一般社団法人 Japan Association for Human Resources in Industrial Product Manufacturing
工業製品製造技能人材機構

FY2026
SSW (ii) Evaluation Exam for Industrial Product Manufacturing Overview Introduction Course

(Machining and metal processing)

— Studying Using the “Study Reference Text” —

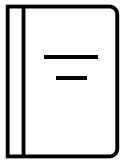
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Introduction

Target audience of this course: People in the manufacturing field with Specified Skilled Worker (i) status ⇒ aiming for (ii)

"Study Reference Text" for the Specified Skilled Worker (ii) Evaluation Exam

Japanese version



Translated version



Available on the My Page for JAIM member companies

In today's course, we will explain the practice questions in the above text.

Introduction

Total: 120 minutes	Program of This Course	Presenter
Approx. 15 minutes	**Introduction** Overview of the Specified Skilled Worker (ii) Evaluation Exam, notes when taking the exam, Japanese used on the exam, and notes for studying	AOTS
Approx. 105 minutes	**Lecture** Explanation of practice questions in the “Study Reference Text,” important keywords, related skills, and overall summary	Instructor

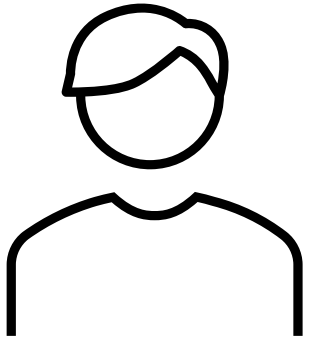
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* The above program times and time allocations are estimates. They vary slightly depending on the category and language of interpretation.

Profile of a Specified Skilled Worker (ii)

Can carry out highly specialized and technical work based on one's own judgment



Can bring together on-site workers and provide instruction and supervision

Has proficient skills based on practical work experience, etc.

Requirements to obtain status of residence for Industrial Product Manufacturing Specified Skilled Worker (ii) personnel

Meet all conditions in either of the following two routes

Specified Skilled Worker (ii) Evaluation Exam route	① Obtain Business Career Certification Grade 3 (either the Production Management Planning category or the Production Management Operation category)
	② Pass the Specified Skilled Worker (ii) Evaluation Exam for Industrial Product Manufacturing (either the Machining and Metal Processing category, the Electric and Electronic Equipment Assembly category, or the Metal Surface Treatment category)
	③ Have 3+ years of practical work experience at a manufacturing site of a company that has a base in Japan
Skills Test route	① Obtain Skills Test Grade 1
	② Have 3+ years of practical work experience at a manufacturing site of a company that has a base in Japan

Chapter 1: Exam Overview and How to Study

Exam Overview☞ “Study Reference Text” p. 1

Exam schedule	FY2026: Round 1: July 29, 2026 – August 1, 2026 (completed) Round 2: November 25, 2026 – November 28, 2026 (planned) Round 3: Around February 2027 (planned)		
Exam location	Test centers provided by Prometric Co., Ltd. (Domestic: throughout Japan)		
Administration format	CBT (Computer-Based Testing) format (practical test*) * Practical test: Questions that require reading content related to actual work processes and materials and choosing the correct answer		
Exam language	Japanese * Furigana provided for kanji		
Exam categories	3 categories (Machining and Metal Processing category / Electric and Electronic Equipment Assembly category / Metal Surface Treatment category)		
Exam level	Based on the level of the Skills Test Grade 1 exam		
Exam time	80 minutes	Number of questions	30 questions
Eligibility	· In principle, foreign nationals who are at least 17 years old on the exam date (at least 18 years old if they are Indonesian) and who intend to work in Japan if they pass the exam · Foreign nationals who have 3+ years of practical work experience at a manufacturing site of a company that has a base in Japan by the day before the exam * A “Work Experience Certificate” proving the above work experience must be submitted, and an eligibility confirmation number must be obtained		
Application	Prometric Specified Skilled Worker (ii) Evaluation Exam for Industrial Product Manufacturing Dedicated Page https://www.prometric-jp.com/ssw/test_list/archives/18		
Exam fee	15,000 yen		
Passing criteria	Correct answer rate of 60% or more		

Notes when taking the exam

☞ “Study Reference Text” p. 2

- Taking exam questions/answers out or sharing them is prohibited

- Security measures

- Response to misconduct

Notes for studying
☞ “Study Reference Text” p. 2

(1) Studying Japanese

① Improving Japanese reading comprehension

Reading comprehension texts for Japanese study, newspapers/magazines, online news, etc.

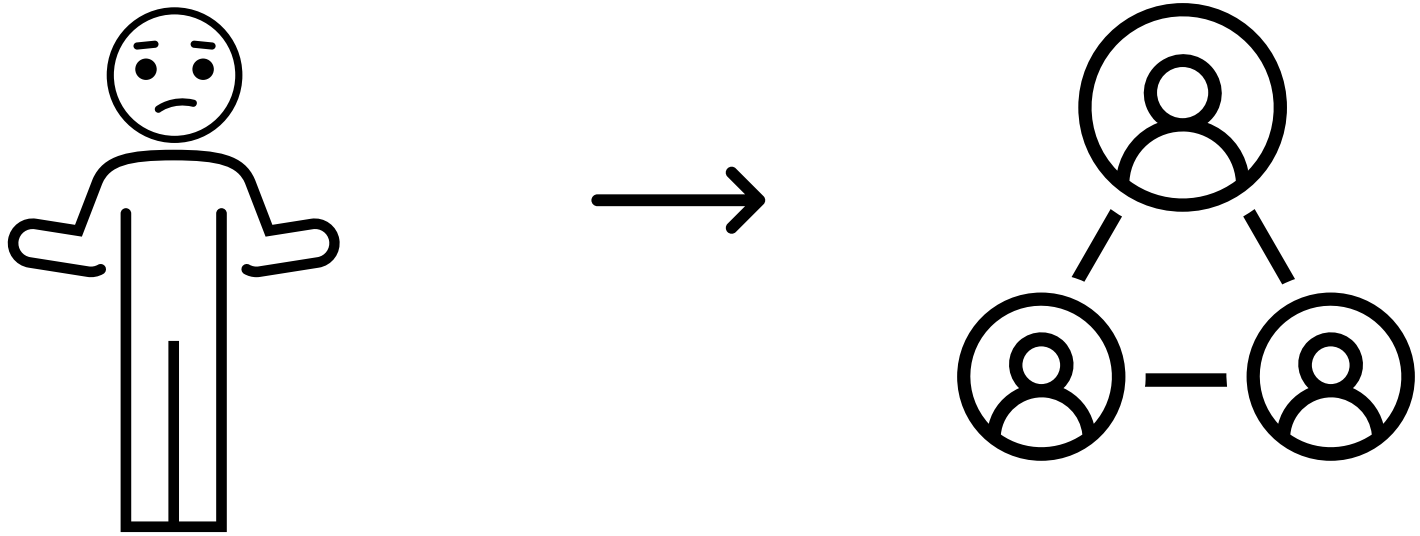
② Expanding specialized vocabulary

Creating your own specialized vocabulary list, etc.

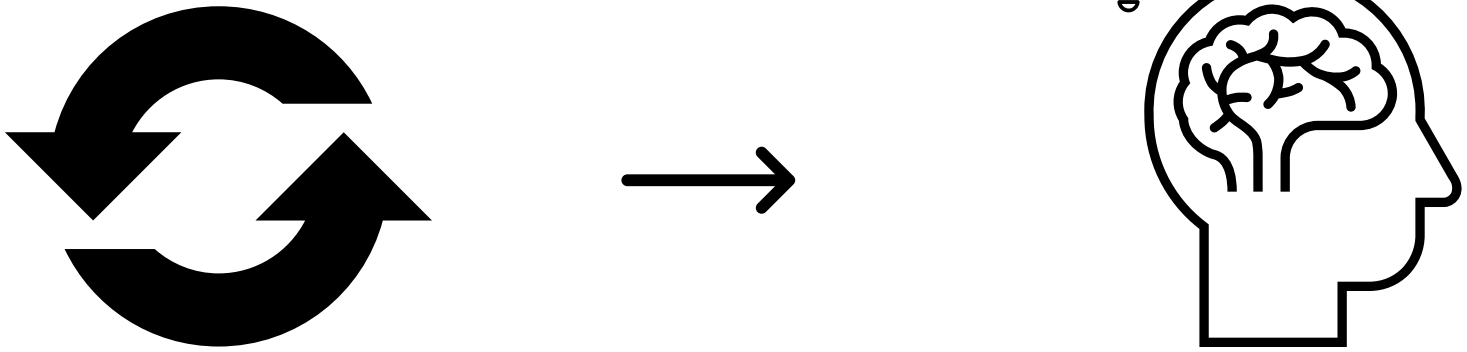
③ Becoming familiar with the Japanese used on the exam

Getting plenty of exposure to exam questions, instructions, and answer choices

(2) Ask supervisors and coworkers at the workplace



(3) Read repeatedly



(4) Read the question and answer choices carefully to the end.



