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Manual concerning Appropriate Handling of Asbestos in Ships

October 2006

Japan Ship Technology Research Association (JSTRA)

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Introduction

Asbestos found use in a wide range of applications due to its excellent characteristics, and the use in ships was no exception. On August 2 of 2006, the Japanese government announced a cabinet order partially amending the Industrial Safety and Health Law Enforcement Order, which completely bans the manufacture and any use of asbestos. This cabinet order became effective on September 1. However, since asbestos was used in many parts of ships, handling of asbestos will continue during ship repair and dismantling.

Because of the unique structural characteristics of ships in general, it is difficult to handle asbestos in ships in the same way as asbestos used in on-land facilities. This manual was prepared with the aim of improving the protection measures for asbestos handled on ships.

Laws and regulations concerning the handling of asbestos have already been established. According to these laws and regulations, certain basic measures are required when handling asbestos, such as (1) preliminary investigation of the conditions of asbestos use, (2) generation of a plan of work, (3) education of workers, (4) assignment of a supervisor in charge of asbestos work, (5) enforcement of the use of protective gear by workers, (6) suppression of asbestos-particle generation by moisturizing, and (7) isolation of the work area, to keep people out.

The amount of asbestos particles generated during work varies substantially depending on the type of asbestos-containing material used in the ship to be repaired or dismantled, as well as on the method of repair or dismantlement. As a result, each of the necessary measures must be implemented in the most appropriate manner. For example, the removal of sprayed-on asbestos generates the highest amount of asbestos particles and produces an extremely hazardous work environment; thus, the worksite must be isolated and moisturized with a chemical solution. In addition, workers must wear high-performance respiratory protective devices and protective clothes. Removal of asbestos-containing molded boards, on the other hand, generates a relatively small amount of asbestos particles. However, if the boards are crushed or cut, a large amount of asbestos-fiber dust will be produced. An appropriate moisturizing measure is thus critical, as is ensuring the use of respiratory protective devices in strict accordance with the risk of particle generation.

People who may come into contact with asbestos used in ships are advised to understand the applicable laws and regulations as well as the contents of this manual thoroughly, in order to take appropriate measures in handling asbestos used in ships and to protect themselves from the health hazards caused by asbestos.

October 2006

Chairman
Exploratory Committee for the Manual concerning
Appropriate Handling of Asbestos in Ships

Norihiko Kohyama Professor Faculty of Economics, Toyo University

Manual concerning Appropriate Handling of Asbestos in Ships

Contents

Chapter 1　About Asbestos

1.　Definition of asbestos

Asbestos is a general term used to refer to various types of fibrous silicate minerals. According to the Industrial Safety and Health Law Enforcement Order and the corresponding enforcement notice, asbestos is explained as follows:

“Asbestos refers to actinolite, amosite (brown asbestos), anthophyllite, chrysotile (white asbestos), crocidolite (blue asbestos), and tremolite in a fibrous form.”

According to the International Labor Organization (ILO), asbestos is defined as follows (1986):

“Asbestos refers to chrysotile (white asbestos), which is a fibrous silicate mineral classified as a serpentine rock-forming mineral; actinolite, amosite (brown asbestos, cummingtonite-grunerite), anthophyllite, and crocidolite, which are fibrous silicate minerals classified as amphibole rock-forming minerals; and a mixture made of or containing one or more of these minerals.”

Chrysotile, a serpentine mineral, is found in fibrous form and is classified as asbestos, but some of the five amphibole minerals indicated above are not in fibrous form when observed with the naked eye or with a microscope; therefore, only those in a fibrous form are considered asbestos. Amosite is fibrous grunerite, while crocidolite is fibrous riebeckite. Anthophyllite, tremolite, and actinolite in a fibrous form are also referred to as asbestos. These materials are referred to as “fibrous anthophyllite asbestos” or “anthophyllite asbestos” to distinguish these materials from their mineral forms.

2.　Types of asbestos

The World Health Organization (WHO), the International Labor Organization (ILO), and relevant official bodies in various countries classify asbestos into six types, as shown in Table 1. These six types are also specified as asbestos by the Asbestos Hazard Prevention Regulations and corresponding enforcement notice.

Table 1　Classification of asbestos: Asbestos names and mineral names

	Asbestos name	Mineral name
Serpentines	Chrysotile	Chrysotile asbestos
Amphiboles	Grunerite	Amosite asbestos (brown asbestos)
	Riebeckite	Crocidolite asbestos (blue asbestos)
	Anthophyllite	Anthophyllite asbestos
	Tremolite	Tremolite asbestos
	Actinolite	Actinolite asbestos

More than 90% of asbestos previously used in Japan and throughout the world consisted of chrysotile, the balance principally comprised of amosite and crocidolite. Anthophyllite asbestos and tremolite asbestos were used in some countries, but only to a very limited extent. Chrysotile is also called white asbestos, and is either white or gray in color. Since the crude ore of amosite is brownish, it is also called brown asbestos, but the raw material amosite in fibrous form looks grayish. Called blue asbestos, crocidolite is blue even when it is a crude ore, as well as when it is made into a fibrous raw material. Its blue color makes it easy to distinguish even with the naked eye. Although crocidolite has excellent physical properties, it has a strong carcinogenic effect. Amosite and crocidolite were used in large quantities as sprayed-on asbestos before asbestos spraying was prohibited in 1975. Tremolite and actinolite are often present in serpentine rocks. Since these materials are sometimes contained in chrysotile, talc, and vermiculite as impurities, caution is required to remove these prior to distribution.

3. Physical properties of asbestos

Asbestos was used commonly and was valued as a material in various industrial applications because asbestos, on its own, offers the following exceptional characteristics.

(1) As pliable as silk cotton and wool, allowing easy processing into yarns and cloths (easy spinning and weaving)

(2) High strength against tensile force (high tensile strength)

(3) Resistant to friction and abrasion (abrasion resistance)

(4) Noncombustible and resistant to high temperatures (heat resistance)

(5) Blocks heat and sound (heat insulation and soundproofing)

(6) Resistant to chemicals (chemical resistance)

(7) Non-conductive of electrical currents (electrical insulation)

(8) Resistant to bacteria and humidity (corrosion resistance)

(9) Large specific surface and excellent adhesion to other materials (excellent compatibility)

(10) Inexpensive (economic efficiency)

Since these characteristics are not offered by any other single natural mineral or artificial substance, asbestos was sometimes called a “miracle mineral.”

Asbestos fibers tend to split finely in the lengthwise direction when crushed. They break into finer fibers in succession while maintaining high aspect ratios (fiber’s length-to-width ratio). Such fine fibers can reach the alveoli of the lung without being blocked or stopped by nasal hairs or the cilia of the bronchus/bronchial tubes. Crocidolite and amosite are less pliable than chrysotile—they are straight, stiff, and harsh fibers. Although crocidolite is not as pliable as chrysotile, it is the highest-performance asbestos, with exceptional characteristics in all of the specific qualities of asbestos.

4. Applications of asbestos

In Japan, asbestos was used commonly in construction materials such as spun and woven fabrics, asbestos cement products, and boards; reinforcement materials for synthetic resin products such as vinyl floor tiles, boat hulls, and gears; spraying materials for heat insulation and soundproofing; thermal insulation materials for boiler pipes and furnaces; friction-resistant materials such as brake linings; filtering materials for chemicals and food; heat- and chemical-resistant sealing materials; paints; mortar; adhesives; packing materials; and others. Table 2 lists some representative applications. Although Table 2 was produced in about 1955, the main applications of asbestos did not change significantly thereafter. Information concerning where asbestos was used in the past is extremely important in the clinical diagnosis of asbestos-related diseases and the protection of workers from asbestos exposure in the future. In this respect, Table 2 provides useful information in its indication of the sites asbestos was likely to be used.

Asbestos found applications in a wide range of industrial fields. At the time of its initial use, it was used in its raw form (bulk) mixed with other materials; cement, for example, to produce asbestos slates and high-pressure fume pipes, or resin, to produce brake linings. However, in the period following discovery of the harmful effects of asbestos, the percentage of asbestos content was reduced in construction materials, brake linings, and other products by mixing the asbestos with one or more of a number of other fibrous forms of natural minerals such as sepiolite and attapulgite; man-made fibrous minerals such as glass fibers, rock wool, potassium titanate whiskers, and basic magnesium sulfate whiskers; and organic fibers such as synthetic fibers and pulps. As a result, it is impossible to determine whether products contain asbestos by simply looking at them with the naked eye. Special analysis is required to detect the presence of asbestos in a material or product.

Table 2 Applications of main asbestos products (circa 1955)

	Product name	Applicable industrial field	Location of use	Classification (class) of asbestos
Asbestos product	Asbestos yarn	Industrial applications that use heat	Asbestos cloths, packings	Crude 3
	Asbestos fabric	Shipbuilding, ironmaking, automobiles	Fireproof curtains, packings, steam vessel lids	3, 4
	Asbestos packing, yarn	Locomotives, ironmaking, scientific industries	Packing for doors and high-temperature lid sections	3, 4
	Asbestos rubber tape	Shipbuilding, chemicals, machinery, paper manufacturing	Tapes for engine covers and chemical tank lids	3, 4
	Processed asbestos-containing rubber	Shipbuilding, power plants, machinery, chemicals	Packings	3, 4
	Graphitized asbestos yarn, cord	Railroads, ironmaking, electrical power, shipbuilding, paper manufacturing, machinery	Packings for valves and spindles	3, 4
	Joint sheets	Industrial applications that use steam	Steam flange packings, high-temperature packings for flat sections	3, 4, 5, 6
	Asbestos boards (mill boards)	Shipbuilding, gas, iron and steel, automobiles	Heat-insulating walls, packings, gaskets (for engines)	5, 6, 7
	Brake linings	Shipbuilding, automobiles, machinery, railroads	Winding machines, automotive brakes	3, 4, 5, 6, 7
	Lumber (Hemit)	Electrical industry, railroads	Heat-resistant base structures	5, 6
	Electrolytic diaphragms	Ammonium sulfate industry, soda industry	Diaphragms for electrolysis	3, 4
	Asbestos paper	Electrical, soda, die-cast heat retention	Electrical wire insulating paper, electrolytic diaphragms	4, 5, 6
Cement products	Asbestos slate	General application, factories, houses	Fire-resistant walls	4, 5, 6, 7
	Asbestos cylinders	General application, factories, houses	Exhaust flues	5, 6, 7
	Asbestos high-pressure pipes	Electrical, water supply	Water supply pipes, electrical cable racks	4, 5 Blue
Other	Asphalt mixtures	Construction, automobiles	Roofs, automobile underbody coatings, tiles	7, etc.
	Cast-iron pipe linings	Machinery, civil engineering	Cast-iron pipes	4, 5
	Lubricating grease	Machinery	Bearing greases	7 Powder

(Source: Information and Transactions of Minerals (Latest Version) authored by Kunio Yoshino, International Trade and Industry Investigation Committee)

5. Harmful effects of asbestos

Health disorders caused by the inhalation of asbestos include pneumoconiosis (lung asbestosis), lung cancer, mesothelioma, benign asbestos pleural effusion (pleurisy), and diffuse pleural thickening. Pleural plaques (pleural thickening plaques) are not considered a disease, but they serve as an important indicator of asbestos exposure. These disorders are summarized in Table 3.

Table 3 Health disorders caused by asbestos exposure

Section	Non-specific to asbestos exposure	Specific to asbestos exposure
Lungs	Pneumoconiosis Lung cancer Diffuse interstitial pneumonia	Lung asbestosis
Pleural membrane	Benign pleurisy Diffuse pleural thickening Round atelectasis	Pleural mesothelioma Pleural plaque
Peritoneum		Peritoneal mesothelioma

(1) Lung asbestosis

Lung asbestosis is a type of pneumoconiosis, and is caused by exposure to a relatively high concentration of asbestos. According to the lung asbestosis control classification specified by the Pneumoconiosis Law, people with lung asbestosis of Type 1 (1/0) or higher detected in chest X-rays are considered to be lung asbestosis patients. It is rare in recent years to see lung asbestosis in an advanced stage, manifested in the honeycombing phenomenon. Although HRCT (high-resolution CT) is useful in the diagnosis of minor lung asbestosis, it does not serve as a diagnostic factor. Observation of pleural plaques using chest CT examination is considered more determinative in distinguishing lung asbestosis from interstitial pulmonary fibrosis.

(2) Lung cancer due to asbestos

Lung cancer can be caused by exposure to asbestos in much lower concentrations relative to lung asbestosis. There is no specific characteristic in terms of the affected location or type of pathology. It is important to note an individual's job history as well as the presence or absence of pleural plaques and asbestos corpuscles in lung tissue when diagnosing lung cancer. It has been proven epidemiologically that the combination of asbestos exposure and cigarette smoking increases the risk of lung cancer. The percentage of Japanese male smokers was once 80%, and remains at approximately 40% today. This raises the concern of future cases of lung cancer resulting from the combination of cigarette smoking and asbestos.

(3) Mesothelioma

Mesothelioma is a disease caused specifically by asbestos exposure. In recent years, the number of cases of lung asbestosis caused by exposure to high-concentration asbestos has been decreasing among asbestos-related diseases in Japan. In contrast, however, the number of mesothelioma cases resulting from exposure to low-concentration asbestos is increasing. In 2006, there were nearly 1,000 reported cases of mesothelioma. In Europe and the United States, the occurrence of mesothelioma is said to have reached a peak. Since the pattern of asbestos use in Japan was some 20 to 30 years behind that seen in Europe and the United States, it is expected that the occurrence of mesothelioma will reach a peak between 2030 and 2040 in Japan, and then decline thereafter. The average incubation period from the time of asbestos exposure to the time of detection of mesothelioma is about 40 years. In some cases, the incubation period can be 50 years or longer.

(4) Benign asbestos pleural effusion (pleurisy)

This refers to nonmalignant pleural effusion caused by asbestos exposure. Diagnosis of this disease is based upon (1) a history of asbestos exposure, (2) the presence of pleural effusion, (3) the absence of another disease that could cause pleural effusion, and (4) the absence of malignant tumor for three years after the manifestation of pleural effusion. This disease can appear within ten years from the first day of asbestos exposure or after 30 to 40 years. Even if malignant cells are not found in the cytological diagnosis conducted during the early stage of pleural effusion, they may be discovered during follow-up observation. Therefore, careful and close attention is required in these cases.

