   - ☐ b. Be sure to collect old drawings as soon as possible after the new ones are distributed.
   - ☐ c. Issue a design change notice.

20.3 Implement the new design

15. The procedures for starting production in cooperation with related departments include:
   - ☐ a. Specify the related departments and their role in the standard for the operating procedure.
   - ☐ b. Decide on the quality characteristics required for each manufacturing process.
   - ☐ c. Explain everything fully to the related departments and operators as soon as possible after starting production.

16. The manufacturing processes should be documented so that personnel from related departments can check:
    - ☐ a. The quality characteristics of the processes.
    - ☐ b. The records of the processes.
    - ☐ c. The success of the processes.
17. If there is a big cost over-run in design and development expenditure, the person in charge should hold an emergency meeting with:
    - ☐ a. All the members of the department.
    - ☐ b. The CEO.
    - ☐ c. The senior design manager.
18. To regulate the design and development processes:
    - ☐ a. Get a good understanding of what the market needs.
    - ☐ b. Review the design standards.
    - ☐ c. Get a good idea of what technology will be required.

20.4 Prepare for the development of the new product

19. To set up a new-product development system:
    - ☐ a. Draw up a plan to increase your company's market share.
    - ☐ b. Draw up a development plan for the technology and equipment your company will require.
    - ☐ c. Carry out trial manufacture and development.
20. To establish evaluation standards and criteria for design review and product testing:
    - ☐ a. Determine the design review procedures.
    - ☐ b. Determine the prototype-testing standard.
    - ☐ c. Determine the market-testing procedures.
21. Parts should be designed that meet:
    - ☐ a. Company standards.
    - ☐ b. Business standards.
    - ☐ c. Common standards.
22. To make sure that the production process can produce products with the required quality characteristics:
    - ☐ a. Decide on the unit of measurement.
    - ☐ b. Decide on the measuring equipment.
    - ☐ c. Determine the scope of the process (type, lot, process, capability).
23. To carry out design reviews:
    - ☐ a. Collect information on customer claims.
    - ☐ b. Carry out a design review from product planning through to product shipping.
    - ☐ c. Train specialists to make sure that the design review is carried out correctly.

20.5 Take a long-term perspective on design and development

24. To organize a long-term new-product development system:
    - ☐ a. Gain a good understanding of market needs.
    - ☐ b. Ensure that there are adequate resources of employees, materials and money.
    - ☐ c. Invest in the latest technology.

25. To control the progress, quality and cost of design and development planning:
    - ☐ a. Clarify the development policy in the medium-term business plan.
    - ☐ b. Prepare a detailed schedule for quality and cost control at each design and development phase.
    - ☐ c. Ensure that there is regular communication between the design and development personnel and those in charge of related departments.
26. To reduce quality problems:
    - ☐ a. Transfer those who cause problems out of the design department.
    - ☐ b. Get a good understanding of critical elements that affect quality.
    - ☐ c. Take recurrence prevention measures.
27. Keep employees informed of quality problems so that:
    - ☐ a. Future savings can be estimated.
    - ☐ b. Employees will become sensitive to them.
    - ☐ c. The design and development budget can be adjusted.
28. The development of a new product must be based first of all on:
    - ☐ a. Market research.
    - ☐ b. The business strategy.
    - ☐ c. The product specifications.
29. To take environmental issues into account:
    - ☐ a. Design the product to have a short lifetime.
    - ☐ b. Improve the recovery and recycling of products that are no longer in use.
    - ☐ c. Use less resources and materials.

Relationship with ISO

20.1 Set up the primary requirements for new product design and development

The CEO's understanding of design and development
5 Management responsibility
6.1 Provision of resources
6.2 Human resources
6.2.2 Competence, awareness and training
6.3 Infrastructure

Prepare written rules and procedures for managing design and development
4.2 Documentation requirements
4.2.1 General
4.2.2 Quality manual
7.3 Design and development

Prepare a new-product development project sheet
7.3.1 Design and development planning

Establish a standard for testing new products
7.3.4 Design and development review

Calculate the cost of development
6.2.2 Competence, awareness and training
5 Management responsibility
7.3.5 Design and development verification
7.3.6 Design and development validation

20.2 Plan for the design and development of the new product

Set up a unit to carry out the design work
5.5.1 Responsibility and authority
6 Resource management
7.3.1 Design and development planning
7.3.4 Design and development review

Establish design standards
4.2.3 Control of documents
5.5.1 Responsibility and authority
7.3.1 Design and development planning

Make clear the responsibility and authority of the designers
7.3.1 Design and development planning

Find out how many problems related to design and development arise each year
8.2.1 Customer satisfaction
8.2.4 Monitoring and measurement of product
8.4 Analysis of data

Plan for corrective action when problems arise
8.5.2 Corrective action

Establish procedures for changing the design standards
7.3.7 Control of design and development changes

20.3 Implement the new design

Establish procedures for starting production
7.1 Planning of product realization
Prepare a flowchart showing the quality characteristics of the manufacturing processes
7.1 Planning of product realization
7.3.5 Design and development validation
7.5.1 Control of production and service provision
Control the design and development budget
5.1 Management commitment
Regulate the design and development processes
7.2.1 Determination of requirements related to the product
7.2.2 Review of requirements related to the product
7.3.1 Design and development planning

20.4 Prepare for the development of the new product

Set up a new-product development system
7.3.1 Design and development planning
Establish evaluation standards and criteria for design review and product testing
7.3.4 Design and development review
7.3.5 Design and development verification
7.3.6 Design and development validation
Design parts that meet common standards
7.2.2 Review of requirements related to the product
7.3.2 Design and development inputs
7.3.3 Design and development outputs
Check the process capability
7.1 Planning and product realization
7.2.2 Review of requirements related to the product
8.2.3 Monitoring and measurement of processes
Carry out design reviews
7.3.4 Design and development review

20.5 Take a long-term perspective on design and development

Ensure that you have a long-term development system
5.1 Management commitment
Control the progress of design and development planning
7.3.1 Design and development planning
Make a continuous effort to reduce quality problems
8.5 Improvement
Base product planning on market research
5.2 Customer focus
7.2 Customer-related processes
Take environmental issues into account in designing a new product
6.3 Infrastructure
6.4 Work environment

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