Examples of question wording

Questions asking for the correct answer

Q. a~dの中から正しいものを選びなさい。

Q. Choose the correct statement from a–d.

Q. 以下の中から、正しいものを選べ。

Q. Choose the correct statement from the following.

Q. 次のうち、正しいものはどれか。

Q. Which of the following statements is correct?

Examples of question wording

Questions asking for the incorrect answer

Q. 次のうち、正しくないものはどれか。

Q. Which of the following statements is not correct?

Q. 次のうち、間違っているものはどれか。

Q. Which of the following statements is wrong?

Q. 次のうち、誤っているものはどれか。

Q. Which of the following statements is incorrect?

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Practice Question 2-1

■ Which of Seiri, Seiton, Seiso, Seiketsu, and Shitsuke does each of the following describe?

① (　　) Clearly distinguish between necessary and unnecessary items.

② (　　) Eliminate unnecessary searching time to improve work efficiency.

③ (　　) Discover equipment abnormalities and problems (e.g., oil leaks and loose parts) while removing dirt.

④ (　　) Maintain good conditions at all times and standardize them so that anyone can follow the same practices.

⑤ (　　) Voluntarily follow established rules even when a leader is not present.

Answer ☞ “Study Reference Text” p. 7

Explanation

① This describes sorting. (Seiri)

② This describes the purpose of setting-in-order. (Seiton)

③ Viewing cleaning as an inspection helps detect abnormalities early. (Seiso)

④ Standardization is important for maintaining a clean and orderly condition. (Seiketsu)

⑤ The goal is to make following rules a habit and create a workplace where each person acts independently. (Shitsuke)

Explanation ☞ “Study Reference Text” p. 6

1.3 Seiri, Seiton, Seiso, Seiketsu, Shitsuke (5S)

These five terms are called 5S because their romanized Japanese forms all begin with the letter S. They are basic rules for performing work safely, reliably, and efficiently. Everyone in the workplace should work together to make 5S a routine practice.

(1) Sorting Seiri

This means separating necessary items from unnecessary items and reducing the number of items.

(2) Setting-in-Order Seiton

This means placing necessary items where they are easy to use. Their locations are designated so that anyone can find them.

Explanation (continued)
☞ “Study Reference Text” p. 6

(3) Cleaning Seiso

This means cleaning thoroughly. Dirt and waste are removed so that the causes of dirt can be identified.

(4) Standardizing Seiketsu

This means maintaining a clean condition. Seiri, Seiton, and Seiso are continued to keep the workplace clean. Establishing rules and standardizing practices are important for this.

(5) Sustaining the Discipline Shitsuke

This means developing the habit of following rules.

- Tool Shadowing for Tool Storage
  - A sponge with cutouts in the shapes of the tools is placed inside the toolbox so that it is clear at a glance where each tool should be returned.
  - At the end of work, empty cutouts immediately show whether any tools have been left behind or lost.
  - This is an example of achieving both Setting-in-Order and Standardizing at the same time.

Practice Question 2-2

■ State the criteria for each of the following.

① What is the minimum height at which safety measures are required for work at height?

② What is the minimum height at which a full-body harness is required for work at height?

③ What is the minimum noise level at which noise level measurements and medical examinations are mandatory?

④ What is the minimum illuminance required for precision work?

⑤ What is the minimum illuminance required for ordinary work?

⑥ What is the minimum lifting load that requires skill training for operating a floor-operated crane?

Answer ☞ “Study Reference Text” p. 14

Explanation

Refer to the main text.

Explanation ☞ “Study Reference Text” p. 11

Noise and illuminance are important health factors in manufacturing workplaces.

Noise can cause hearing loss and stress.

At workplaces where noise exceeds 85 decibels (dB):

- Regular noise level measurements and medical examinations are mandatory.
- Noise reduction measures (e.g., soundproof covers) and protective equipment (e.g., earplugs) are required.

Explanation (continued)
☞ “Study Reference Text” p. 11

Low illuminance (brightness) may cause eye strain or accidents.

The following standards apply (Industrial Safety and Health Act).

- Precision work: 300 lux (lx) or more
- Ordinary work: 150 lux or more
- Rough work: 70 lux or more

Explanation (continued)
☞ “Study Reference Text” p. 13

(2) Safety Measures for Work at Height (2 m or More)

Work at height is work performed at a height of 2 meters or more above the ground or floor.

There are strict rules to prevent falls.

- **Installation of work platforms:** In principle, a work platform must be provided, and handrails or enclosures must be installed.
- **Wearing a safety harness:** If a work platform cannot be provided, the use of fall arrest equipment (a safety harness) is mandatory.
  In particular, for work where there is a risk of falling from a height exceeding 6.75 m, a full-body harness (a safety harness consisting of multiple straps around the shoulders, thighs, chest, etc., that distribute the impact) must be worn.

Explanation (continued)
☞ “Study Reference Text” p. 13

(3) Crane Operation

Qualifications and inspections are mandatory for crane work to ensure safety.

- **Operating qualifications:** Depending on the type of crane and the operating method, special training, skill training, or a license is required.

Explanation (continued)

☞ “Study Reference Text” p. 13

Example

- **Hoist cranes** Qualifications required for hoist cranes (floor-operated cranes)

  Lifting loads of 5 tons or more: Completion of the skill training course for operation of floor-operated cranes

  Lifting loads of less than 5 tons: Completion of special training for crane operation
- **Suspending loads** Qualifications required for slinging (suspending loads)

  Lifting loads of 1 ton or more: Skill training course for slinging

  Lifting loads of less than 1 ton: Special Training for slinging

Explanation (continued)

☞ “Study Reference Text” p. 13

- **Periodic inspections:** Cranes must undergo voluntary inspections of safety devices, brakes, etc., every year after installation and every month.

- Check the Notices at Your Workplace
  - Noise measurement results and signs indicating PPE-required areas are often posted in the workplace.
  - Check the notices to confirm which classification your work area falls under.
  - If it is unclear, ask the person in charge of health and safety.

- “It’s Not Very High” Can Be Dangerous
  - There is a near-miss incident in which a worker nearly fell from a stepladder after losing balance when a wrench slipped while retightening a bolt.
  - When performing work requiring force at height, balance can be lost the moment the tool slips.
  - Do not skip procedures just because “it will only take a short time” or “it is not very high.”

Practice Question 3-3

■ Which of the 7 QC Tools does each of the following describe?

① A method most useful for identifying items that should be addressed as priorities by classifying defects by type and ranking them from the highest to the lowest number of occurrences.

② A method that systematically organizes the factors (causes) of a result (characteristic) into large, medium, and small branches and visualizes them in the shape of a fishbone.

③ A method used to understand how collected data varies, that is, the shape of the data distribution.

Practice Question 3-3 (continued)

☞ "Study Reference Text" p. 45

④ A method suitable for understanding the relationship between two different variables, such as work time and defect rate or temperature and product characteristics.

⑤ A method that uses upper and lower control limits to monitor over time whether a process is stable or abnormal variation has occurred.

⑥ A simple form used to easily and accurately collect data in the workplace and record and tally items such as types of defects and locations where they occur.

Answer ☞ “Study Reference Text” p. 45

Explanation

① Pareto chart

② Cause-and-effect diagram

③ Histogram

④ Scatter diagram

⑤ Control chart

⑥ Check sheet

Explanation ☞ “Study Reference Text” p. 38

3. QC Seven Tools

The 7 QC Tools are seven basic methods used in quality control to manage and improve manufacturing processes. They are mainly used to visually analyze numerical data and can be used without specialized knowledge.

3.1 Check sheet

A check sheet is a form with predefined items for collecting data. It is used to record types and locations of defects and organize data efficiently.

Explanation (continued)

☞ “Study Reference Text” p. 38

Table 3-6 Example of a check sheet

Defect Item Checklist

	4/5	4/6	4/7	4/8
Crack	𝍸	𝍷	𝍸	𝍷
Pinhole	𝍷		𝍷	
Wrinkle	𝍷	𝍷	𝍷	𝍷
Scratch	𝍷	𝍷	𝍸	
Stain/Dirt	𝍸			𝍷
Other	𝍷	𝍸	𝍸	𝍷

Explanation (continued)
☞ “Study Reference Text” p. 39

3.2 Pareto chart

A Pareto chart combines a bar graph showing the causes of problems or types of defects in descending order of frequency with a line graph showing the cumulative percentage. It helps identify important items and prioritize improvement activities.

Explanation (continued)

☞ “Study Reference Text” p. 39

Procedure

① Clarify the purpose.

② Determine the items and period to be surveyed.

③ Collect the necessary data.

④ Summarize the data in a table.

⑤ Sort the values in descending order.

⑥ Calculate the percentage and cumulative percentage for each value.

⑦ Create the graph.
(Left axis: values; right axis: cumulative percentage)

⑧ Arrange the bars in descending order from left to right.