(5) Pleural plaques

Pleural plaques are not fatal and they do not cause any impairment of lung function. However, because they are caused specifically by asbestos exposure, they serve as an important indicator of such exposure. When pleural plaques are detected in a patient with lung cancer or mesothelioma, a number of scenarios may be suspected: asbestos exposure from working with asbestos, indirect job-related asbestos exposure, exposure to asbestos used in close proximity, or asbestos exposure via family contact.

(6) Diffuse pleural thickening

Diffuse pleural thickening consists of pathologic lesions in the visceral pleura, and causes adhesion of the parietal pleura. This pathology stands in contrast to the case of pleural plaques, which consist of pathological lesions in the parietal pleura and do not cause adhesion of the visceral (lung) pleura. Diffuse pleural thickening is not as directly related to asbestos exposure as pleural plaques, and can be often caused by factors other than asbestos exposure.

(7) Magnitude of risk of asbestos exposure

According to the results of an epidemiological study conducted in the United States in which the number of asbestos heat-insulation workers who died of cancer and the number of cigarette smokers who died of cancer were compared, the number of excess deaths of asbestos heat-insulation workers was five times the number of deaths of non-smokers who did not work with asbestos, while the number of excess deaths of cigarette smokers was 11 times higher. The number of excess deaths of asbestos heat-insulation workers who also smoked cigarettes was 55 times higher than the number of deaths of non-smokers who did not work with asbestos.

Assuming that people live their entire lives in an environment containing 0.4 airborne asbestos fibers per liter (a typical amount of asbestos particles in the air in Japan in recent years, according to the results of a survey conducted by the Ministry of the Environment), the lifetime risk of cancer corresponds to 29 cases per 100,000 persons among cigarette smokers and three cases per 100,000 persons for non-smokers, while the lifetime risk of mesothelioma is 15 cases per 100,000 persons, according to some reports. [Reference: “Health hazards of low-concentration asbestos,” Japanese Medical Journal No. 3345, Morinaga et al. (1988)]

6. Risk of asbestos exposure

Asbestos exposure on the job can be divided into direct asbestos exposure and indirect asbestos exposure. Direct asbestos exposure results when a worker contacts asbestos directly by manufacturing or handling asbestos products. In these cases, the worker is aware of being in contact with asbestos. In contrast, indirect asbestos exposure occurs when a worker becomes exposed to asbestos while working at a task apparently unrelated to asbestos, such as routing electrical wires or installing air conditioners in a building or on a site where asbestos has been used.

In addition to asbestos exposure on the job, other cases of asbestos exposure have been reported, such as inhalation of asbestos among wives while washing the work clothes of husbands who worked with asbestos, and the exposure to asbestos through contact with asbestos products brought home by other family members.

The following shows the main work types with a high risk of asbestos exposure.

(1) Manufacturing and processing of asbestos products
(2) Unloading, transporting, and storing of asbestos raw materials
(3) Building, repairing, and dismantling of ships and vehicles
(4) Heat insulation work, and repair/removal of heat insulation
(5) Spraying asbestos, and working in areas with sprayed-on asbestos
Construction-related work such as asbestos spraying work, electric wiring work, elevator installation/replacement/repair work, and telephone/telecommunications-related work
(6) Construction and demolition work
(7) Welding and casting work
(8) Automobile repair/maintenance work

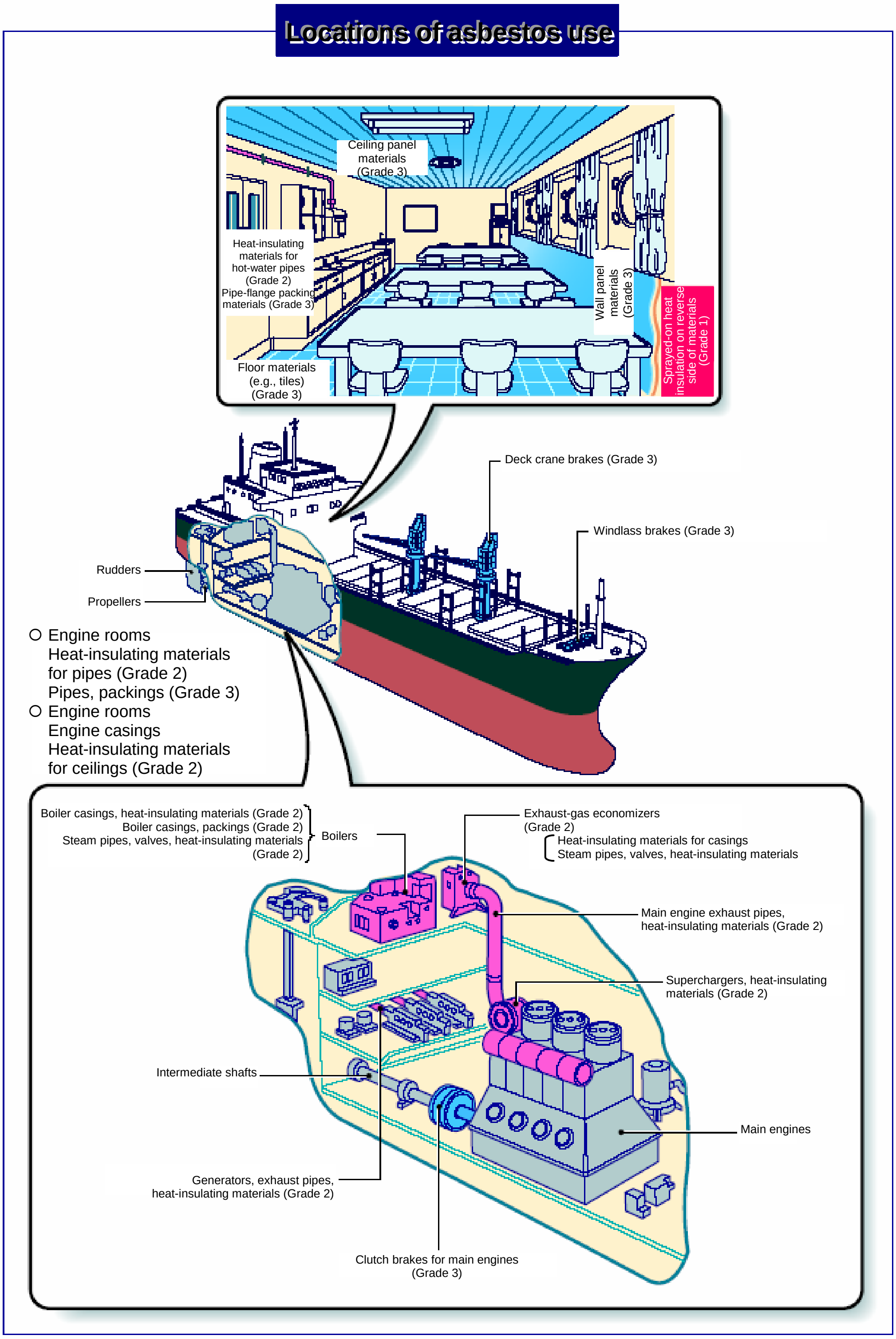
Although workers exposed to the highest concentrations of asbestos were those who worked in asbestos factories where asbestos products were manufactured and processed, it is believed that people who were exposed to the next-highest concentrations were workers in the shipbuilding and construction fields, engine operators in ships and trains, and workers who had been engaged in the manufacture, installation, and repair of boilers, pipes, blast furnaces, heat-insulators/retainers, packings, plastic moldings, electrical wiring, and brakes. In most cases, these people were subject to such high-concentration asbestos exposure primarily because they were simply unaware that they were in contact with asbestos. It is also suspected that people involved in other tasks at these work sites, people wearing heat-resistant clothes and gloves made of asbestos, and people transporting or warehousing asbestos raw materials or products were also exposed to asbestos at a relatively high frequency.

People who were exposed to high-concentration asbestos consisted mainly of those who worked in building interiors made of asbestos cement sheets and flooring materials, carpenters and plasterers involved in the construction of houses, and people engaged in the demolition of buildings made with a large amount of asbestos.

Chapter 2　Use of Asbestos in Ships

1.　General locations of asbestos in ships

The following diagram shows the locations within a ship where asbestos might be used.



* See page 14 for details on the Grade indications in the diagram.

In addition to the applications shown in the diagram, asbestos may have been used in the packings, sealants, linings, and other elements of nautical instruments, electrical products, and other devices, as well as in the electrical insulation and heat insulation of electrical circuit breakers.

CAUTION!

Effective October 1, 2004, the production, importation, and use of almost all asbestos-containing products were prohibited. On September 1, 2006, a total ban on asbestos-containing products was enacted. Nevertheless, strict and careful management of work continues to be required when dismantling or repairing equipment and devices containing asbestos products.

On exhaust pipes and steam pipes with an asbestos cloth or ribbon on the surface, asbestos is solidified or enclosed in some sections in order to prevent it from scattering, and this makes it difficult to judge whether or not the material contains asbestos. Utmost caution should be exercised when working with such pipes.

Unlike buildings and other structures, dismantling or repairing a ship requires a variety of specific work processes. Therefore, the highest priority should be placed on ensuring an appropriate work environment and on securing safe and healthy conditions for workers.

Asbestos use based on ship’s age

○ Ships built prior to 1975

Asbestos, including sprayed-on asbestos, may have been used in various places for fireproofing, heat insulation, sound insulation, sealing materials, etc.

○ Ships built between 1975 and 1990

Asbestos may have been used in interior materials, pipe packings, sealing materials, and friction-resistant materials for brakes and clutches.

○ Ships built after 1990

Asbestos may have been used in pipe packings and some anti-friction materials for brakes and clutches.

* For further details, see Reference 2, “Main Asbestos-containing Sections in Products and Suspected Usage Period in Ships.”

2. Spraying materials [asbestos content: up to 70%]

○ About spraying materials

A spraying material containing asbestos is usually made by mixing asbestos and a cement-based bonding material together with water in prescribed ratios. It is sprayed on mainly for fire resistance, sound and heat insulation, or to prevent dew condensation. Asbestos-containing spraying materials were used from about 1955 to about 1975. Sprayed-on asbestos is considered most likely to generate airborne asbestos particles during handling.

(These materials were available under the brand names Tomrex, Probestos, among others)

○ Main applications, locations of use, etc.

- Fire-resistant covering:
  - Asbestos was used commonly in areas requiring A-60 class protection, such as walls in immediate proximity to an engine room or an emergency pump room, and, in the case of ferries, on the reverse sides of decks in the accommodation space in immediate proximity to the wagon deck.
- Sound absorption, heat insulation:
  - Ceilings of steering gear rooms, ceilings of engine rooms, walls and ceilings of wagon decks in ferries, etc.
- Dew condensation prevention:
  - Refrigeration zones, bathroom, lavatory, kitchens, battery rooms, etc.

(Sprayed-on asbestos on reverse side of wall in accommodation space)

(Asbestos sprayed on ceiling to prevent dew condensation)

(Sprayed-on surface is held in place by plaster. The right photo shows a section in which part of the surface has been removed.)

3. Heat-insulating material

○ About heat-insulating materials

Asbestos-containing heat-insulating materials are used on steam pipes, steam drainpipes, hot water pipes, fuel pipes, gas pipes, air conditioner ducts, boilers, tanks, and other elements that are typically at temperatures higher (or lower) than room temperature. Asbestos used for this purpose is the second-easiest to scatter, following sprayed-on asbestos.

Heat-insulating products that contain asbestos include heat-insulating boards and tubes made by molding a mixture of amosite and bonding material, as well as asbestos cloths, asbestos ribbons, and asbestos blankets.

Some heat-insulating materials were produced by molding and solidifying a plaster-like material made by kneading asbestos fibers and water.

○ Examples, main applications, and locations of use of heat-insulating materials

- Heat-insulating boards [asbestos content: up to 30%]
  - Heat-insulating boards and tubes were used as the external walls of equipment such as boilers and tanks, and as a covering material for pipes and valves. These are held in place by stud bolts or wires. Their surfaces are sometimes covered with an asbestos cloth or tin sheet.

(Asbestos was used for insulating tanks. An asbestos cloth was pasted on the surface of the heat-insulating board and then reinforced with wire netting. Asbestos in the right photo is reinforced with a tin sheet.)

- Asbestos cloths [asbestos content: up to 100%]
  - Asbestos cloths were used to cover asbestos-mixed heat-insulating materials. These were also used as heat insulation on pipes, heat insulation to prevent dew condensation, asbestos blankets, and flexible joints for air trunks.

(Cloth made from asbestos yarn)

(Asbestos cloth wrapped around steam pipe)

- Asbestos ribbons [asbestos content: up to 100%]
  - Asbestos ribbons were used to cover medium-temperature pipes to prevent dew condensation. They were also used as door packings for high-temperature areas and as fire-door packings.

(Asbestos ribbon)

(Asbestos rope)

- Asbestos blankets [asbestos content: up to 100%]
  – An asbestos blanket was made by enclosing amosite asbestos batting with an asbestos cloth and sewing with asbestos yarn. Asbestos blankets were used on irregularly shaped pipe sections, and on vibrating sections such as valves, pipe flanges, and expansion sections of exhaust pipes.

(Asbestos blanket used on steam valve)

(Asbestos blanket on expansion section of exhaust pipe)

4. Molded product [asbestos content: up to 30%]

○ About molded products

Asbestos-containing molded products include sound-absorbing ceiling materials, base materials for walls, vinyl floor titles, and flange sheet packings. These are mostly hard materials and the amount of asbestos scattered by such materials is believed to be minimal. However, when these materials are crushed under dry conditions, rubbed rigorously, or cut, asbestos particles will naturally scatter.

○ Examples, main applications, and locations of use of molded products

- Ceiling materials, wall materials:
  – Asbestos perlite boards, asbestos calcium silicate boards, etc. were used as ceiling materials and as base materials for walls. They were also processed for a decorative finish and used as interior surface materials. Sound-absorbing perforated boards represent one example of ceiling materials containing asbestos.

(Sound-absorbing ceiling material)

- Floor materials:
  – Asbestos was used as a raw material in vinyl floor tiles, vinyl floor sheets, and plastic tiles.

(Vinyl floor tiles)

- Packing materials:
  - Asbestos was used commonly in pipe packings, gland packings, sheet packings for machines, and gaskets.