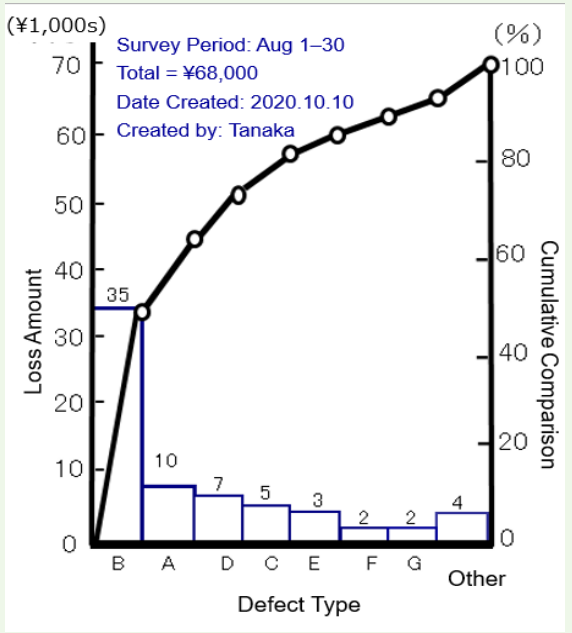


Fig. 3-3 Example of a Pareto Chart (Pareto Chart of Loss Amounts Due to Defects)

In this Pareto chart, B has the largest loss amount, and the top three items (B, A, and D) account for 70% of the total. By focusing on these three items, the loss amount can be effectively reduced.

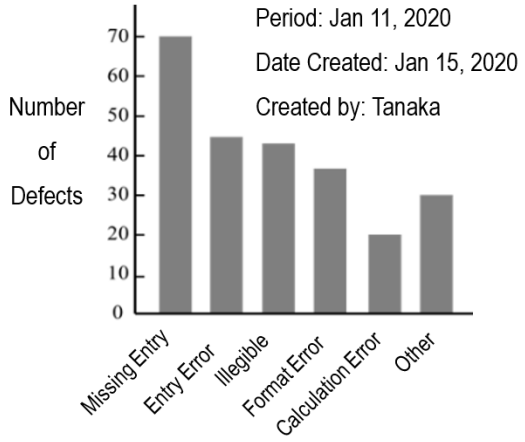
Explanation (continued)
☞ “Study Reference Text” p. 40

3.3 Graphs

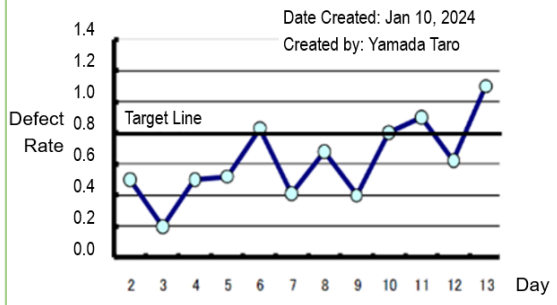
Graphs are tools for visually presenting data. Different types are used depending on the purpose.

Table 3-7 Explanations and examples of each graph

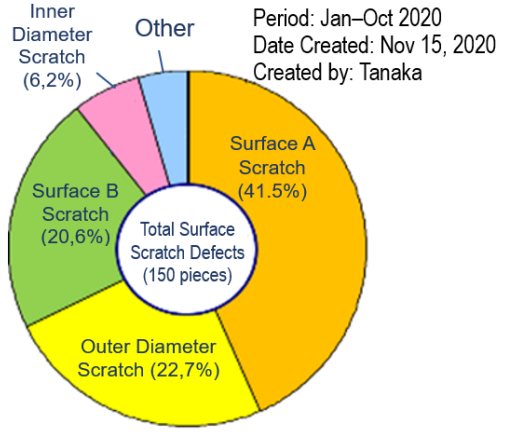
Bar graph	Line graph	Pie chart
Compares the size and quantity of each element.	Shows changes in control items over time.	Compares the proportion of each element in the whole.



Bar Graph of "Production Daily Report Defects"



Line Graph of "December Package Defects"



Pie Chart of "Occurrence Status of Surface Scratch Defects"

Explanation (continued)
☞ “Study Reference Text” p. 41

3.4 Cause-and-effect diagram

A cause-and-effect diagram organizes the factors affecting a problem in the shape of a fishbone. It helps identify the root cause by examining causes from the 4M perspectives of Man, Machine, Material, and Method.

Procedure

① Gather the relevant people.

② Write the target theme or characteristic at the right end and draw the backbone.

③ Draw the major branches and write the factor categories.

④ Repeatedly ask “Why? Why?” as you add medium, small, and sub-branches, and enter the factors.

⑤ Discuss the factors, narrow them down to the important ones, and target them for countermeasures.

Explanation (continued)

☞ "Study Reference Text" p. 41

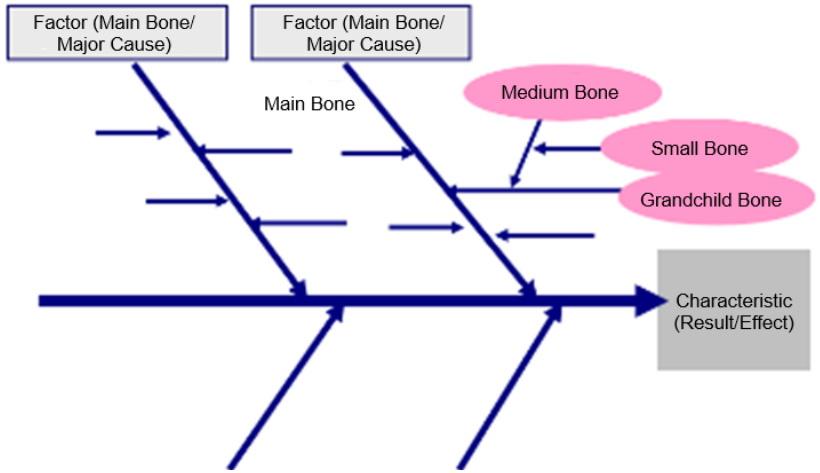


Fig. 3-4 Structure of a Cause-and-effect Diagram

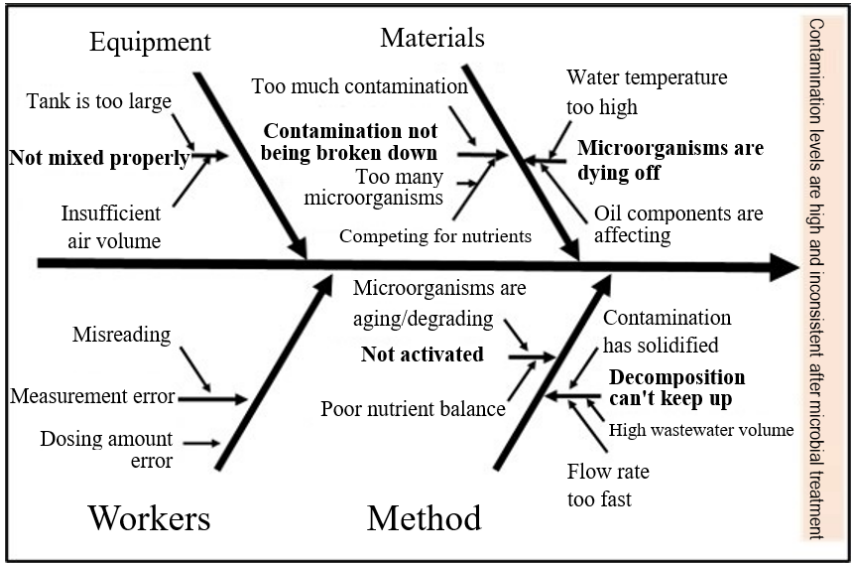


Fig. 3-5 Example of a Cause-and-effect Diagram

Explanation (continued)
☞ “Study Reference Text” p. 42

3.5 Histogram

A histogram is a bar graph that shows the variation and shape of the data distribution by the number of data points in each interval. It is used to analyze process capability by showing how data such as product dimensions and weights are distributed.

Explanation (continued)
☞ “Study Reference Text” p. 42

Procedure

① Clarify the purpose and collect data.

② Determine the class width.

③ Determine the class boundaries so that all data are included and count the number of values in each class.

⑦ Create a bar graph.
(Horizontal axis: classes; vertical axis: number of data points)

⑤ Enter the type of data, period, number of data points, mean, standard deviation, etc.

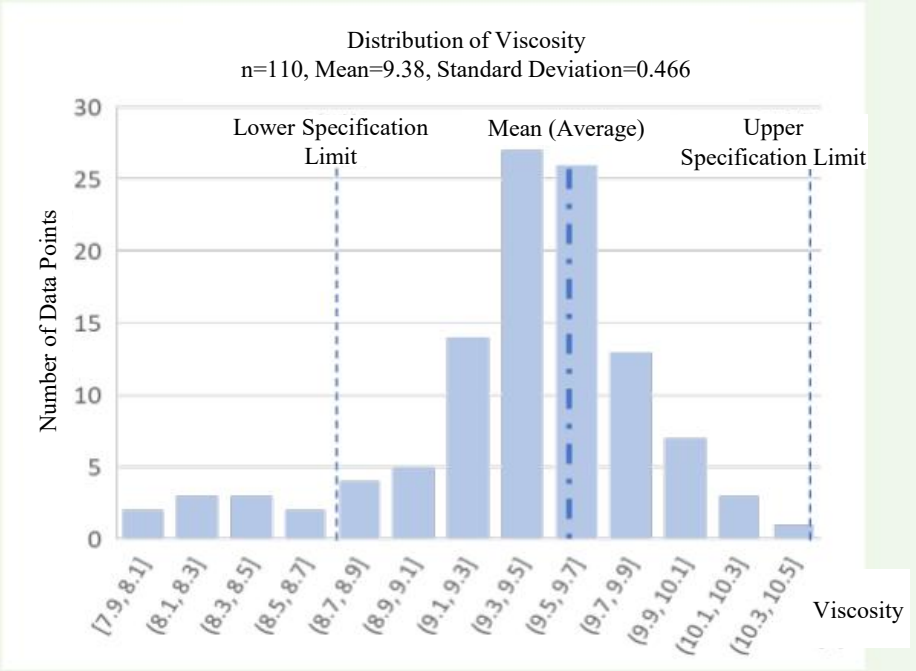


Fig. 3-6 Example of a Histogram

Explanation (continued)
☞ “Study Reference Text” p. 43

3.6 Control chart

A control chart is a time-series line graph used to monitor whether a manufacturing process is stable.

By setting upper and lower control limits and monitoring whether the data fall within those limits, abnormalities can be detected early.

A typical control chart is the Xbar-R control chart. This is a typical control chart for **measurement data** used to simultaneously monitor the **mean** and **variation in a manufacturing process** and determine whether the process is in a stable state (**under statistical control**).

Explanation (continued)

☞ “Study Reference Text” p. 43

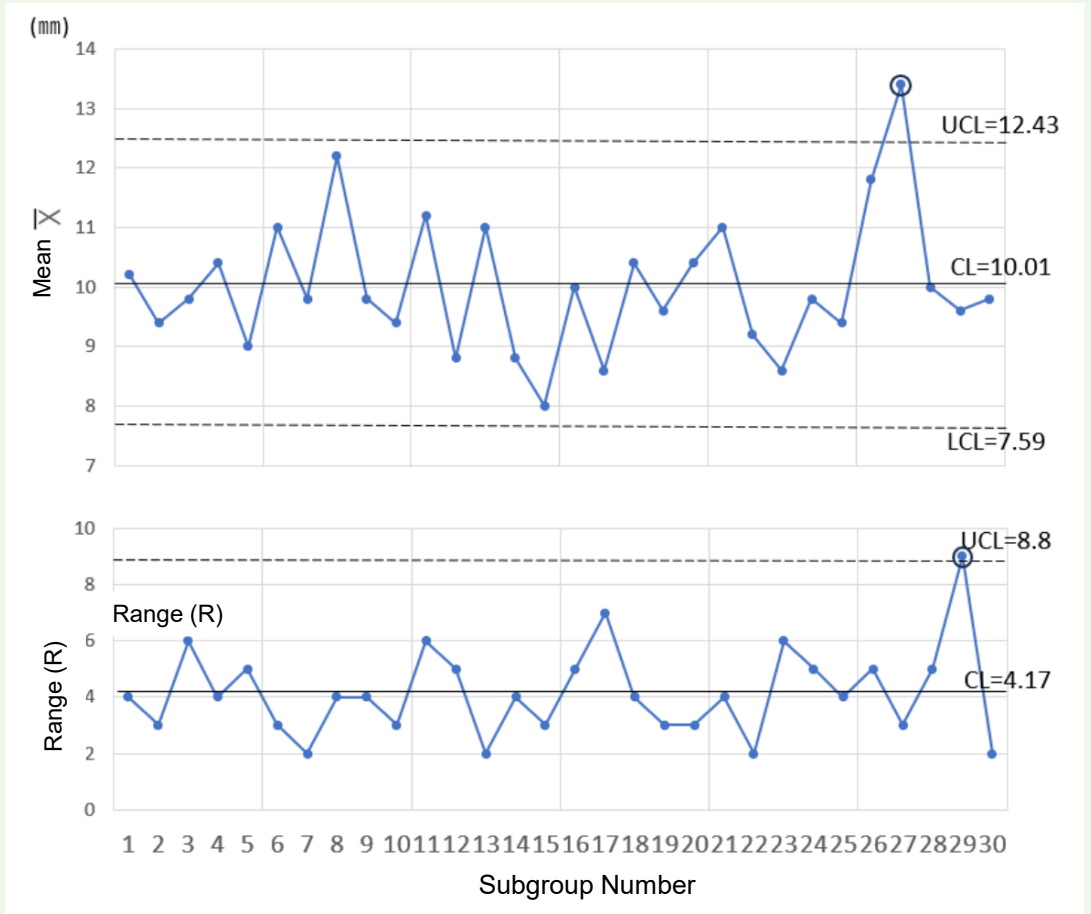


Fig. 3-7 Example of a Control Chart (Xbar-R Control Chart for Part Dimensions)

Explanation (continued)
☞ “Study Reference Text” p. 44

3.7 Scatter Diagram

A scatter diagram plots the relationship between two different variables on the vertical and horizontal axes.

It is used to analyze whether there is a correlation between two variables, such as work time and the number of defective products.

Explanation (continued)

☞ “Study Reference Text” p. 44

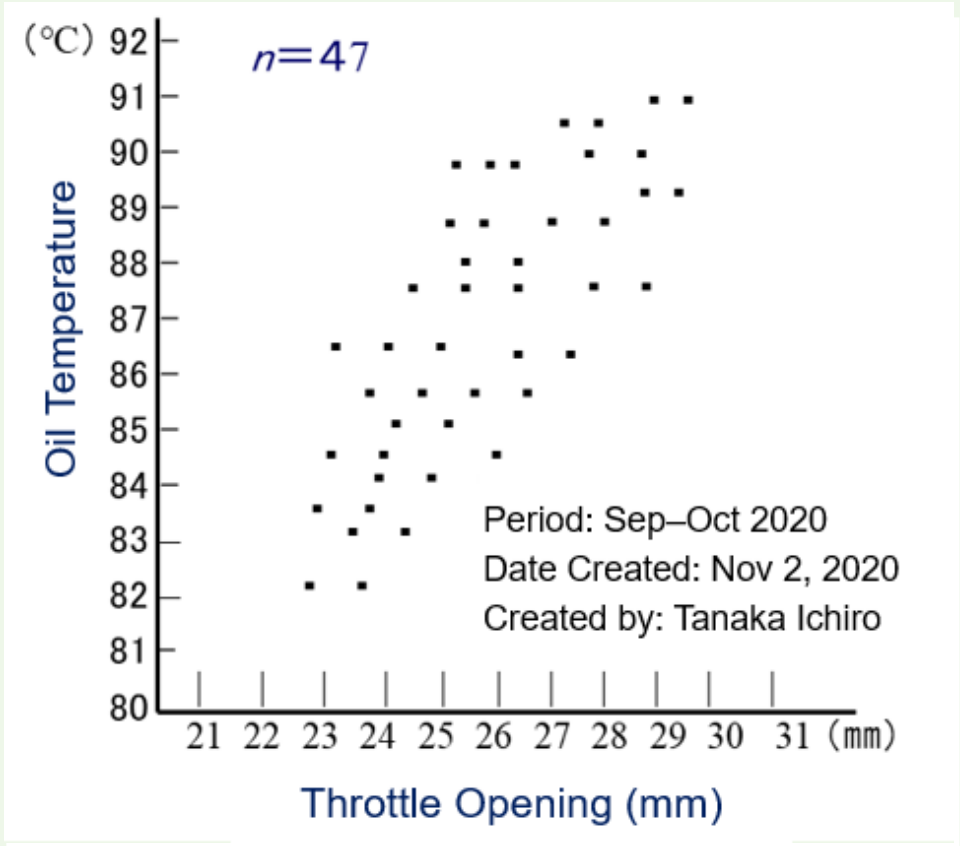


Fig. 3-8 Example of a Scatter Diagram

Practice Question 4-2

■ Choose A if the statement is correct and B if it is incorrect.

① ( ) In sampling inspection, samples to be inspected are selected at random from the lot.

② ( ) Destructive testing is not performed in 100% inspection.

Answer ☞ “Study Reference Text” p. 56

Explanation

① In sampling inspection, the method used to select samples must follow the inspection standards, but samples are generally selected at random from the lot.

Answer: A

② Destructive testing makes the product unusable. Therefore, if destructive testing is performed, sampling inspection is used.

Answer: A

Explanation ☞ “Study Reference Text” p. 54

1.2 Types of Inspection

(1) Timing of Quality Inspections

Quality inspections are performed at various stages. These include **incoming inspection** when purchased items are delivered, **in-process inspection** during the manufacturing process (also called inter-process inspection or inspection within the process), and **shipping inspection** after products are completed (also called final inspection).

In incoming inspection, purchased items are inspected to determine whether they conform to the required specifications. In in-process inspection, the characteristics produced in that process are inspected. For example, in lathe machining, the dimensions of the machined inner and outer diameters are measured. The purposes are to prevent nonconforming products from being sent to the next process (to detect nonconforming products early) and to check for abnormalities in the machining process. In shipping inspection, a final check is made to determine whether the products conform to customer requirements, internal specifications, standards, etc.