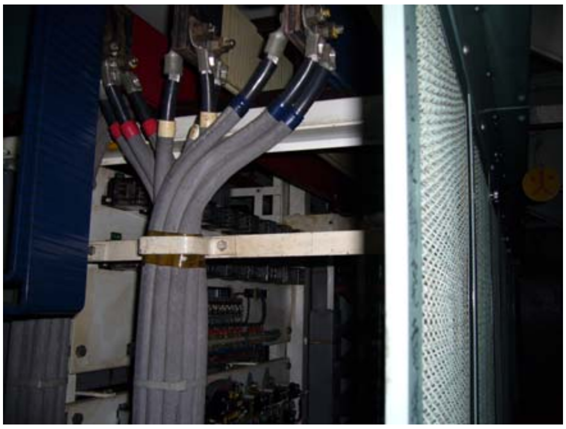
(Flange sheet packings for low-pressure pipes)

(Gland packing for valves)

- Friction-resistant materials:
  - Asbestos was incorporated in many machine clutch and brake linings.

(Brake lining for windlass)

- Heat-insulating and electrical insulation materials:
  - Asbestos was used in components of electrical junction boxes and distribution panels. Asbestos was also used in components and wire insulators of electric circuit breakers, air circuit breakers, space heaters, etc.



(Reverse side of electrical junction box)

Chapter 3 Work Categorization (Grades) for Suppression of Asbestos Scattering and Exposure in Ships

To minimize the generation of asbestos particles during repair or dismantling work and to prevent exposure to harmful asbestos particles, it is recommended to determine a work grade according to the difficulty of each task and to select an appropriate work method based on this grade, to ensure that such work is performed safely under the supervision of responsible personnel. Since the difficulty of performing a task can be estimated by the type of use of asbestos-containing material, three work grades have been established in accordance with the type of material handled in repair or dismantling work.

Note 1: The details of Grade 1 through Grade 3 correspond closely to those of Level 1 through Level 3 of building demolition work specified in the “Manual for Prevention of Exposure to Asbestos Particle Dust” published by the Japan Construction Safety and Health Association.

Note 2: The work grade should be determined carefully, bearing in mind that the difficulty of preventing asbestos scattering varies depending on not only the material but also on the amount of work required and the method of work.

Work grade classification

Work grade	Description of work
Work grade 1	Work that results in the generation of a large amount of asbestos particles at the worksite (such as complete removal of sprayed-on asbestos material), thus requiring extensive measures to prevent asbestos scattering and exposure
Work grade 2	Work that results in the generation of a large amount of asbestos particles in some parts depending on the work method (such as removal or restoration of heat-insulating materials containing asbestos), thus requiring extensive measures to prevent asbestos scattering and exposure at the worksite, second in degree only to those implemented for work grade 1
Work grade 3	Work that results in the generation of a relatively small amount of asbestos particles, such as removal of molded asbestos products such as packings, molded linings, and boards

As indicated above, three work grades may apply. These work grades should be used as guidelines, and the work grade to be applied must be in accordance with the quantity of work, work environment, work method, and other applicable factors, in order to ensure the appropriate management of work and proper implementation of measures to prevent asbestos scattering and exposure.

For example, even when the work to be performed may initially be classified as Grade 2, if such work involves the removal of asbestos-containing heat-insulating material from all room walls, it should be considered Grade 1 work. When the work to be performed may initially be classified as Grade 3, if the work involves rubbing, cutting, or crushing an asbestos product or use of a chipper, grinder, sander, drill, or saw, and results in the scattering of particles from a molded asbestos product, the work grade must be raised to Grade 2.

As described above, the work grade should be determined based on the actual work to be performed (quantity, content, method), and any supervisor of asbestos-related work must take the utmost care to ensure implementation of thorough measures to prevent asbestos scattering and exposure.

The details of work procedures specified by individual work grades are summarized in the table shown in Section 4, Chapter 5.

Chapter 4　Procedures for Determining Work Grade

1.　Preliminary survey

A preliminary survey represents the first step when engaging in asbestos-handling work on a ship, and requires the most careful attention.

Note that workers who perform the actual work will not be able to tell whether or not a material contains asbestos through visual inspection.

When determining the work grade, the person responsible for the work to be performed must examine the work specifications submitted by the client and discuss work operations (including any appurtenant work) thoroughly with the person in charge of the work at the client company, before conducting a survey on the use of asbestos within the section to be dismantled or repaired.

Be sure to enact comprehensive and thorough measures to ensure safety during such work, including but not limited to protection against the hazards of asbestos, remaining aware that the shipyard is responsible for overall safety and health management on the premises.

< Reference: Article 3 of Asbestos Hazard Prevention Regulations >

Method of survey:

- Interview with ship owner and ship crew concerning the details of work
- Examination of site drawings
- Confirmation with equipment manufacturers
- Confirmation with shipbuilder based on work details
- Sampling test (JIS A1481), if necessary

○ If it is not known whether or not the material to be worked on contains asbestos, the material must be handled as an asbestos-containing material.

Column

Whether the asbestos content exceeds 0.1 weight % or not must be determined based on the method of measuring asbestos in building materials and products specified in JIS A 1481. For the detection of asbestos in a given material, newly developed microscopes (phase-contrast dispersion microscope or polarization microscope) now enable quick judgment.

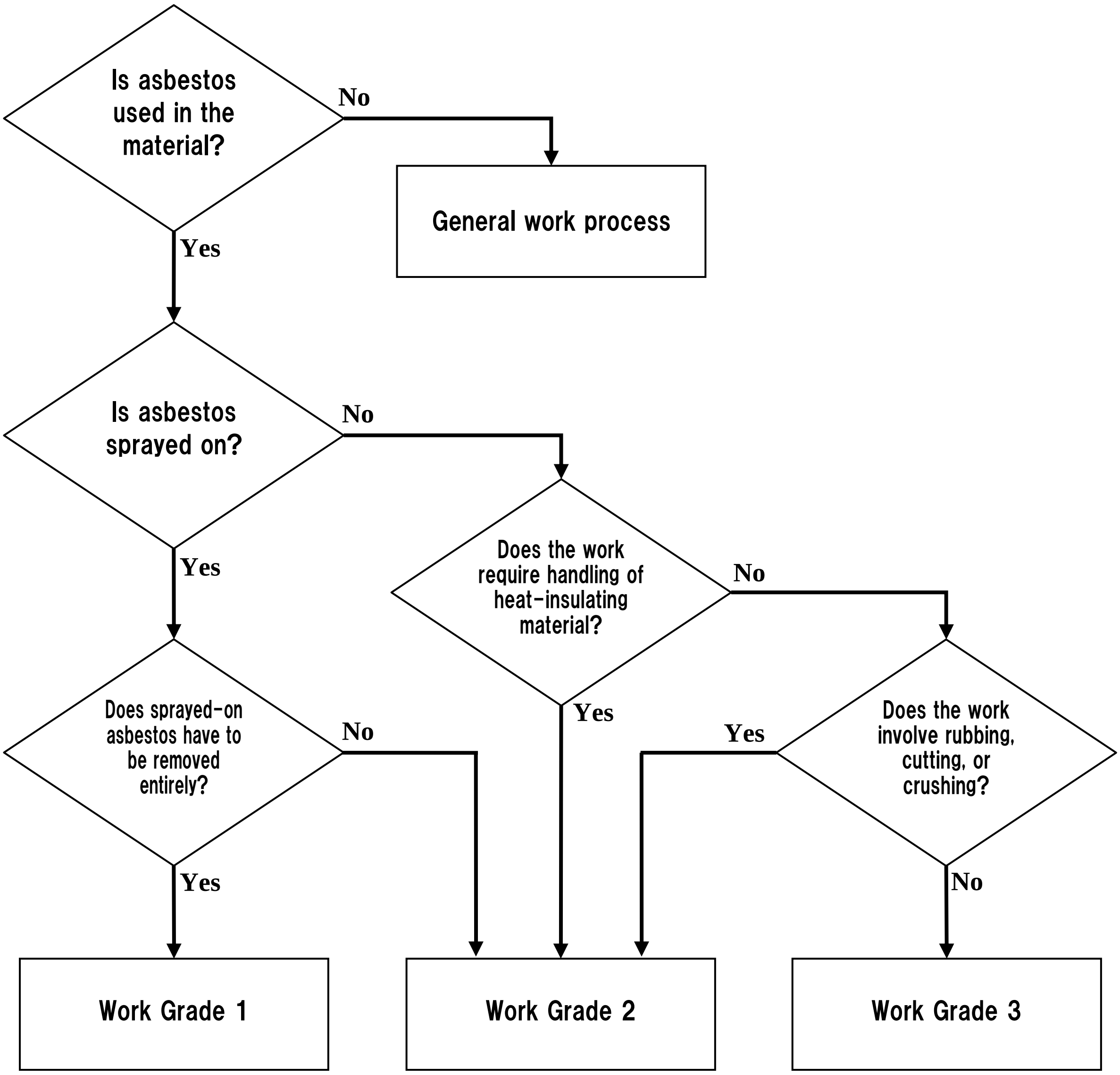
Many measuring and testing organizations have such microscopes, and their services can be solicited for the detection of the presence or absence of asbestos. Some organizations can provide results in around half a day.

The website of the Japan Association for Working Environment Measurement posts a list of organizations capable of detecting or measuring asbestos in a given material. (http://www.jawe.or.jp/)

(Information provided by the Japan Association for Working Environment Measurement)

2. Work grade determination flow

Based on survey results, the work grade is determined in accordance with the following flow.



Work grade determination flowchart

Chapter 5　Work Procedures for Each Work Grade

1.　Work grade 1

The person responsible for the work must conduct the following for asbestos-related tasks. Since the items are listed roughly in chronological order, they can be followed in the listed order, to prevent omissions.

1.1　Notification of work

Notification is not mandatory for asbestos-related work conducted during the dismantling or repair of a ship. However, when work calls for complete removal of a sprayed-on asbestos material, it is advisable to notify (and/or inquire of) the relevant labor standards inspection office, given the risk involved in such work.

Note that some municipal governments require notification. It is thus advisable to check with the relevant municipal government in advance.

1.2　Preparation for work

□ Assign a supervisor in charge of asbestos-related work (supervisor of specified chemical-substance-handling work).

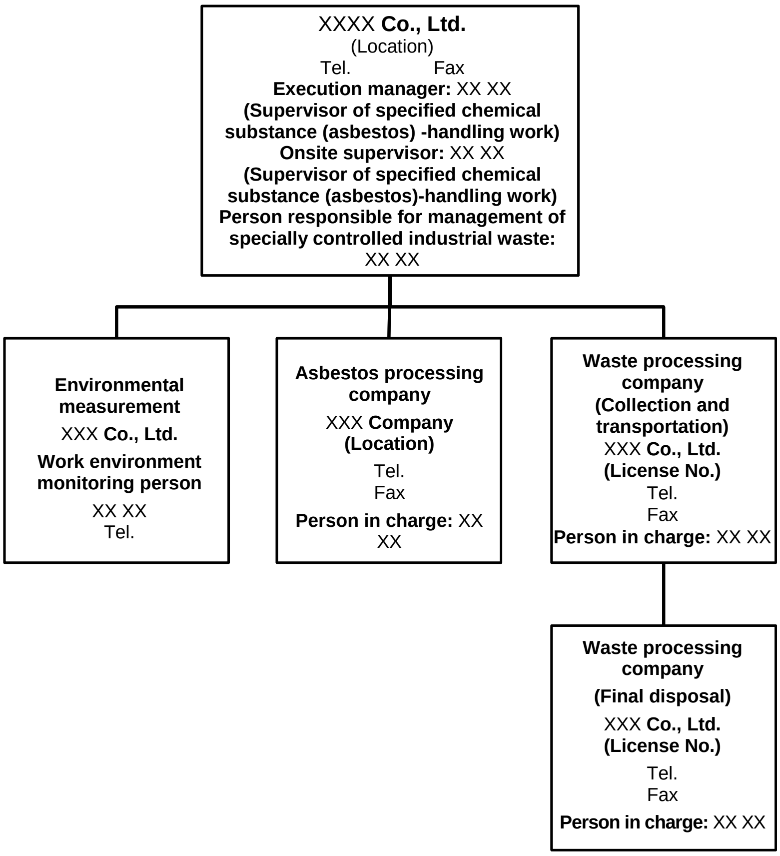
< Article 14 of Industrial Safety and Health Law >
< Section 23 in Article 6 of Industrial Safety and Health Law Enforcement Order >
< Article 19 of Asbestos Hazard Prevention Regulations >

□ Organize a safety management system

- Assign a general manager for overall safety and health, a safety and health controller, and a supervisor responsible for asbestos-related work, and generate a diagram depicting the safety and health management system, as well as a chart of asbestos-related work-management organizations.

< Articles 10, 11, and 14 of Industrial Safety and Health Law >

Table of execution management organizations



(Example chart of work-management organizations)

□ Generate a work plan.

- The work plan should include a process chart, work procedures, method of preventing asbestos scattering and exposure, method of storing waste, and method of processing waste.

< Reference: Article 4 of Asbestos Hazard Prevention Regulations >

□ Educate workers.

- The education provided should include the following information:

  (1) Harmful effects of asbestos

  (2) Conditions of use of asbestos and related items

  (3) Methods of suppressing scattering of particles such as asbestos dust

  (4) Methods of use of protective gear

  (5) Methods of handling waste, etc.
  (Refer to “Notice No. 132 of the Ministry of Health, Labor and Welfare” in Reference 4.)

< Reference: Article 27 of Asbestos Hazard Prevention Regulations >

□ Seal and isolate the work area with plastic sheets or the like, and set up a negative-pressure dust collector.