Explanation (continued)
☞ “Study Reference Text” p. 54

(2) 100% Inspection and Sampling Inspection

Quality inspection of all products or parts is called **100% inspection**, while quality inspection of only some products or parts is called **sampling inspection**.

A 100% inspection is performed when nonconformities must not occur, such as for critical product characteristics or parts related to human safety.

Sampling inspection is performed when it is acceptable for a small number of nonconforming products to be mixed with conforming products. There are various methods of sampling inspection, but a commonly used method considered to be good practice is described here.

Explanation (continued)

☞ “Study Reference Text” p. 54, 55

A group of products or parts manufactured under the same conditions is called **a lot**. Products or parts to be inspected (samples) are selected at random from the lot. The number of samples (sample size) is specified in the inspection standards or inspection procedure manual. The larger the number of products or parts in a lot (lot size), the larger the sample size. After the samples are inspected, the lot is accepted if the number of nonconforming products is equal to or less than the acceptance number, and rejected if it is equal to or greater than the rejection number. How a rejected lot is handled is determined by an authorized person. Options include scrapping the entire lot (or returning it in the case of purchased items), sorting (performing 100% inspection and shipping only conforming products), and rework.

Explanation (continued)
☞ "Study Reference Text" p. 55

(3) Destructive Testing and Nondestructive Testing

Quality inspections include **destructive testing** and **nondestructive testing**. Destructive testing involves cutting out part of a product for inspection or testing the product itself until it is destroyed. Because destructive testing makes the product unusable, sampling inspection is used. Nondestructive testing does not affect product quality. Nondestructive testing may be performed as either sampling inspection or 100% inspection.

Explanation (continued)
☞ “Study Reference Text” p. 55

(4) Measurement Data and Count Data

Data used in quality inspection can be divided into **measurement data** and **count data**.

Measurement data is data that can be measured as continuous values. For example, length and weight are measurement data.

Count data is data obtained by counting. For example, the number of scratches and the number of nonconforming products are count data.

Practice Question 4-3

- Solve the following problem.

  If 200 samples are inspected and 199 are conforming products and 1 is a nonconforming product, calculate the nonconforming product rate.

Answer ☞ “Study Reference Text” p. 58

Explanation

The nonconforming product rate is calculated by dividing the number of nonconforming products by the number of samples taken.

$$\frac{1}{200} \times 100 = 0.5\%$$

The calculation gives an answer of 0.5%.

Answer: 0.5%

Explanation ☞ “Study Reference Text” p. 57

1.3 Calculation of the Nonconforming Product Rate

Recording and managing quality inspection results is important in the manufacturing industry. The **nonconforming product rate** (also called the nonconformity rate or defect rate) is one of the most important indicators.

The nonconforming product rate is the proportion of nonconforming products to the number of products produced. It can be expressed by the following formula.

$$\text{Nonconforming product rate (\%)} = \frac{\text{Number of nonconforming products}}{\text{Number of products produced}} \times 100$$

For example, if five out of 1,000 products produced are nonconforming, the nonconforming product rate is 0.5%.

Explanation (continued)

☞ “Study Reference Text” p. 57

When sampling inspection is performed, the nonconforming product rate can also be estimated from the number of nonconforming products found among the samples taken.

$$\text{Nonconforming product rate (\%)} = \frac{\text{Number of nonconforming products}}{\text{Number of samples taken}} \times 100$$

For example, if 100 items are sampled and one nonconforming product is found, the nonconforming product rate is 1%.

- Product Nonconformity Rate Is a Basic Item in Daily Reports
  - In many workplaces, daily reports have fields for “production quantity” and “number of defects.”
  - The product nonconformity rate can be calculated from these two numbers.
  - Daily records themselves serve as quality indicators.

Practice Question 5-2

■ Choose A if the statement is correct and B if it is incorrect.

① ( ) A vernier caliper cannot measure inside diameters.

② ( ) A vernier caliper can reduce measurement error by using the tips of its jaws.

③ ( ) A vernier caliper can measure an H7 fit tolerance.

④ ( ) A vernier caliper is suitable for measuring general tolerances.

Answer ☞ “Study Reference Text” p. 78

Explanation

① A vernier caliper can measure outside diameters using its outside measuring faces and inside diameters using its inside measuring faces. A vernier caliper with a depth bar can also measure depth.

Answer: B

② A vernier caliper can reduce measurement error by using the jaws as close to the base as possible.

Answer: B

③ A fit tolerance is a dimensional rule used when precisely fitting a hole and shaft together. A vernier caliper is not suitable for high-precision measurements such as an H7 fit tolerance.

Answer: B

Answer (continued) ☞ **"Study Reference Text" p. 79**

④ A general tolerance is a dimensional rule used for machining at normal machining accuracy in a factory. A vernier caliper is suitable for measurements that do not require such high precision, such as those with general tolerances.

Answer: A

Explanation ☞ “Study Reference Text” p. 76

2.1 Vernier caliper

(1) What Is a Vernier Caliper?

A **vernier caliper** is a measuring instrument with a slider that moves along the main scale. The main scale has a fixed jaw, and the slider has a movable jaw. Measurements are made by holding the part to be measured between the measuring faces of the jaws. A typical vernier caliper has inside jaws and outside jaws, allowing both inside and outside dimensions to be measured. A vernier caliper with a depth bar can also measure depth.

A vernier caliper with inside jaws separate from the outside jaws is called an M-type vernier caliper. A vernier caliper with both outside and inside measuring faces on the same jaws is called a CM-type vernier caliper.

Explanation (continued)

☞ “Study Reference Text” p. 76

Dimensions may be displayed either analog or digitally. Analog types include those with a vernier scale and those with a dial scale.

Vernier scales are available with minimum readings of 0.1 mm, 0.05 mm, and 0.02 mm. The 0.05 mm type is commonly used.

Explanation (continued)

☞ “Study Reference Text” p. 76

The minimum display increment of a digital vernier caliper is 0.01 mm.

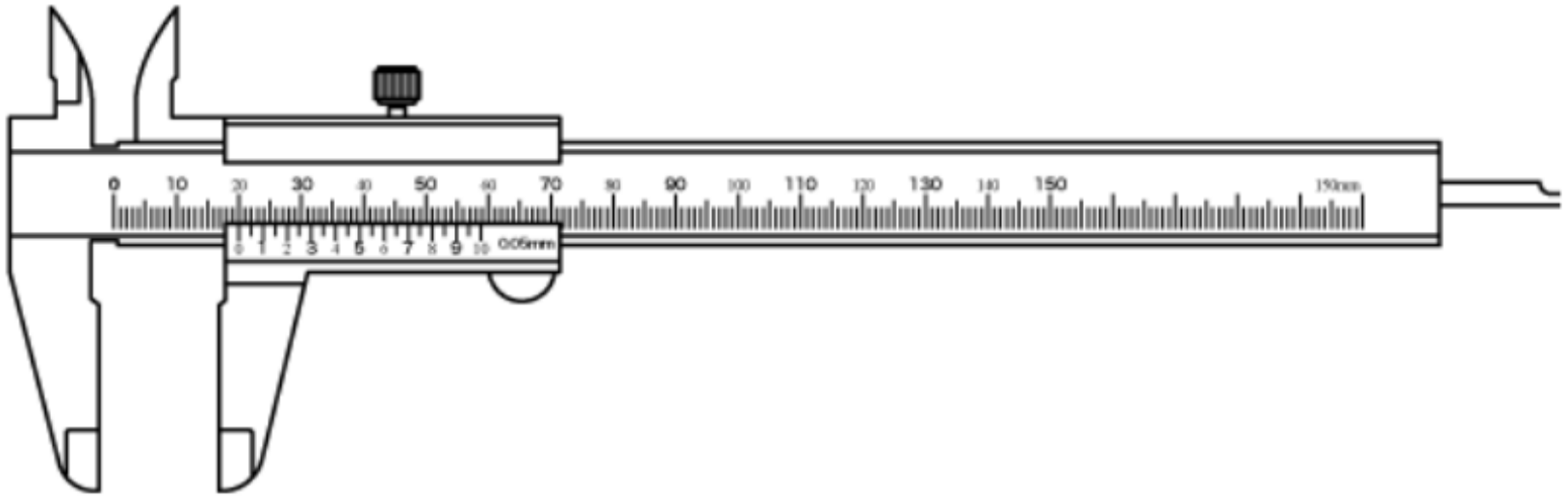


Fig. 5-1 Vernier Caliper

Explanation (continued)
☞ “Study Reference Text” p. 77

(2) Preparation for Using a Vernier Caliper

Before measuring, wipe the measuring faces and sliding surfaces. Check that the slider moves smoothly and has no play. Close the jaws, hold them up to the light, and check that there is no gap between them. Also check that the scale reads 0 when the jaws are closed. On a digital vernier caliper, the display can be set to 0 by pressing the zero-reset button.