< Reference: Articles 6 and 7 of Asbestos Hazard Prevention Regulations >
< Article 15 of Asbestos Hazard Prevention Regulations >

(Two polyethylene film sheets; duct leading to negative-pressure dust collector)

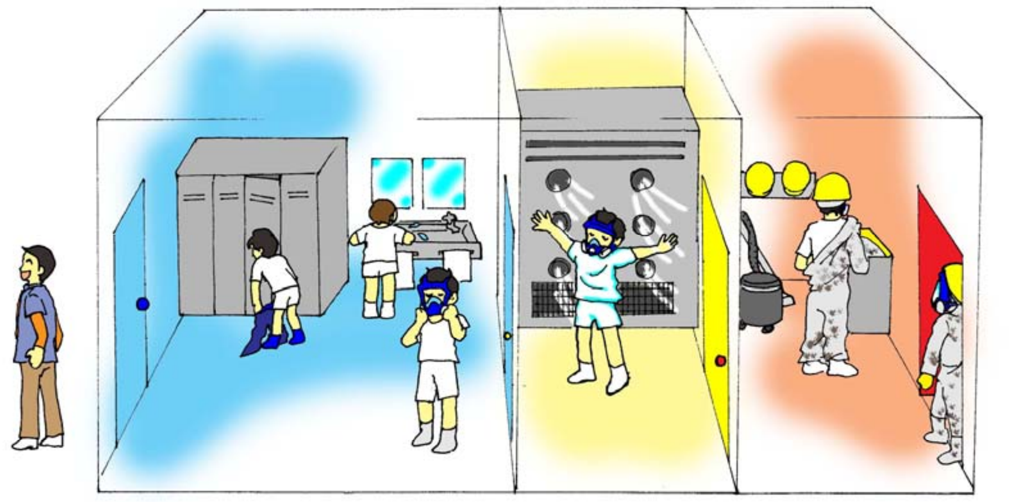
(Negative-pressure dust collector)

- Sealing/isolating the work area and creating negative pressure in the work area (indoors) are methods of preventing asbestos from contaminating the air outside the work area. The negative-pressure dust collector must have sufficient discharge capacity to ventilate the work area (indoors) at least four times per hour.

- The opening of the suction duct of the dust collector used for the work area (indoors) should be located away from the (outside) air-intake opening (normally situated within the security zone doorway) in order to prevent the collection of contaminated air inside the work area.

□ Establish a security zone (dressing room, cleaning room).

< Article 31 and Section 2 in Article 32 of Asbestos Hazard Prevention Regulations >



(Dressing room) (Cleaning room) (Doorway to work area)

□ Secure a vacuum cleaner that is structured to prevent scattering of particles by exhaust air and equipped with a HEPA (High Efficiency Particulate Air) filter.

< Article 30 of Asbestos Hazard Prevention Regulations >

(Vacuum cleaners with HEPA filters)

□ Prepare a particle scattering inhibitor.

- When asbestos particles are moisturized by water, the particles will easily scatter after drying. If they are moisturized by a particle scattering inhibitor, however, they will not scatter easily even after they dry. (See Reference 1.)

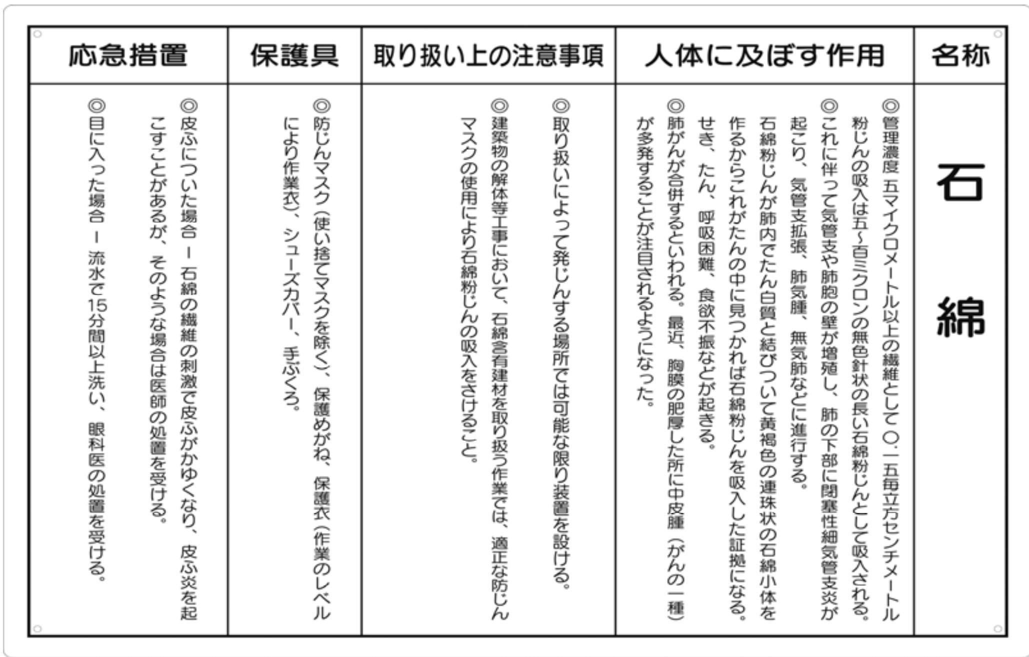
□ Arrange a temporary storage place exclusively for asbestos-containing waste.

< Article 32 of Asbestos Hazard Prevention Regulations >

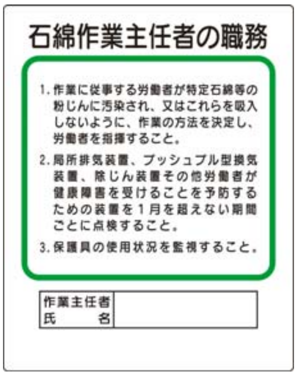
(Temporary storage site signboard)

- Post caution signs and “Asbestos being processed! Do not enter!” signs around the worksite.

< Article 15 of Asbestos Hazard Prevention Regulations >



(Asbestos caution sign)



(Work supervisor signboard)

(Signboards warning people to keep away)

- Protective gear (See Reference 3)
  - The protective work clothes and gloves must minimize the penetration and adhesion of asbestos particles.
  - It is necessary to seal with tape any gaps between the mask and clothing, between gloves and clothing, and between feet covers and clothing.
  - Full-face dust protective masks (RL-3) should be worn. If possible, pressure-demand-type (in which positive pressure is maintained inside the face piece even during inspiration) air-line masks should be used.

< Articles 14, 44, and 45 of Asbestos Hazard Prevention Regulations >

(Full-face dust protective mask and protective clothes)

(Pressure-demand-type air-line mask and protective clothes)

□ Others

- Remember to enact general safety measures, including the following.

  (1) Flat scaffold boards should be laid out closely to create a temporary floor at the worksite. Stepladders, ladders, and items that can tip over must not be used.

  (2) Note that many protective clothes for construction workers (Tyvek brand, etc.) are not resistant to flames (i.e., they burn easily).

1.3 During work

□ The work environment should be monitored while the work is in process.

< Reference: Article 65 of Industrial Safety and Health Law >

□ Moisturize asbestos with a particle scattering inhibitor.

- When asbestos particles are moisturized by water, the particles easily scatter after they dry. If they are moisturized by a particle scattering inhibitor, however, they do not scatter easily even when they dry. (See Reference 1.)

< Article 13 of Asbestos Hazard Prevention Regulations >

(Moisturizing asbestos using atomizer)

- Clean the area after the end of each task. Remove adhered dust particles from protective clothes, masks, gloves, tools, etc. using a vacuum cleaner. Place waste in a designated sealable asbestos waste container.

< Article 30, Article 32, Section 2 in Article 32, and Article 46 of Asbestos Hazard Prevention Regulations >

(Sealable bags designed for asbestos waste)

- Produce a daily work record and store it for 40 years after the completion of work.

< Article 35 of Asbestos Hazard Prevention Regulations >

1.4 Processing of asbestos waste

Waste must be processed and disposed of in accordance with the **Waste Disposal and Public Cleansing Law**. Sealed bags containing asbestos waste generated during the work process, as well as sealed bags containing covering sheets, dust protective masks, dust filters, gloves, and protective clothes used during work, must themselves be placed in sealable bags to prevent scattering of particles during temporary storage and transportation to a disposal site by a subcontracted company. Note that diffusible asbestos particles must be processed as specially controlled industrial waste.

Since different waste-handling procedures may be specified by some municipal governments, it is necessary to inquire of the relevant municipal government in advance.

< Reference: Section 2 in Article 12 of Waste Disposal and Public Cleansing Law >
< Reference: Section 17 in Article 8 of Waste Disposal and Public Cleansing Law Enforcement Regulations >

2. Work grade 2

The person responsible for the work must conduct the following with respect to any asbestos-related tasks.

2.1 Notification of work

It is not mandatory to notify the relevant standards inspection office of asbestos-related work. However, in the event of any concern, it is advisable to consult the relevant labor standards inspection office or other applicable office.

2.2 Preparation for work

- Assign a supervisor in charge of asbestos-related work (supervisor of specified chemical substance handling work).

< Article 14 of Industrial Safety and Health Law >
< Section 23 in Article 6 of Industrial Safety and Health Law Enforcement Order >
< Article 19 of Asbestos Hazard Prevention Regulations >

- Organize a safety management system.

- Assign a general manager for overall safety and health, a safety and health controller, and a supervisor responsible for asbestos-related work, and generate a diagram depicting the safety and health management system, as well as a chart of asbestos-related work-management organizations.

< Articles 10, 11, 14, etc. of Industrial Safety and Health Law >

□ Generate a work plan.

- The work plan should include a process chart, work procedures, method of preventing asbestos scattering and exposure, method of storing waste, and method of processing waste. Concurrent execution of other tasks is prohibited. Cutting or grinding using a pneumatic or electrical tool is also prohibited.

< Reference: Article 4 of Asbestos Hazard Prevention Regulations >

□ Educate workers.

- The education provided should include the following information:

  (1) Harmful effects of asbestos

  (2) Conditions of use of asbestos and related items

  (3) Methods of suppressing scattering of particles such as asbestos dust

  (4) Methods of use of protective gear

  (5) Methods of handling waste, etc.
  (Refer to “Notice No. 132 of the Ministry of Health, Labor and Welfare” in Reference 4.)

< Reference: Article 27 of Asbestos Hazard Prevention Regulations >

□ Cover the floor in the work area and the surrounding areas with plastic sheets and the like to protect against scattering asbestos, and mark the work area clearly to distinguish it from other work areas.

- To prevent concurrent execution of other types of work when asbestos-related tasks are conducted in a location such as the engine room of a small ship, the entire area—the whole engine room, for example—should be off-limits during asbestos removal work, or the entire body of a machine containing asbestos should be un-mounted and removed from the ship before work is performed.

< Reference: Articles 6 and 7 of Asbestos Hazard Prevention Regulations >
< Article 15 of Asbestos Hazard Prevention Regulations >

□ Prepare a dust scattering inhibitor.

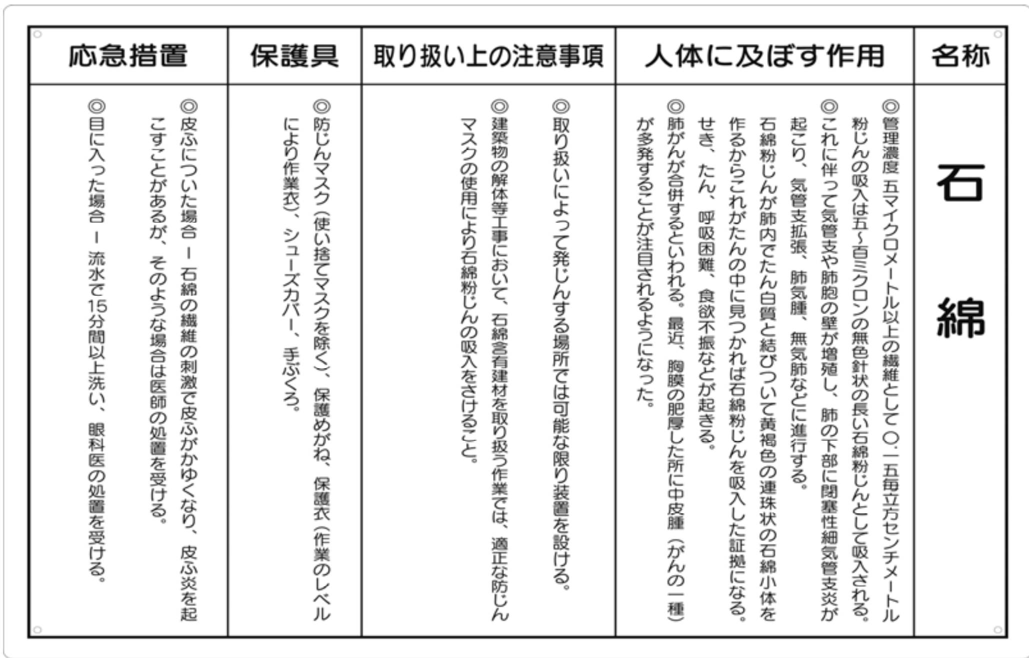
- When asbestos particles are moisturized by water, the particles easily scatter after they dry. If they are moisturized by a dust scattering inhibitor, however, they will not scatter easily even when they dry. (See Reference 1.)

□ Secure a vacuum cleaner equipped with a HEPA (High Efficiency Particulate Air) filter.

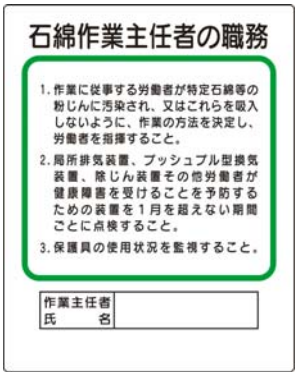
(Vacuum cleaners with HEPA filters)

< Article 30 of Asbestos Hazard Prevention Regulations >

□ Post “Asbestos being processed! Do not enter!” signs around the worksite.



(Asbestos caution sign)



(Work supervisor signboard)

(Signboards warning people to keep away)

< Article 15 of Asbestos Hazard Prevention Regulations >

□ Prepare sealable containers (bags) designed for asbestos waste.

(Sealable bags designed for asbestos waste)

< Article 32 of Asbestos Hazard Prevention Regulations >

□ To remove airborne asbestos particles that may attach to the clothes before leaving the worksite, set up a temporary cleaning room near the site and install cleaning equipment, such as an air shower.

< Articles 31 and 46 of Asbestos Hazard Prevention Regulations >

(Example of cleaning room)

(Example of air shower equipment)

□ Protective gear (See Reference 3)

- The protective work clothes and gloves must minimize the penetration and adhesion of asbestos particles.
- It is necessary to seal with tape any gaps between the mask and clothing, between gloves and clothing, and between feet covers and clothing.
- Half-face dust protective masks (RL-3, RS-3) must be worn.
- Protective goggles must be worn.

< Articles 14, 44, and 45 of Asbestos Hazard Prevention Regulations >

(Protective clothes)

(RL-3 dust protective mask)

(Goggle)

2.3 During work

□ A particle scattering inhibitor should be used to moisturize asbestos particles, with caution exercised to prevent asbestos particles from subsequently drying and scattering.

- When asbestos particles are moisturized by water, the particles easily scatter after they dry. If they are moisturized by a dust scattering inhibitor, however, they do not scatter easily even when they dry. (See Reference 1.)

< Article 13 of Asbestos Hazard Prevention Regulations >

- Clean the area after the end of each task. Remove adhered dust particles from protective clothes, masks, gloves, tools, etc. using a vacuum cleaner. Place waste in a designated sealable container for asbestos waste.

< Article 30, Article 32, Section 2 in Article 32, and Article 46 of Asbestos Hazard Prevention Regulations >

- Clean the work area using a vacuum cleaner that is structured to prevent the scattering of particles by exhaust air and equipped with a HEPA (High Efficiency Particulate Air) filter.

< Article 30 of Asbestos Hazard Prevention Regulations >

- Before leaving the worksite, clean all work clothes, shoes, and gloves to which airborne asbestos is suspected to have adhered using cleaning equipment (such as an air shower) inside the cleaning room.

< Article 46 of Asbestos Hazard Prevention Regulations >

- Produce a work record and store it for 40 years after the completion of work.

< Article 35 of Asbestos Hazard Prevention Regulations >

2.4 Processing of asbestos waste

Waste must be processed and disposed of in accordance with the **Waste Disposal and Public Cleansing Law**. Sealed bags containing asbestos waste generated during a given work process, as well as sealed bags containing covering sheets, dust protective masks, dust filters, gloves, and protective clothes that were used during the work, must themselves be placed in sealable plastic bags, to prevent scattering of particles during temporary storage and transportation to a disposal site by a subcontracted company. Note that diffusible asbestos particles must be processed as specially controlled industrial waste.

Since different waste-handling procedures may be specified by some municipal governments, it is necessary to inquire of the relevant municipal government in advance.

< Reference: Section 2 in Article 12 of Waste Disposal and Public Cleansing Law >
< Reference: Section 17 in Article 8 of Waste Disposal and Public Cleansing Law Enforcement Regulations >

3. Work grade 3

The person responsible for the work must conduct the following with respect to any asbestos-related tasks.

3.1 Notification of work

It is not mandatory to notify the relevant standards inspection office of asbestos-related work. However, in the event of any concern, it is advisable to consult the relevant labor standards inspection office or other applicable office.

3.2 Preparation for work

- Assign a supervisor in charge of asbestos-related work (supervisor of specified chemical substance handling work).

< Article 14 of Industrial Safety and Health Law >
< Section 23 in Article 6 of Industrial Safety and Health Law Enforcement Order >
< Article 19 of Asbestos Hazard Prevention Regulations >

- Organize a safety management system
  - Assign a general manager for overall safety and health, a safety and health controller, and a supervisor responsible for asbestos-related work, and generate a diagram depicting the safety and health management system, as well as a chart of asbestos-related work-management organizations (in accordance with the scale of work to be conducted).

< Articles 10, 11, 14, etc. of Industrial Safety and Health Law >

□ Generate a work plan.

- The work plan should include a process chart, work procedures, method of preventing asbestos scattering and exposure, method of storing waste, and method of processing waste. Cutting or grinding using a pneumatic or electrical tool is prohibited.

< Reference: Article 4 of Asbestos Hazard Prevention Regulations >

□ Educate workers.

- The education provided should include the following information:

(1) Harmful effects of asbestos

(2) Conditions of use of asbestos and related items

(3) Methods of suppressing scattering of particles such as asbestos dust

(4) Methods of use of protective gear

(5) Methods of handling waste, etc.
(Refer to “Notice No. 132 of the Ministry of Health, Labor and Welfare” in Reference 4.)

□ Prepare a dust scattering inhibitor.

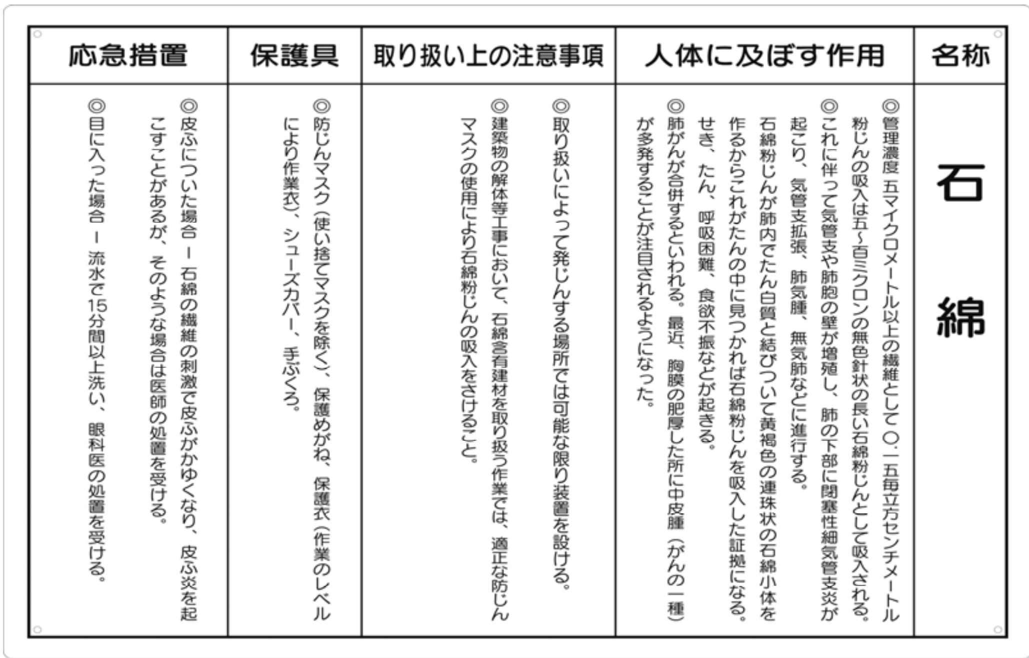
- When asbestos particles are moisturized by water, the particles easily scatter after they dry. If they are moisturized by a dust scattering inhibitor, however, they will not scatter easily even when they dry. (See Reference 1.)

□ Secure a vacuum cleaner equipped with a HEPA (High Efficiency Particulate Air) filter.

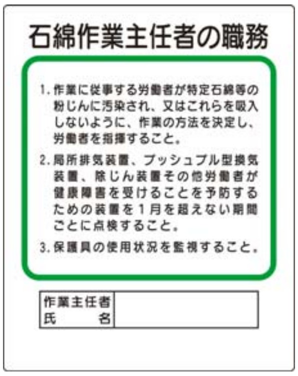
(Vacuum cleaners with HEPA filters)

< Article 30 of Asbestos Hazard Prevention Regulations >

□ Post “Asbestos being processed! Do not enter!” signs around the worksite.



(Asbestos caution sign)



(Work supervisor signboard)

(Signboards warning people to keep away)

< Article 15 of Asbestos Hazard Prevention Regulations >

- Prepare sealable containers (bags) designed for asbestos waste.

(Sealable bags designed for asbestos waste)

< Article 32 of Asbestos Hazard Prevention Regulations >

- Protective gear (See Reference 3)
  - The protective work clothes and gloves must minimize the penetration and adhesion of asbestos particles.

- Half-face dust protective masks (RL-2, RS-2) must be used.
- Protective goggles must be worn.

(RL-2 dust protective mask)

(Goggle)

< Articles 14, 44, and 45 of Asbestos Hazard Prevention Regulations >

2.3 During work

□ During the removal of asbestos materials, molded products must not be damaged, cut, or ground.

- If asbestos products must be crushed, cut, or ground during removal, use a particle scattering inhibitor to moisturize the asbestos material.

< Article 13 of Asbestos Hazard Prevention Regulations >

CAUTION!

The results of a test showed that using an electric sander on asbestos sheet packings moisturized with water increased the amount of scattered asbestos particles, relative to sanding such sheet packings that were not moisturized with water. (See Reference 1.)

Never use an electric sander on sheet packings.

□ Clean the area after the end of each task. Remove adhered dust particles from the protective clothes, masks, gloves, tools, etc. using a vacuum cleaner. Place waste in a designated sealable container for asbestos waste.

< Article 30, Article 32, Section 2 in Article 32, and Article 46 of Asbestos Hazard Prevention Regulations >

□ Clean the work area using a vacuum cleaner that is structured to prevent the scattering of particles by exhaust air and equipped with a HEPA (High Efficiency Particulate Air) filter.

< Article 30 of Asbestos Hazard Prevention Regulations >

□ Clean all work clothes, shoes, and gloves to which airborne asbestos is suspected to have adhered using a vacuum cleaner that is structured to prevent scattering of particles by exhaust air.

< Article 46 of Asbestos Hazard Prevention Regulations >

- Produce a work record and store it for 40 years after the completion of work.

< Article 35 of Asbestos Hazard Prevention Regulations >

3.4 Processing of asbestos waste

Waste must be processed and disposed of in accordance with the **Waste Disposal and Public Cleansing Law**. Sealed bags containing asbestos waste generated during the work process, as well as sealed bags containing covering sheets, dust protective masks, dust filters, gloves, and protective clothes used during work, must themselves be placed in sealable bags to prevent scattering of particles during temporary storage and transportation to a disposal site by a subcontracted company. Note that diffusible asbestos particles must be processed as specially controlled industrial waste.

Since different waste-handling procedures may be specified by some municipal governments, it is necessary to inquire of the pertinent municipal government in advance.

< Reference: Section 2 in Article 12 of Waste Disposal and Public Cleansing Law >
< Reference: Section 17 in Article 8 of Waste Disposal and Public Cleansing Law Enforcement Regulations >

4. Work procedures by work grade

	Grade 1 (Generation of an extremely large amount of asbestos particles)	Grade 2 (Generation of a large amount of asbestos particles)	Grade 3 (Generation of a small amount of asbestos particles)
Applicable work type	• Removal of sprayed-on asbestos • Removal of a large amount of asbestos cloths, etc. • Removal of a large amount of wall/ceiling sound-insulating materials	• Removal of sectional heat-insulating materials, such as asbestos cloths and ribbons, installed in or on equipment and pipes	• Removal of sections of asbestos molded products such as molded boards, vinyl tiles, molded packings, and molded linings (Stripping using an electric sander is prohibited.)
Work plan	Generation of a plan for preventing asbestos particle generation and asbestos exposure		
Notification	Although notification of work is not mandatory, it is advisable to check with the relevant labor standards inspection office or municipal government in advance.		
Work supervisor	Assignment of supervisor to be in charge of asbestos-related work		
Education	Provision of specific education to workers		
Protective gear	• Full-face dust protective mask (Category: RL-3) (if possible, pressure-demand-type air-line mask), or • Respiratory protective device with electric fan • Protective gloves	Same as those for grade 1, or • Half-face dust protective mask (Category: RL-3, RS-3) • Goggles • Protective gloves	Same as those for grade 2, or • Half-face dust protective mask (Category: RL-2, RS-2) • Goggles • Protective gloves
Worksite preparation	• Isolation and covering of worksite with plastic sheets, etc. • Use of negative-pressure dust collector (worksite) • Establishment of security zone (dressing room, cleaning room, doorway room) • Posting of signs such as “Do not enter!” signs • Use of vacuum cleaner with HEPA filter • Use of sealable containers for asbestos waste	• Covering of worksite with plastic sheets, etc. • Establishment of clean room (also referred to as a cleaning room) • Posting of signs such as “Do not enter!” signs • Use of vacuum cleaner with HEPA filter	• Covering of worksite with plastic sheets, etc. • Posting of signs such as “Do not enter!” signs • Use of vacuum cleaner with HEPA filter
During/after work	• Moisturization of asbestos particles with particle scattering inhibitor • Work-environment monitoring • Storage of waste in designated temporary waste storage site • Cleaning of worksite • Cleaning of workers’ work clothes, etc. • Production and storage of work record	• Moisturization of asbestos particles with particle scattering inhibitor • Cleaning of worksite • Cleaning of workers’ work clothes, etc. • Production and storage of work record	• Prohibition against breaking, cutting, grinding, etc. (If such processing is unavoidable, asbestos particles must be moisturized with particle scattering inhibitor.) • Cleaning of worksite • Cleaning of workers’ work clothes, etc. • Production and storage of work record
Waste processing	Diffusible asbestos • Sprayed-on asbestos materials, asbestos heat-insulating materials, covering materials, filters, gloves, protective clothes • Treated as specially controlled industrial waste		
	Non-diffusible asbestos • Asbestos-containing molded materials * Since different waste-handling procedures may be specified by some municipal governments, it is necessary to inquire of the relevant municipal government in advance.		

Chapter 6 Brief History of Asbestos-related Laws and Regulations

Year	Description of law/regulations
1972	• Establishment of Ordinance on Prevention of Hazards due to Specified Chemical Substances – Appointment of work supervisor
1975	• Amendment of Ordinance on Prevention of Hazards due to Specified Chemical Substances – Prohibition of asbestos spraying work
1989	• WHO's recommendation on prohibition of asbestos use • Amendment of Air Pollution Control Law – Establishment of property border standards for specified particle-generating facilities
1995	• Amendment of Industrial Safety and Health Law – Prohibition of manufacture, import, and use of blue asbestos and brown asbestos
1996	• Amendment of Air Pollution Control Law – Compliance with work standards for demolition/repair work of buildings in which asbestos is used
2002	• Amendment of ministerial ordinance related to Law for Safety of Vessels – General prohibition of use of asbestos-containing materials in ships based on revised SOLAS
2004	• Amendment of Industrial Safety and Health Law – Prohibition of manufacture, use, etc. of asbestos-containing products (10 items)
2005	• Establishment of Asbestos Hazard Prevention Regulations
2006	• Amendment of Industrial Safety and Health Law – Total ban on asbestos manufacture, etc. (except for certain items such as joint sheet gaskets for submarines) – Decrease of legal restriction on asbestos content from "more than 1%" to "more than 0.1%" • Amendment of ministerial ordinance related to Law for Safety of Vessels – Total ban on new use of asbestos-containing materials in ships • Amendment of Air Pollution Control Law, associated enforcement order, and enforcement regulations – Expansion of the scope of facilities required for compliance with work standards for demolition/repair work from "buildings" to "structures" • Amendment of Waste Disposal and Public Cleansing Law and associated enforcement order – Expansion of the scope of generating source of "asbestos waste, etc." (categorized as specially controlled industrial waste) from "buildings" to "structures" – Establishment of standards for collection, transportation, processing, etc. of asbestos-containing waste

(References)

○ Applicable laws and regulations

Industrial Safety and Health Law, associated enforcement order, Ordinance on Labor Safety and Hygiene, Asbestos Hazard Prevention Regulations

Pneumoconiosis Law and associated enforcement regulations

Air Pollution Control Law and associated enforcement order and enforcement regulations

Waste Disposal and Public Cleansing Law and associated enforcement order and enforcement regulations

Laws concerning the Reporting of the Release into the Environment of Specific Chemical Substances and Promotion of Improvements in their Management

References

1. Results of Asbestos Scattering Experiment

○ Report on asbestos scattering experiment

October 12, 2006

Japan Association for Working Environment Measurement

1. Purpose

The experiment was conducted to verify the effectiveness of measures to suppress asbestos scattering in the removal of (or other work relating to) asbestos in ships.