Explanation (continued)
☞ “Study Reference Text” p. 77

(3) How to Use a Vernier Caliper

First, clean the object to be measured. Remove any burrs. Use the outside measuring faces to measure outside diameters and overall lengths. Use the inside measuring faces to measure inside diameters and groove widths. Use the depth measuring face to measure the depth of holes and grooves.

For any measurement, holding the caliper at an angle increases measurement error, so keep it properly aligned when measuring.

Using the tips of the jaws can increase measurement error because the jaws may tilt. Measure as close to the main scale as possible, at the base of the jaws.

Applying too much force can also cause the jaws to tilt and result in measurement error, so apply only light contact.

Explanation (continued)
☞ “Study Reference Text” p. 77

(4) How to Read the Vernier Scale

When measuring a dimension using a vernier scale, first read the main scale at the 0 mark of the vernier scale. Next, find the mark on the vernier scale that aligns with a mark on the main scale. The measured value is the sum of the main scale reading and the vernier scale reading.

Explanation (continued)

☞ “Study Reference Text” p. 77, 78

For example, suppose the measured dimension is 30.35 mm. First, check where the 0 mark of the vernier scale is located on the main scale. If it is between 30 and 31, the measured value is between 30 mm and 31 mm. Next, find the mark on the vernier scale that aligns with a mark on the main scale. If the 0.35 mark aligns, the vernier scale reading is 0.35 mm. Therefore, adding the main scale reading of 30 mm and the vernier scale reading of 0.35 mm gives a measured value of 30.35 mm.



Fig. 5-2 Vernier Caliper Scale

Practice Question 6-3

- Choose A if the statement is correct and B if it is incorrect.

① ( ) Compared with 30h9, 30h6 has a smaller tolerance.

② ( ) The symbol for radius is ⌀.

③ ( ) A shallow counterbore may be omitted from the drawing.

④ ( ) A reference dimension does not need to be measured.

Answer ☞ “Study Reference Text” p. 107

Explanation

① The smaller the size tolerance grade number, the smaller the tolerance.

Answer: A

② The symbol for radius is R. The symbol for diameter is ⌀.

Answer: B

③ Shallow counterbores and similar features may be omitted from the drawing.

Answer: A

④ Reference dimensions are not subject to dimensional measurement.

Answer: A

Explanation
☞ “Study Reference Text” p. 101

3.4 Indication of Tolerances

If the dimensions of a machine are incorrect, it will not function as intended. Therefore, it is necessary to specify the allowable limits of dimensions within which it will function correctly. This allowable range is called a **tolerance**.

Explanation (continued)
☞ “Study Reference Text” p. 102

(1) Method Using Numerical Values

One common method for indicating the allowable range is shown in the figure.

In this example, the allowable range is from 31.76 mm to 32.12 mm.

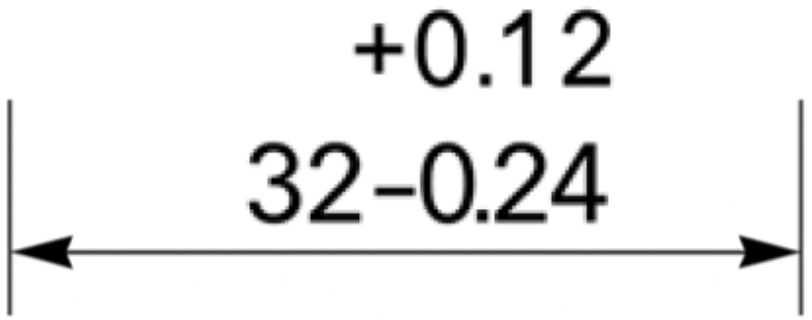


Fig. 6-6 How to Indicate Tolerances

Explanation (continued)
☞ “Study Reference Text” p. 102

(2) Method Using Symbols

The allowable range can also be indicated using a tolerance class, as shown in the figure. In this example, the fundamental deviation symbol is f, and the size tolerance grade number is 7.

This method is called the ISO code system (commonly referred to as fit tolerances). It is often used for fits between holes and shafts.

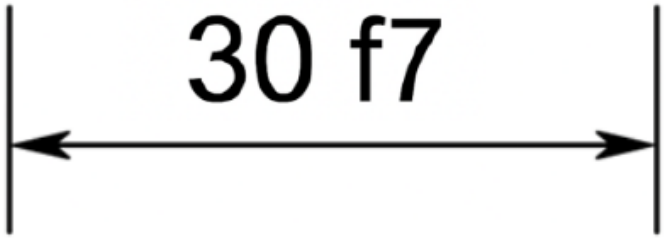


Fig. 6-7 How to Indicate Tolerances Using the ISO Code System

Explanation (continued)

☞ “Study Reference Text” p. 102

For fundamental deviation symbols, uppercase letters indicate holes and lowercase letters indicate shafts. The closer the letter is to A, the looser the fit and the larger the clearance. The closer it is to Z, the tighter the fit and the less movement is allowed.

The smaller the size tolerance grade number, the smaller the tolerance.

Explanation (continued)
☞ “Study Reference Text” p. 103

3.5 Supplementary Dimension Symbols

Adding a symbol before a dimension value gives the meaning shown in the t

Table 6-2 Supplementary Dimension Symbols

ø	Diameter of a circle; diameter of an arc exceeding 180 degrees
Sø	Diameter of a sphere; diameter of a spherical arc exceeding 180 degrees
□	Side of a square
R	Radius
CR	Controlled radius
SR	Spherical radius

Explanation (continued)

☞ “Study Reference Text” p. 103

	Arc length
C	45° chamfer
	Conical chamfer
t	Thickness
	Counterbore, deep counterbore
	Countersink
	Hole depth

Explanation (continued)
☞ “Study Reference Text” p. 106

3.7 Reference Dimensions

Dimensions provided for reference are called **reference dimensions**. The dimension values are enclosed in parentheses. Reference dimensions are not subject to dimensional measurement.

Practice Question 7-2 ☞
“Study Reference Text” p. 125

Practice Question 7-2

- Choose the one correct statement regarding the knowledge needed to act safely and prevent injuries and accidents in the workplace.

  A. Checking machine operation and inspecting equipment before work can be omitted.

  B. Machines that use electricity directly as a power source require grounding.

  C. When using a drill press, gloves must be worn because the cutting tool is sharp and dangerous.

  D. When lifting a load, the angle of the wire ropes should be increased.

Answer ☞
“Study Reference Text” p. 125

Explanation

A. **(Incorrect)** Checking machine operation and inspecting equipment is always necessary to detect machine failures or abnormalities in advance and prevent unexpected accidents such as electric shock, injury, and fire. This also helps prevent work interruptions and product defects caused by equipment malfunctions and maintain efficiency and quality.

B. **(Correct)** To prevent electric shock and fire, machines that use electricity directly as a power source require grounding. If electricity leaks from inside the machine (electrical leakage), it flows safely to the ground through the ground wire, preventing electric shock and equipment failure.

C. **(Incorrect)** The cutting tool of a drill press rotates at high speed. If a glove gets caught in the cutting tool, there is a risk of serious injury to the fingers or hands. Therefore, gloves must not be worn.

D. **(Incorrect)** As the angle of the wire ropes increases, the force applied to the wire ropes increases, increasing the risk of the wire ropes breaking.

Answer: B

Explanation ☞
“Study Reference Text” p. 123

1.3 Machine Operation and Hazard Prevention

(1) How to Use Machines Safely

To use machines safely, it is necessary to fully understand how to use them correctly and what hazards they pose. **Never touch unfamiliar machines or tools without permission.** They may start unexpectedly and cause unforeseen injury.

Before starting work, always check that the machine operates correctly. If anything is broken, repair it before use.

In addition, machines that use electricity directly as a power source must be grounded to prevent electric shock. Never touch electrical outlets or switches with wet hands because of the risk of electric shock.

Explanation (continued) ☞
“Study Reference Text” p. 124

(2) Precautions for Each Machine

The following are points requiring special attention for each type of machine.

① Rotating Machines and Tools

Drill Press: The drill bit rotates at high speed. If a glove gets caught in the cutting tool, there is a risk of serious injury, including amputation of a finger or hand. Therefore, gloves must never be worn while working.

Grinder: If the grinding wheel used on a grinder has cracks or damage, it may shatter at high speed during use. Before use, always inspect it visually, run it briefly with no load, and check that it is properly mounted. The side of a grinding wheel is also fragile, and using the side for grinding may cause the wheel to break.

Explanation (continued) ☞
"Study Reference Text" p. 124

② Machines That Produce Chips

Lathe: Chips produced by a lathe are sharp, so touching them with bare hands can cause burns or injuries. **Always stop the machine before cleaning them up with a brush or broom.** Do not touch them with bare hands.

③ Machines for Lifting Loads

Crane: When lifting a heavy load with a crane, there is a risk of the wire ropes breaking or the load falling. Never go under a suspended load. As the angle of the wire ropes increases, the force applied to the wire ropes increases, increasing the risk.

- Drill Presses and Gloves
  - There is a near-miss incident in which a worker's glove was almost caught in a drill press while drilling.
  - If a glove gets caught in a rotating cutting tool, this can cause a serious injury, including the loss of a finger.
  - The idea that "gloves should be worn because the cutting tool is dangerous" can actually create a hazard. Gloves are not used with rotating machines.