2. Experimental method

A test chamber measuring 8 m^3 (2 m x 2 m x 2 m), a dressing room, an air shower room, and a security zone were established for use in an experiment in the seminar room at the Precision Management Center (2nd floor, VIP Ogibashi Center Hall A, 1-21-25, Ogibashi, Koto-ku, Tokyo) of the Japan Association for Working Environment Measurement (Tuesday, August 22 through Thursday, August 24, 2006), as illustrated in Fig. 1. Measurement was repeated three times for each process. To prevent a prior work process from affecting a subsequent process, the exhaust system was activated between processes to remove dust particles and fibers. A particle meter was operated continuously, with examination of the relative concentration of dust particles and assessment of the cleanliness of the test chamber.

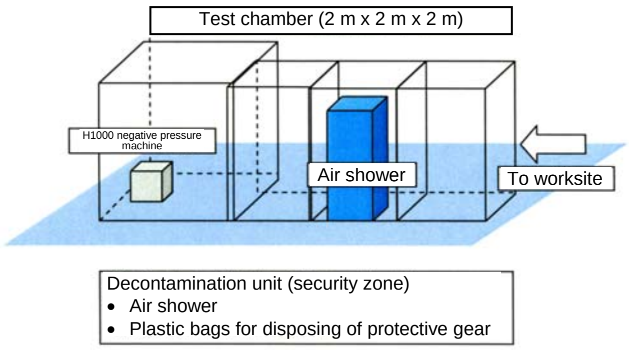


Fig. 1 Test chamber schematic view

3. Outline of measurement points

In the test chamber, five measurement points were set up as shown in Fig. 2. Measurements were all taken at a height of approximately 160 cm. A sampler was attached to a location near the mouth of the worker to obtain samples at the level of the worker's breathing area. (See Photo 1.)

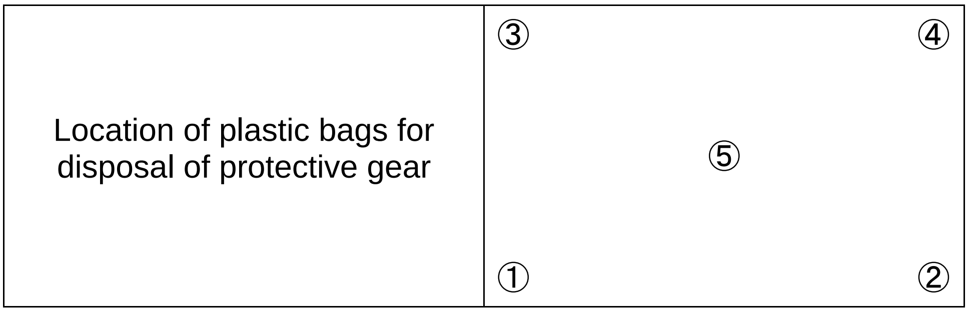


Fig. 2 Outline of measurement positions

Photo 1

4. Materials used in experiment, details of experiment, test equipment, description of work

4.1 Materials used in experiment

Table 1 shows the materials used in the experiment and the respective asbestos content of each. These materials are presented in Photos 2 through 4.

Table 1 Names of materials

Process	Name of material	Asbestos content reported by manufacturer	Result of asbestos content analysis
1	Asbestos ribbon	Chrysotile 85%	Chrysotile 89.0%
2	Asbestos flange packing	Chrysotile 65 to 70%	Chrysotile 65.3%
3	Asbestos-containing brake lining	Unknown	Chrysotile 36.0%

Photo 2
Asbestos ribbon

Photo 3
Flange packing

Photo 4
Brake lining

4.2 Details of experiment

The experiment was conducted using the test materials in each of the following processes.

Process 1:
- (1) Testing the material in dry condition
- (2) Testing the material sprayed with water
- (3) Testing the material sprayed with particle scattering inhibitor
- (4) Testing the material sprayed with particle scattering inhibitor and then dried

Process 2:
- (1) Testing the material in dry condition
- (2) Testing the material sprayed with water

Process 3:
- (1) Testing the material in dry condition
- (2) Testing the material sprayed with water
- (3) Testing the material sprayed with particle scattering inhibitor

4.3 Test equipment

The equipment, devices, etc. used in the experiment are shown in Photos 5 through 8.

Photo 5 Apparatus used for spraying water
(Auto spray ε-value AS-2500N)

Photo 6 Particle scattering inhibitor

Photo 7 Process 2 Disc sander
(Hitachi PDA-100F)

Photo 8 Process 3 Electric drill
(Matsushita Electric Works MYJOY EZT107)

4.4 Description of work

Process 1: One asbestos ribbon cut to a length of 30 cm was used in each test.

(1) Description of test with the material in dry condition
Immediately after the start of sampling, the asbestos ribbon was rubbed ten times with a vinyl glove. This rubbing process was then repeated 20 times at 30-second intervals.

(2) Description of test with material sprayed with water
Water was sprayed before the start of work, and immediately after the start of sampling, the asbestos ribbon was rubbed ten times with a vinyl glove. This rubbing process was then repeated 20 times at 30-second intervals.

(3) Description of test with the material sprayed with particle scattering inhibitor
A particle scattering inhibitor was applied before the start of work. Immediately after the start of sampling, the asbestos ribbon was rubbed ten times with a vinyl glove. This rubbing process was then repeated 20 times at 30-second intervals.

(4) Description of test with the material sprayed with particle scattering inhibitor, followed by drying
A particle scattering inhibitor was applied to the asbestos ribbon, which was then left for several hours until it had sufficiently dried. Subsequently, immediately after the start of sampling, the asbestos ribbon was rubbed ten times with a vinyl glove. This rubbing process was then repeated 20 times at 30-second intervals.

Process 2: One asbestos flange packing measuring 20 cm by 20 cm was used in each test.

(1) Description of test with the material in dry condition
Immediately after the start of sampling, the surface of the material was sanded once. The sanding process was conducted again after two minutes, then again after four minutes, for a total of three sanding operations.

(2) Description of test with the material sprayed with water
Water was sprayed immediately after the start of sampling, and the surface was sanded once. Water was then sprayed again after two minutes and the sanding process was conducted once again. Water was sprayed again after four minutes, and the sanding process was repeated. In total, water was sprayed three times and the surface was sanded three times.

Process 3: A number of holes, each measuring 10 mm in diameter, were drilled in an asbestos-containing brake lining using an electric drill.

(1) Description of test with the material in dry condition
Immediately after the start of sampling, two holes were drilled with an electric drill. This process was then repeated 20 times at 30-second intervals.

(2) Description of test with the material sprayed with water
Water was sprayed before the start of sampling. Immediately after the start of sampling, two holes were drilled with an electric drill. The process of water spraying followed by drilling of two holes was then repeated 20 times at 30-second intervals.

(3) Description of test with the material sprayed with particle scattering inhibitor
A particle scattering inhibitor was sprayed for five seconds, followed approximately one minute later by sampling. Immediately after the start of sampling, two holes were drilled. The process of drilling two holes was then repeated 20 times at 30-second intervals.

5. Sampling methods

5.1 Sampling for measurement of total fiber concentration and chrysotile fiber concentration

Using a 25-mm-diameter white cellulose ester membrane filter (manufactured by Millipore) with 0.8-μm pores, sampling took place for five to ten continuous minutes through a cowl-equipped open-face holder at a suction rate of 1 L per minute.

5.2 Measurement of particle concentration using relative dust concentration detector

In each process, the concentration of dust particles in the chamber was measured with a dust particle meter (manufactured by Sibata Scientific Technology Ltd.) while the work was conducted. Dust particle meters obtain dust concentration measurements based on the principle of light dispersion when airborne particles in the chamber are illuminated. The degree of dispersion is proportional to the concentration of particles if the optical system and particle system are consistent. Dust particle meters measure the intensity of dispersed light and calculate the relative concentration (units: cpm) of particles based on the measured light intensity. Since dust particle meters are not dedicated devices for measuring asbestos concentrations, dust particles in the chamber (which included any asbestos particles) were separately sampled and measured with a relative dust concentration detector.

6. Analysis methods

6.1 Analysis of total fiber concentration and chrysotile fiber concentration

The total fiber concentration and chrysotile fiber concentration were analyzed according to the methods described below.

(1) Total fiber concentration
For the analysis of total fiber concentration, a white membrane filter was placed on a slide glass plate with the particle-collecting side facing up, and acetone steam from an acetone steam generator was used to achieve transparency. Triacetin was then used to fix the sample. Using a phase-contrast microscope mounted with a 40x objective lens (Olympus: UPlan FL N, Nikon: Plan DL), a fiber count analysis was conducted at a total magnification rate of 400 times.

The effective diameter of the filter paper was 22 mm, and the diameter of the counting visual field was 0.3 mm. We obtained fiber counts for a minimum number of visual fields necessary to meet or exceed a count of 200 fibers, up to a maximum of 50 visual fields.

(2) Chrysotile fiber concentration
For the analysis of chrysotile fiber concentration, a new white membrane filter was placed on a slide glass plate, and acetone steam from an acetone steam generator was used to affix the filter to the plate. Another filter with collected particles was then placed on the fixed section of the filter, with its particle-collecting side facing down. Acetone steam was then again applied to affix the filter. A low-temperature ashing process was then conducted using a plasma reactor (PR-31) (output power at 200 W, reflected power at 8 W or lower, oxygen flow rate at 70 mL/min, 10 hours or longer).

Following completion of the low-temperature ashing process, an immersion liquid with a refraction factor (n_D) of 1.55 was added to the sample. Using the Olympus BX51N phase-contrast microscope mounted with a 40x objective lens, a fiber count analysis was then conducted at a total magnification rate of 400 times.

The effective diameter of the filter paper was 22 mm, and the diameter of the counting visual field was 0.3 mm. We obtained fiber counts for a minimum number of visual fields necessary to meet or exceed a count of 200 fibers, up to a maximum of 50 visual fields.

6.2 Calculation of fiber concentration

6.2.1 Method of calculating fiber concentration

The following formula was used to obtain the fiber concentration:

$$C_F = \frac{A \cdot (N - Nb)}{a \cdot n \cdot Q}$$

Where,
C_F: Fiber concentration (f/L)
A: Particle collecting area (effective filtering area of membrane filter) (mm^2)
N: Total fiber count (f)
N_b: Blank value (f)
a: Area of one visual field counted in microscopic observation (mm^2)
Q: Sampled air volume (L)
n: Number of visual fields counted

6.2.2 Minimum limit of determination

The following formula was used to obtain the minimum limit of determination:

$$S = \frac{A \cdot 2.645}{a \cdot n \cdot Q}$$

Where,
S: Minimum limit of determination (f/L)
A: Particle collecting area of filter (mm^2)
a: Area of one visual field counted in microscopic observation (mm^2)
n: Number of visual fields counted (50 visual fields)
Q: Sampled air volume (L)

7. Analysis results

The three measurements of total fiber concentration, chrysotile fiber concentration, and particle concentration in the chamber obtained using a relative dust concentration detector are indicated for each process. In this experiment, each work process was performed in an enclosed space without ventilation that would otherwise have discharged air from the chamber. The results therefore showed substantially higher levels of total fiber concentration and chrysotile fiber concentration than those that would be obtained if similar work were to be conducted at an actual worksite.

7.1 Process 1: Asbestos ribbon

(1) Material in dry condition

Table 2 shows the total fiber concentration and chrysotile concentration measurement results obtained in Process 1-(1). Based on the three repeated Process 1-(1) measurements, the geometric average of fixed-point total fiber concentration was 1,648.8 (f/L) and the geometric average of chrysotile fiber concentration was 1,122.7 (f/L).

The average value of total fiber concentration for a given individual was 1,505.9 (f/L) and the average value of chrysotile fiber concentration for a given individual was 1,055.3 (f/L).

Fig. 3 shows the dust particle concentration in the chamber measured with a relative duct concentration detector during the work process. Among the three measurements, the relative concentration was the highest in the third measurement, recording approximately 200 cpm of relative concentration.