- Check the Locations of Emergency Stop Buttons
  - Check where and how many emergency stop buttons are on the machine you use.
  - Check whether they are within reach and not blocked by objects.
  - It will be too late to look for them after an abnormality occurs.

Practice Question 7-4 ☞
“Study Reference Text” p. 129

Practice Question 7-4

- Choose the one correct statement regarding the knowledge needed to act safely and prevent injuries and accidents in the workplace.

  A. A dust mask can protect against harmful gases.

  B. Select appropriate personal protective equipment for the work yourself and bring it to the worksite.

  C. Do not wear neck-hanging name tags or other items that could get caught in machinery.

  D. A fire broke out at an electrical outlet, so water was poured on it to extinguish it.

Answer ☞
“Study Reference Text” p. 129

Explanation

A. **(Incorrect)** A dust mask filters particles such as dust, but gases pass through it, so it cannot protect against harmful gases. A dedicated gas mask is required for harmful gases.

B. **(Incorrect)** Use appropriate personal protective equipment selected by the person responsible for personal protective equipment.

C. **(Correct)** Items such as cords that could get caught in machinery must be removed.

D. **(Incorrect)** Because of the risk of electric shock, water must not be poured on an electrical outlet. Always turn off the power and use a dry chemical or carbon dioxide fire extinguisher.

Answer: C

Explanation ☞
“Study Reference Text” p. 127

1.4 Use of Personal Protective Equipment and Emergency Respons

(1) Specific Precautions for Personal Protective Equipment and Work Clothes

To prevent injuries during work, it is mandatory to wear safe clothing and correctly use personal protective equipment appropriate for the work being performed. Appropriate personal protective equipment selected and provided by the person responsible for personal protective equipment must be used.

- **Safe Clothing:** Do not wear name tags around the neck or other items that could get caught in machinery.
- **When Handling High-Temperature Objects:** To prevent burns, never roll up the sleeves of work clothes.

Explanation (continued) ☞ "Study Reference Text" p. 127

- **Safety Glasses**: These prevent cutting chips, oil, grinding debris, and other materials from entering the eyes. **Shaded safety glasses** are required for gas cutting work.
- **Safety Shoes**: These protect the feet from falling objects and obstacles underfoot.
- **Gloves**: These are used to protect the hands, except in work where wearing gloves is dangerous. However, gloves must never be worn when working with rotating machines such as drill presses.

Explanation (continued) ☞
"Study Reference Text" p. 127

- **Dust Mask**: This filters fine particles such as dust but cannot protect against harmful gases. **A dedicated gas mask** is required for harmful gases.



Fig. 7-1 Example of Appropriate Clothing and Personal Protective Equipment for Gas Cutting Work

Explanation (continued) ☞ “Study Reference Text” p. 128

(2) Response to Abnormalities

If you notice any abnormality (strange noise, odor, vibration, etc.) during work, stop the machine immediately, report it to your supervisor, and follow their instructions.

If a fire occurs, use the appropriate extinguishing method for the type of fire. Fires are mainly classified into three types according to the type of material that is burning.

- **Ordinary Fire (Class A Fire):** A fire involving wood, paper, cloth, or similar materials. It can be extinguished by cooling it with water.
- **Oil Fire (Class B Fire):** A fire involving gasoline, cooking oil, or similar materials. Pouring water on it may cause the fire to spread. Use a foam or dry chemical fire extinguisher to cut off the oxygen and extinguish the fire.
- **Electrical Fire (Class C Fire):** A fire caused by electrical outlets, wiring, or similar equipment. Because of the risk of electric shock, water must not be poured on it. Always turn off the power and use a dry chemical or carbon dioxide fire extinguisher.

- Different Work Requires Different Protective Equipment
  - There is a near-miss incident in which flying drill chips almost entered a worker's eye while machining with a drill press.
  - The same person may perform cutting in the morning and painting in the afternoon, requiring safety glasses for cutting and a gas mask for painting.
  - The focus should be on "protective equipment for today's work," rather than "the usual protective equipment."

Practice Question 8-2 ☞
“Study Reference Text” p. 138

Practice Question 8-2

- Choose the one correct statement about the mechanical properties of metal materials and their methods of evaluation.

A. When bending a steel sheet, the smaller the bend radius, the more likely the sheet is to crack.

B. The property of a material to deform when force is applied and return to its original shape when the force is released is called plasticity.

C. An impact test for metal materials is a test to determine the hardness of the material.

D. The number 330 in SS330, a common steel material, indicates the hardness value of the material measured in a hardness test.

Answer ☞
“Study Reference Text” p. 138

Explanation

A. **(Correct)** The smaller the bend radius, the greater the concentration of force on the bent part of the material. The smaller the bend radius, the more likely the material is to crack because greater force is concentrated on the bent part.

B. **(Incorrect)** The property of a material to deform when force is applied and return to its original shape when the force is released is called elasticity.

C. **(Incorrect)** An impact test for metal materials is a test to determine the toughness of the material.

D. **(Incorrect)** The 330 in SS330 is the strength value measured in a tensile test (330 N/mm^2 or more). It is not the result of a hardness test.

Answer: A

Explanation ☞
“Study Reference Text” p. 137

1.2 Mechanical Properties and Evaluation

(1) Mechanical Properties of Metals

The mechanical properties of metal materials are important for evaluating how a material behaves when subjected to an external force. Some specific properties are described below.

- **Elasticity**: Elasticity is the mechanical property of a material to deform when force is applied and return to its original shape when the force is released.
- **Plasticity**: Plasticity is the property of a material to deform when force is applied and retain its deformed shape without returning to its original shape when the force is removed. In steel sheet bending, which is a type of plastic working, the larger the bend radius, the less likely the sheet is to crack.
- **Hardness**: Hardness is a mechanical property that indicates how resistant the surface of a material is to scratching or deformation caused by an external force.

Explanation (continued) ☞
“Study Reference Text” p. 137

(2) Test Methods for Evaluation

Various tests are conducted to accurately measure these mechanical properties.

- **Hardness Test**: A test used to measure the hardness of a material. A small diamond indenter or similar tool is pressed into the material, and the hardness is evaluated based on factors such as the size of the resulting indentation. **Rockwell hardness** and **Vickers hardness** are typical hardness testing methods.
- **Tensile Test**: A test in which a material is pulled to determine how much force is required to break it. This test can be used to evaluate the strength and ductility of the material. The number 330 in SS330, a rolled steel for general structure, indicates that the tensile strength measured in this test is 330 N/mm^2 or more.
- **Impact Test**: A test in which a material is struck suddenly with a hammer-like tool to determine how much impact it can withstand. This test can be used to evaluate the toughness of the material.

- Look Up One Material You Handle
  - Check the symbol for the material used most often in your workplace on a drawing or on the label in the material storage area.
  - Look up what the symbol represents and what its tensile strength is.
  - Starting with a material you handle every day makes it easier to remember.

Practice Question 8-4 ☞
“Study Reference Text” p. 151

Practice Question 8-4

■ Choose A if the statement is correct and B if it is incorrect.

① (　　) A lathe is a machine that manufactures products by rotating and cutting a workpiece.

② (　　) The fiber flow formed in forging is an important factor in evaluating a material’s impact value.

③ (　　) A special-purpose helmet (welding shield) and personal protective equipment must always be worn when welding.

Answer ☞
“Study Reference Text” p. 151

Explanation

① A lathe is used for turning, a machining method in which a workpiece is rotated and cut.

Answer: A

② The fiber flow formed in forging is an important factor in evaluating a material’s impact value.

Answer: A

③ A special-purpose helmet (welding shield) and personal protective equipment must always be worn when welding.

Answer: A

Explanation ☞
“Study Reference Text” p. 143

2.1 Cutting

Cutting is a processing method in which tools are used to remove metal material little by little to create the desired shape. Just as a sculptor carves wood into shape, metal is cut using cutting tools. Various types of machines are used for this processing method, such as lathes, milling machines, and drill presses.

Explanation (continued) ☞ “Study Reference Text” p. 143

Peripheral speed is important in cutting. Peripheral speed is the distance traveled in one minute by the outermost cutting edge of a rotating tool (such as a drill or end mill) or a rotating workpiece (such as in lathe machining). Because it represents the speed of the cutting edge actually cutting the metal, it is an important condition in cutting. If the cutting speed is too high, the tool may wear quickly, or problems may occur on the machined surface. If the cutting speed is too low, machining takes too long and productivity decreases. For rotating tools such as drills and end mills, the peripheral speed V ($m \cdot min^{-1}$) is calculated using the tool diameter (D mm) and rotational speed (N rpm (min^{-1})) in the following formula.

$$V = (\pi \times D \times N) \div 1000$$

For example, to calculate the peripheral speed V at the cutting edge when an end mill with a diameter of 16 mm is rotating at 400 rpm (min^{-1}), substitute the values into the formula. Using 3.14 for pi:

$$V = (3.14 \times 16 \times 400) \div 1000 = 20.096 \fallingdotseq 20.1\ m \cdot min^{-1}$$

In this way, it is important to calculate the peripheral speed and set an appropriate rotational speed.