Table 2 Process 1-(1): Asbestos ribbon (in dry condition)

Measurement point	1st measurement		2nd measurement		3rd measurement		Average	
	Total fiber concentration (f/L)	Chrysotile fiber concentration (f/L)	Total fiber concentration (f/L)	Chrysotile fiber concentration (f/L)	Total fiber concentration (f/L)	Chrysotile fiber concentration (f/L)	Total fiber concentration (f/L)	Chrysotile fiber concentration (f/L)
1	1634.8	1570.3	1452.0	1086.3	2414.0	1796.2	1833.6	1484.3
2	1376.7	1097.1	1129.3	634.6	1505.8	1129.3	1337.3	953.7
3	1742.4	688.4	1408.9	1021.8	2883.3	1484.3	2011.5	1064.8
4	1172.4	871.2	1097.1	871.2	2560.8	1419.7	1610.1	1054.0
5	1387.5	1204.6	1279.9	957.2	1936.0	1570.3	1534.5	1244.0
Geometric average	1448.6	1044.7	1265.4	899.1	2203.6	1463.4	1648.8	1122.7
Arithmetic average	1462.8	1086.3	1273.4	941.2	2260.0	1480.0	1665.4	1160.1
Individual	1102.4	743.9	1299.6	1066.6	2115.7	1355.5	1505.9	1055.3

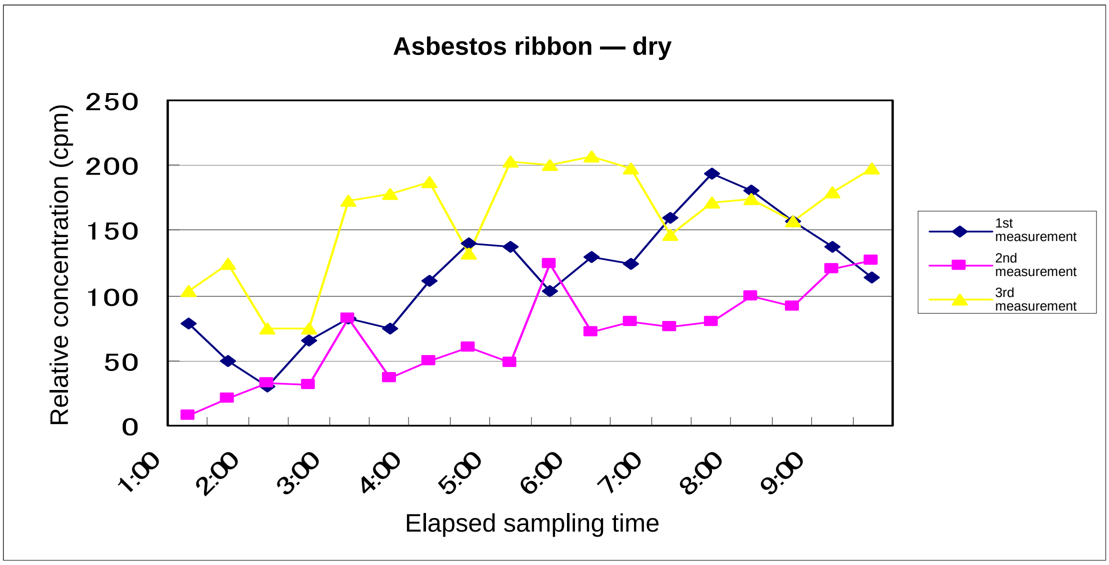


Fig. 3 Dust particle concentration measured with relative dust concentration detector (asbestos ribbon in dry condition)

(2) Material sprayed with water

Table 3 shows the total fiber concentration and chrysotile concentration measurement results obtained in Process 1-(2). Based on the three repeated Process 1-(2) measurements, the geometric average of fixed-point total fiber concentration was 46.7 (f/L) and the geometric average of chrysotile fiber concentration was 30.6 (f/L).

The average value of total fiber concentration for a given individual was 44.8 (f/L) and the average value of chrysotile fiber concentration for a given individual was 24.8 (f/L).

Fig. 4 shows the dust particle concentration in the chamber measured with a relative duct concentration detector during the work process. Among the three measurements, the relative concentration was the highest in the first measurement, recording approximately 25 cpm of relative concentration. Based on a comparison with the results of measurement with dry material (as illustrated in Fig. 3), the spraying of water reduced dust particle concentration.

Table 3 Process 1-(2): Asbestos ribbon (sprayed with water)

Measurement point	1st measurement		2nd measurement		3rd measurement		Average	
	Total fiber concentration (f/L)	Chrysotile fiber concentration (f/L)	Total fiber concentration (f/L)	Chrysotile fiber concentration (f/L)	Total fiber concentration (f/L)	Chrysotile fiber concentration (f/L)	Total fiber concentration (f/L)	Chrysotile fiber concentration (f/L)
1	53.8	32.3	43.0	21.5	64.5	10.8	53.8	21.5
2	53.8	43.0	43.0	10.8	21.5	21.5	39.4	25.1
3	161.3	150.6	43.0	28.4 or less	43.0	28.4 or less	82.4	69.1
4	75.3	43.0	21.5	10.8	21.5	28.4 or less	39.4	27.4
5	43.0	21.5	32.3	28.4 or less	21.5	28.4 or less	32.3	26.1
Geometric average	68.5	45.4	35.4	18.2	30.8	22.1	46.7	30.6
Arithmetic average	77.4	58.1	36.6	20.0	34.4	23.5	49.5	33.8
Individual	80.7	26.9	26.9	23.7 or less	26.9	23.7 or less	44.8	24.8

Water spraying condition: Approximately 25 mL of water was sprayed onto the asbestos ribbon each time.

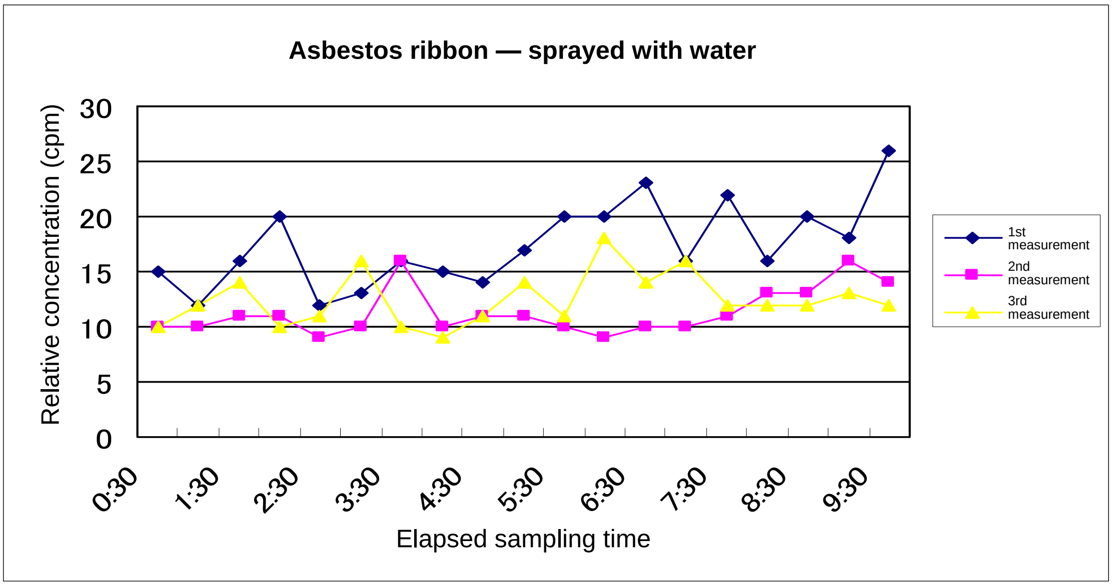


Fig. 4 Dust particle concentration measured with relative dust concentration detector (asbestos ribbon sprayed with water)

(3) Material sprayed with asbestos scattering inhibitor

Table 4 shows the total fiber concentration and chrysotile concentration measurement results obtained in Process 1-(3). Based on the three repeated Process 1-(3) measurements, the geometric average of fixed-point total fiber concentration was 62.4 (f/L) and the geometric average of chrysotile fiber concentration was 20.5 (f/L).

The average value of total fiber concentration for a given individual was 92.6 (f/L) and the average value of chrysotile fiber concentration for a given individual was 28.8 (f/L).

Fig. 5 shows the dust particle concentration in the chamber measured with a relative dust concentration detector during the work process. Among the three measurements, the relative concentration was the highest in the second measurement, recording approximately 30 cpm of relative concentration. Based on a comparison with the results of measurement with dry material (as illustrated in Fig. 3), spraying of asbestos scattering inhibitor reduced dust particle concentration.

Table 4 Process 1-(3): Asbestos ribbon (sprayed with asbestos scattering inhibitor)

Measurement point	1st measurement		2nd measurement		3rd measurement		Average	
	Total fiber concentration (f/L)	Chrysotile fiber concentration (f/L)	Total fiber concentration (f/L)	Chrysotile fiber concentration (f/L)	Total fiber concentration (f/L)	Chrysotile fiber concentration (f/L)	Total fiber concentration (f/L)	Chrysotile fiber concentration (f/L)
1	32.3	10.8	53.8	28.4 or less	64.5	32.3	50.2	23.8
2	43.0	32.3	64.5	21.5	64.5	10.8	57.3	21.5
3	193.6	32.3	43.0	10.8	64.5	10.8	100.4	18.0
4	53.8	10.8	64.5	10.8	43.0	28.4 or less	53.8	16.7
5	64.5	21.5	43.0	28.4 or less	75.3	21.5	60.9	23.8
Geometric average	62.2	19.2	52.9	18.2	61.3	18.7	62.4	20.5
Arithmetic average	77.4	21.5	53.8	20.0	62.4	20.8	64.5	20.8
Individual	107.6	35.9	62.7	23.7 or less	107.6	26.9	92.6	28.8

Particle scattering inhibitor spraying condition: Approximately 25 mL of inhibitor was sprayed onto the asbestos ribbon each time.

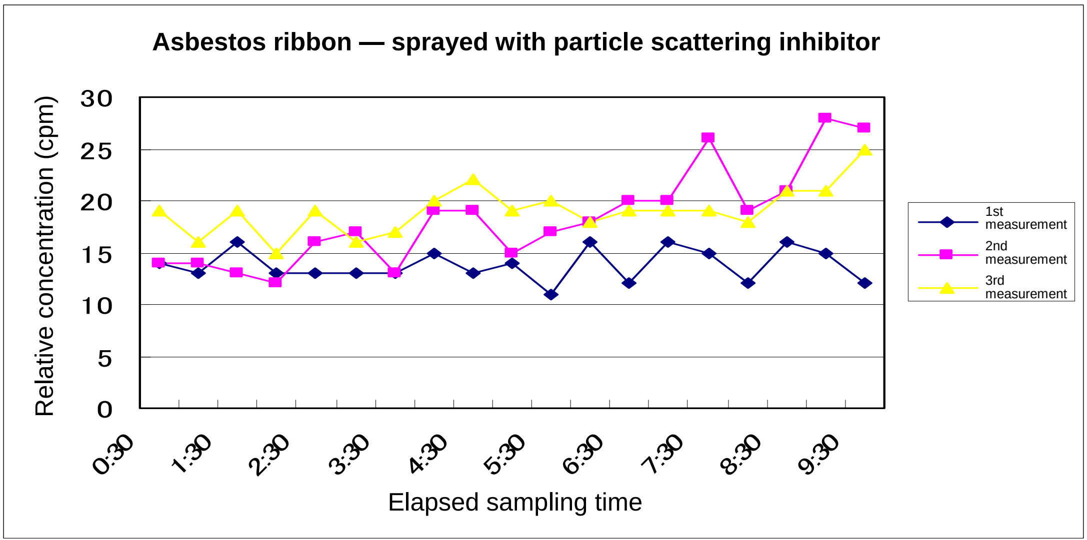


Fig. 5 Dust particle concentration measured with relative dust concentration detector (asbestos ribbon sprayed with asbestos scattering inhibitor)

(4) Material sprayed with asbestos scattering inhibitor and then dried

Table 5 shows the total fiber concentration and chrysotile concentration measurement results obtained in Process 1-(4). Based on the three repeated Process 1-(4) measurements, the geometric average of fixed-point total fiber concentration was 254.7 (f/L) and the geometric average of chrysotile fiber concentration was 152.0 (f/L).

The average value of total fiber concentration for a given individual was 170.3 (f/L) and the average value of chrysotile fiber concentration for a given individual was 116.5 (f/L).

Fig. 6 shows the dust particle concentration in the chamber measured with a relative dust concentration detector during the work process. Among the three measurements, the relative concentration was the highest in the first measurement, recording a relative concentration of approximately 130 cpm. Based on comparison with the results of measurement with dry material as illustrated in Fig. 3, the dust particle concentration was reduced when the material was sprayed with an asbestos scattering inhibitor and then dried. However, the particle scattering suppression was not as high as when the material was processed by spraying with water or an asbestos scattering inhibitor.

Table 5 Process 1-(4): Asbestos ribbon (sprayed with asbestos scattering inhibitor and then dried)

Measurement point	1st measurement		2nd measurement		3rd measurement		Average	
	Total fiber concentration (f/L)	Chrysotile fiber concentration (f/L)	Total fiber concentration (f/L)	Chrysotile fiber concentration (f/L)	Total fiber concentration (f/L)	Chrysotile fiber concentration (f/L)	Total fiber concentration (f/L)	Chrysotile fiber concentration (f/L)
1	107.6	75.3	430.2	172.1	376.4	215.1	304.7	154.2
2	43.0	32.3	376.4	172.1	354.9	247.4	258.1	150.2
3	118.3	86.0	344.2	204.4	484.0	398.0	315.5	200.8
4	75.3	53.8	172.1	182.8	365.7	204.4	204.4	147.0
5	64.5	32.3	225.9	129.1	344.2	193.6	211.5	118.3
Geometric average	76.7	51.5	293.2	170.2	382.0	242.3	254.7	152.0
Arithmetic average	81.7	55.9	309.8	172.1	385.0	251.7	258.8	154.2
Individual	80.7	17.9	206.1	161.3	224.1	170.3	170.3	116.5

Particle scattering inhibitor spraying and drying conditions:

Approximately 25 mL of inhibitor was sprayed onto the asbestos ribbon each time, and the ribbon was dried afterward for 15 hours.