Explanation (continued) ☞
“Study Reference Text” p. 143

(1) Lathe

A general-purpose lathe is suitable for producing round rod-shaped or disk-shaped products by rotating a metal round bar or similar workpiece and cutting it with a cutting tool (tool bit). It is a basic and highly versatile machine tool.

Explanation (continued) ☞
“Study Reference Text” p. 148

2.3 Welding, Casting, and Plastic Working

Welding, casting, and plastic working are important techniques for shaping metal into the desired form. Rather than removing material as in cutting, these processes change the shape of the metal by taking advantage of its properties.

(1) Welding

Welding is a technique that uses heat or pressure to melt and firmly join multiple metal parts into one. It can create a stronger joint than using adhesives or screws. It is widely used for products that require high strength, such as automobiles, ships, bridges, and building frames. One common welding method is arc welding. In this method, electric current is passed between the metal and an electrode to generate an arc, and the resulting heat melts the metal and joins the parts together.

Explanation (continued) ☞
"Study Reference Text" p. 150

(2) Casting

Casting is a processing method in which metal is melted at high temperature, poured into a mold (**casting mold**) made of sand or similar material, and then cooled and solidified to form the desired shape. It can produce parts with complex shapes in a single process and is suitable for mass production.

Precautions for Casting: Casting involves handling high-temperature metal. Because the factory can become very hot, take precautions against heatstroke.

(3) Plastic Working

Plastic working is a processing method in which force is applied to metal while it remains solid (not melted) to deform it into the desired shape. It utilizes the property of metal to change shape when force is applied and retain the deformed shape (**plasticity**).

Explanation (continued) ☞
“Study Reference Text” p. 150

Examples of Plastic Working

① **Press Working:** A process in which a thin metal sheet is pressed against a die from above with great force to form it into the desired shape. Many products, such as automobile bodies and exterior panels of electrical appliances, are made using this method.

② **Forging:** A process in which metal is heated to soften it and then hammered into shape. This makes the metal structure denser and produces strong parts. Japanese swords are a typical example of forging.

③ **Rolling:** A process in which a block of metal is passed between two rollers to make it thinner and longer. Steel sheets, aluminum foil, and similar products are made using this method.

Practice Question 9-2 ☞ “Study Reference Text” p. 156

Practice Question 9-2

- Which of the following statements about rules for preventing electric shock when working safely in a factory is incorrect?

A. Before performing repairs or cleaning, always unplug the power cord before starting work.

B. If you find a coworker receiving an electric shock, tap them to check whether they are all right.

C. Grounding is used to allow leaked electricity to flow safely to the ground in the event of an electrical leakage.

D. Even with company permission, unqualified persons must not touch or work on electrical wiring.

Answer ☞ “Study Reference Text” p. 156

Explanation

A. **(Correct)** Touching a machine while the power is on poses a risk of electric shock. Before performing repairs or cleaning, always unplug the power cord before starting work.

B. **(Incorrect)** If you touch a person receiving an electric shock, you may also receive an electric shock. First, turn off the power from a safe location, and then use a nonconductive object, such as a stick (e.g., a wooden stick), to pull the person away.

C. **(Correct)** Grounding is performed to allow leaked electricity to flow safely to the ground and prevent electric shock in the event of electrical leakage.

D. **(Correct)** Persons who do not have the required qualifications for handling electricity must not handle or work on electrical wiring.

Answer: B

Explanation ☞ “Study Reference Text” p. 155

1.2 Safe Operation of Electrical Equipment and Prevention of Electric Shock

Because electricity is invisible, its dangers must not be underestimated. In particular, the safe operation of electrical equipment and the prevention of electric shock are important rules for working in a factory.

To prevent electric shock, be sure to follow the basic rules below.

- **Do Not Touch Electrical Equipment with Wet Hands:** Water conducts electricity easily, so touching an electrical outlet or switch with wet hands is dangerous.
- **Always Perform Grounding:** Grounding is a system that allows electricity to flow safely to the ground if electricity leaks from electrical equipment. If the equipment has a ground wire, be sure to connect it. Grounding is an important “lifeline” that protects against electric shock accidents.

Explanation (continued) ☞ **"Study Reference Text" p. 155**

- **Always Turn Off the Power Before Inspecting or Repairing Machinery:** Touching a machine while the power is on poses a risk of electric shock. When performing repairs or cleaning, always unplug the power cord before starting work.
- **Do Not Touch Electrical Wiring Without Permission:** Electrical wiring in factories often carries high voltage and is dangerous. If an unqualified person touches it without permission, it can result in a serious electric shock accident.

If you see a coworker receiving an electric shock, do not try to help by touching them directly with your hands. You may also receive an electric shock. First, turn off the power from a safe location, and then use a nonconductive object, such as a stick (e.g., a wooden stick), to pull the person away. Then report the incident to your supervisor immediately and call an ambulance.

Practice Question 9-6 ☞ "Study Reference Text" p. 166

Practice Question 9-6

- Choose the one correct statement about the types of molding processes and their characteristics.

A. Extrusion molding is a method in which material is placed in a mold and pressed (compressed) with great force from above to form a shape. It is mainly used to manufacture thermosetting plastics and rubber products.

B. Blow molding is a processing method in which molten plastic is inflated like a balloon to form a shape. It is mainly used to manufacture products with a constant cross-section along their length, such as window frames and pipes.

C. Compression molding is a method in which molten plastic is placed in a mold and inflated by blowing air into it until it conforms to the mold. It is mainly used to manufacture hollow products such as plastic bottles and tanks.

D. Injection Molding: Parts with complex shapes can be produced in a single process, making it possible to reduce costs in mass production.

Answer ☞ “Study Reference Text” p. 167

Explanation

A. **(Incorrect)** This describes compression molding. Extrusion molding is a method used to make long products.

B. **(Incorrect)** The first part, “molten plastic is inflated like a balloon to form a shape,” is correct, but the second part, “products with a constant cross-section along their length, such as window frames and pipes,” is incorrect. These products are mainly made by extrusion molding. Blow molding is suitable for manufacturing hollow products such as plastic bottles and tanks.

C. **(Incorrect)** This describes blow molding. Compression molding is a method in which material is strongly compressed in a mold.

D. **(Correct)** Injection molding can form even complex shapes in a single process, making it possible to reduce costs in mass production.

Answer: D

Explanation ☞
“Study Reference Text” p. 164

3.1 Plastic Molding

(1) What Is Plastic Molding?

Plastic molding is a processing technique in which plastic material is placed in a mold and formed into the desired shape using heat, pressure, or both. This method is suitable for efficiently producing large quantities of products with the same shape. Because material can be used with little waste and complex shapes can be produced in a single process, costs can be reduced.

Explanation (continued) ☞ “Study Reference Text” p. 164

(2) Types of Plastic Molding

① Injection Molding

This is one of the most common plastic molding methods. First, plastic particles (pellets) are heated and melted inside a machine until they become a thick liquid. Next, the molten plastic is “injected” (as with a syringe) at high pressure into a metal mold. Once the plastic cools and solidifies inside the mold, the mold is opened, and the product is removed.

Characteristics

Parts with complex shapes can be produced in a single process, providing high productivity. Many everyday products, such as toys and plastic parts for smartphones and automobiles, are made using this method.

Explanation (continued) ☞ “Study Reference Text” p. 165

② Blow Molding

This is a processing method in which air is blown into the plastic to inflate it and form the product. First, molten plastic is formed into a tube. Next, the tube is placed in a mold, and the mold is closed. Air is then blown into the tube inside the mold, inflating it like a balloon and pressing it against the mold. Once the plastic cools and solidifies, the product is removed.

Characteristics

This method is suitable for mass-producing hollow products, such as plastic bottles, containers, and tanks.

Explanation (continued) ☞ "Study Reference Text" p. 165

③ Compression Molding

This is a processing method in which material is placed in a mold and pressed with great force from above to form a shape. It is mainly used for molding thermosetting plastics and rubber.

Characteristics

This method is suitable for products with relatively simple shapes and can produce strong parts.

Explanation (continued) ☞ “Study Reference Text” p. 165

④ Extrusion Molding

This is a processing method in which molten plastic is extruded through an opening of a specified shape (**die**) to produce long shapes, such as rods, pipes, and sheets.

Characteristics

This method is used to manufacture long products with a constant cross-section, such as pipes, hoses, and window frames.

How to Study　Five Steps

- ① Read the Text First
  - Read through it once to see what is covered in the chapter.
- ② Solve the Practice Questions
  - Think them through and solve them yourself before looking at the answers.
- ③ Reread the Relevant Sections of the Text for Questions You Got Wrong
  - Read the Explanation below the practice question together with the main text of that section.
  - If necessary, consult the References or a textbook in your native language.
- ④ Relate It to Work in Your Own Workplace
  - Think about how what is written in the text is applied in your own workplace.
  - If you do not understand something, ask your supervisor or coworkers.
- ⑤ Repeat Many Times
  - Get into the habit of reading each sentence carefully to the end to determine whether it is correct or incorrect.

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