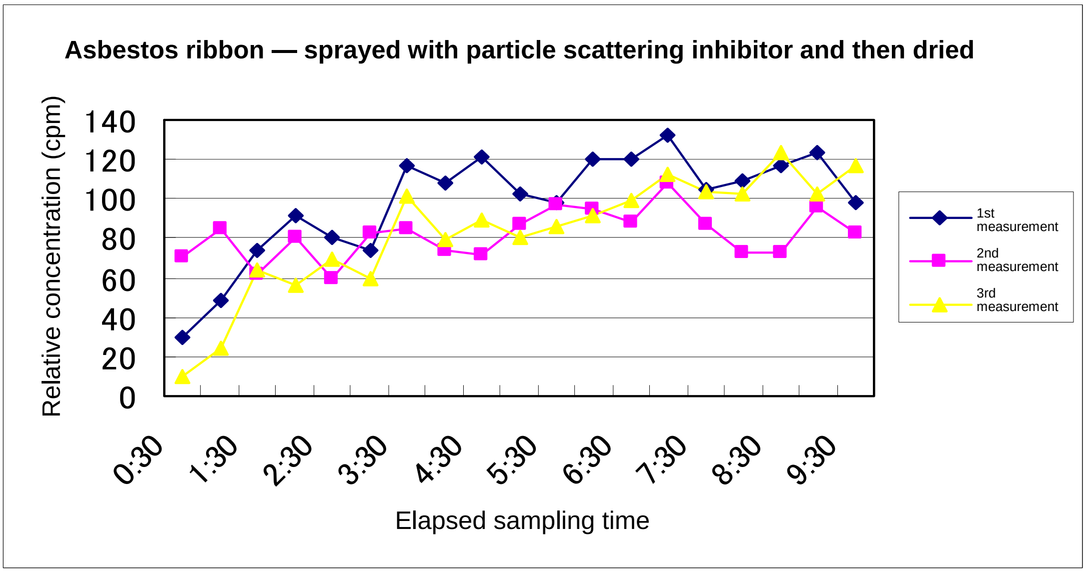


Fig. 6 Dust particle concentration measured with relative dust concentration detector (asbestos ribbon sprayed with asbestos scattering inhibitor and then dried)

7.2 Process 2: Asbestos flange packing

(1) Material in dry condition

Table 6 shows the total fiber concentration and chrysotile concentration measurement results obtained in Process 2-(1). Based on the three repeated Process 2-(1) measurements, the geometric average of fixed-point total fiber concentration was 4,462.9 (f/L) and the geometric average of chrysotile fiber concentration was 3,944.7 (f/L). The average value of total fiber concentration for a given individual was 3,692.7 (f/L) and the average value of chrysotile fiber concentration for a given individual was 3,141.3 (f/L).

Fig. 7 shows the dust particle concentration in the chamber measured with a relative dust concentration detector during the work process. Among the three measurements, the relative concentration was the highest in the third measurement, recording a relative concentration of approximately 1,300 cpm.

Table 6　Process 2-(1): Asbestos flange packing (in dry condition)

Measurement point	1st measurement		2nd measurement		3rd measurement		Average	
	Total fiber concentration (f/L)	Chrysotile fiber concentration (f/L)	Total fiber concentration (f/L)	Chrysotile fiber concentration (f/L)	Total fiber concentration (f/L)	Chrysotile fiber concentration (f/L)	Total fiber concentration (f/L)	Chrysotile fiber concentration (f/L)
1	3226.7	3076.1	7125.6	6789.4	4937.8	4409.8	5096.7	4758.4
2	2129.6	1850.0	5566.0	5404.0	4065.6	3119.1	3920.4	3457.7
3	3829.0	3613.9	7251.3	7046.7	3764.4	3183.6	4948.2	4614.7
4	2323.2	2019.4	4828.0	4593.5	3119.1	2839.5	3423.4	3150.8
5	3033.1	2774.9	6856.7	5846.6	5802.3	3355.7	5230.7	3992.4
Geometric average	2842.0	2584.2	6247.9	5865.6	4238.3	3342.6	4462.9	3944.7
Arithmetic average	2908.3	2666.9	6325.4	4866.1	4337.8	3381.5	4523.9	3994.8
Individual	2827.1	2735.0	5147.3	4353.4	3103.7	2335.5	3692.7	3141.3

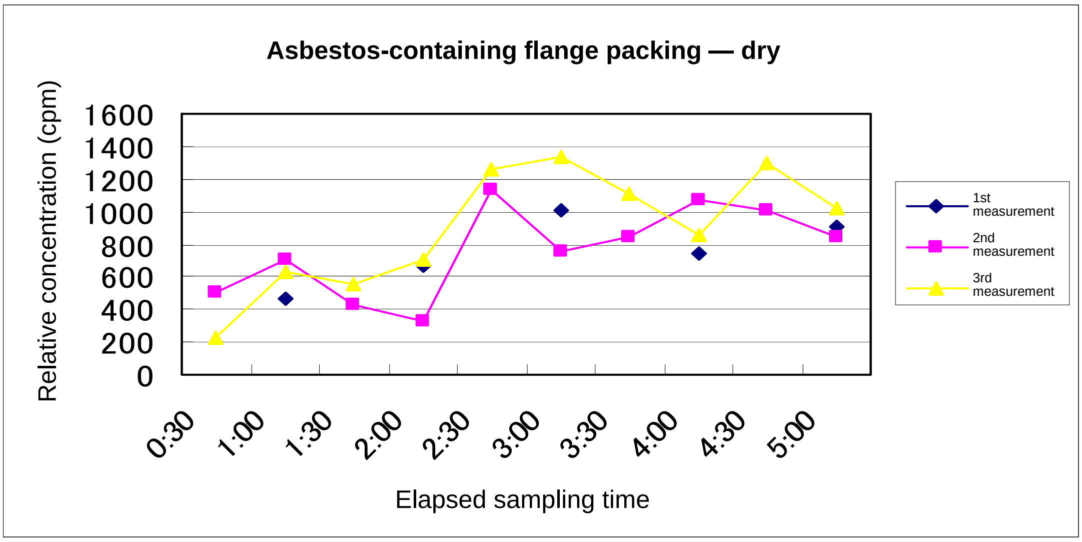


Fig. 7　Dust particle concentration measured with relative dust concentration detector (asbestos-containing flange packing in dry condition)

(2)　Material sprayed with water

Table 7 shows the total fiber concentration and chrysotile concentration measurement results obtained in Process 2-(2). Based on the three repeated Process 2-(2) measurements, the geometric average of fixed-point total fiber concentration was 64,023.4 (f/L), and the geometric average of chrysotile fiber concentration was 11,097.4 (f/L).

The average value of total fiber concentration for a given individual was 56,914.8 (f/L) and the average value of chrysotile fiber concentration for a given individual was 9,032.1 (f/L).

Fig. 8 shows the dust particle concentration in the chamber measured with a relative dust concentration detector during the work process. Among the three measurements, the relative concentration was the highest in the third measurement, recording a relative concentration of approximately 2,500 cpm. Based on comparison with the results of measurement with dry material as illustrated in Fig. 7, spraying of water led to increased dust particle concentration.

Table 7 Process 2-(2): Asbestos flange packing (sprayed with water)

Measurement point	1st measurement		2nd measurement		3rd measurement		Average	
	Total fiber concentration (f/L)	Chrysotile fiber concentration (f/L)	Total fiber concentration (f/L)	Chrysotile fiber concentration (f/L)	Total fiber concentration (f/L)	Chrysotile fiber concentration (f/L)	Total fiber concentration (f/L)	Chrysotile fiber concentration (f/L)
1	133368.9	15979.7	62920.0	10863.1	38540.7	9586.5	78276.5	12143.1
2	88195.6	14049.4	50551.1	9034.7	42484.4	9120.7	60410.4	10734.9
3	117773.3	14488.4	32727.6	7759.4	35800.6	8948.6	62100.5	10398.8
4	89271.1	15846.5	47754.7	10970.7	35339.7	8011.0	57455.2	11609.4
5	90705.1	14116.7	59155.6	7751.4	41408.9	10217.8	63756.5	10695.3
Geometric average	102324.2	14872.5	49395.7	9167.7	38608.2	9147.4	64023.9	11097.4
Arithmetic average	103862.8	14896.1	50621.8	9275.9	38714.9	9176.9	64399.8	11116.3
Individual	96031.7	12072.6	47055.6	8877.6	27657.1	6146.0	56914.8	9032.1

Water spraying condition: Approximately 27 mL of water was sprayed onto the asbestos flange packing each time.

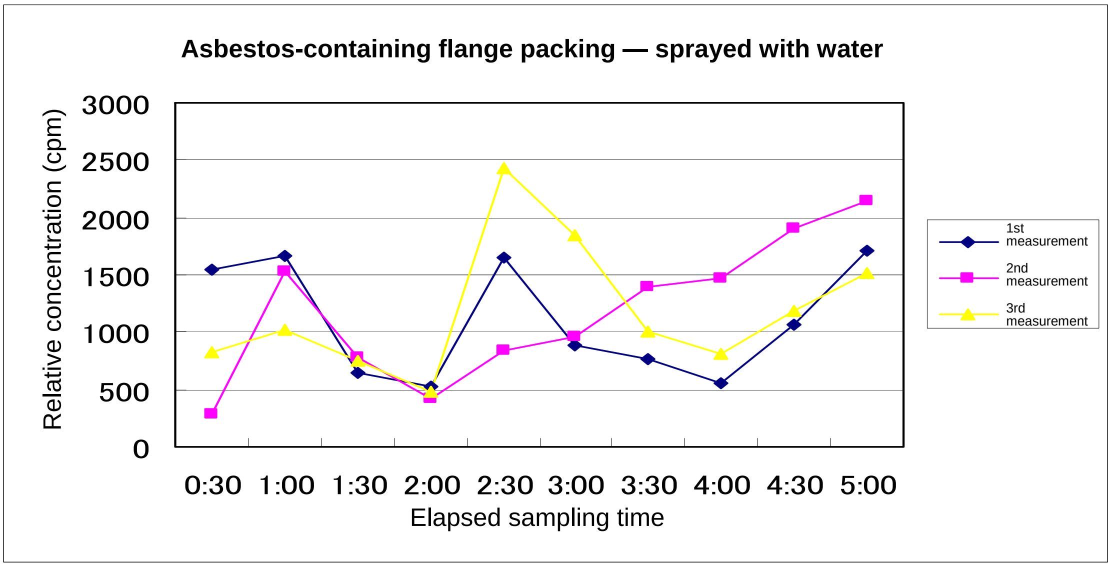


Fig. 8 Dust particle concentration measured with relative dust concentration detector (asbestos flange packing sprayed with water)

7.3 Process 3: Asbestos-containing brake lining

(1) Material in dry condition

Table 8 shows the total fiber concentration and chrysotile concentration measurement results obtained in Process 3-(1). Based on the three repeated Process 3-(1) measurements, the geometric average of fixed-point total fiber concentration was 274.6 (f/L) and the geometric average of chrysotile fiber concentration was 20.0 (f/L).

The average value of total fiber concentration for a given individual was 332.4 (f/L) and the average value of chrysotile fiber concentration for a given individual was 20.9 (f/L).

Fig. 9 shows the dust particle concentration in the chamber measured with a relative dust concentration detector during the work process. Among the three measurements, the relative concentration was the highest in the third measurement, recording a relative concentration of approximately 55 cpm.

Table 8 Process 3-(1): Asbestos-containing brake lining (in dry condition)

Measurement point	1st measurement		2nd measurement		3rd measurement		Average	
	Total fiber concentration (f/L)	Chrysotile fiber concentration (f/L)	Total fiber concentration (f/L)	Chrysotile fiber concentration (f/L)	Total fiber concentration (f/L)	Chrysotile fiber concentration (f/L)	Total fiber concentration (f/L)	Chrysotile fiber concentration (f/L)
1	376.4	21.5	182.8	21.5	139.8	10.8	233.0	17.9
2	344.2	21.5	301.2	21.5	161.3	10.8	268.9	17.9
3	656.1	10.8	236.6	10.8	172.1	10.8	354.9	10.8
4	666.8	64.5	107.6	10.8	129.1	21.5	301.2	32.3
5	419.5	10.8	96.8	43.0	182.8	32.3	233.0	28.7
Geometric average	473.4	20.3	168.5	18.8	155.7	15.4	274.6	20.0
Arithmetic average	492.6	25.8	185.0	21.5	157.0	17.2	278.2	21.5
Individual	755.2	9.0	98.6	35.9	143.4	17.9	332.4	20.9

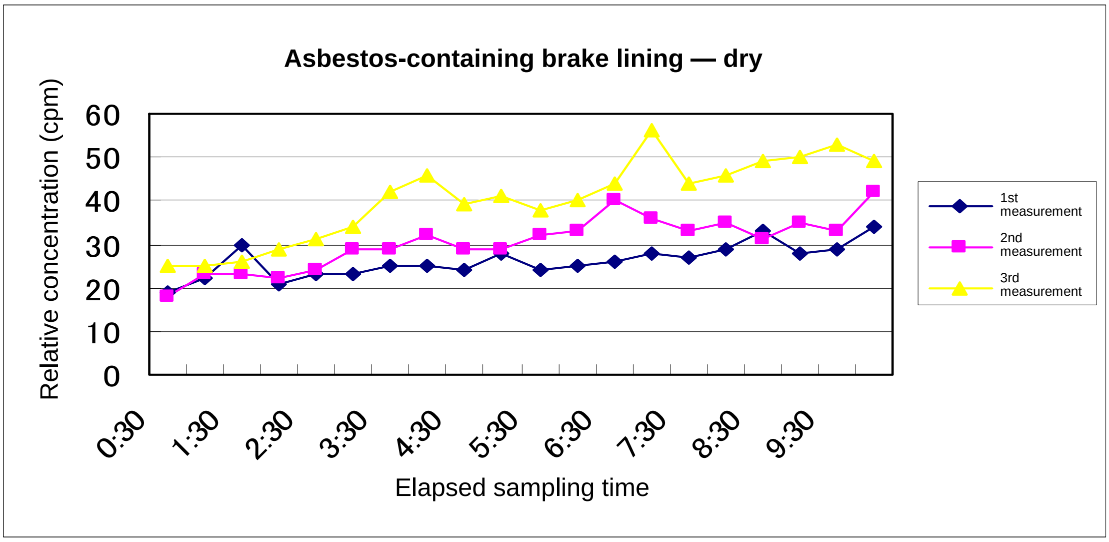


Fig. 9 Dust particle concentration measured with relative dust concentration detector (asbestos-containing brake lining in dry condition)

(2) Material sprayed with water

Table 9 shows the total fiber concentration and chrysotile concentration measurement results obtained in Process 3-(2). Based on the three repeated Process 3-(2) measurements, the geometric average of fixed-point total fiber concentration was 200.5 (f/L) and the geometric average of chrysotile fiber concentration was 21.7 (f/L).

The average value of total fiber concentration for a given individual was 146.4 (f/L) and the average value of chrysotile fiber concentration for a given individual was 12.0 (f/L).

Fig. 10 shows the dust particle concentration in the chamber measured with a relative dust concentration detector during the work process. Among the three measurements, the relative concentration was the highest in the first measurement, recording a relative concentration of approximately 45 cpm. The dust particle concentration was slightly higher than in the results of measurement with dry material, as illustrated in Fig. 9.

Table 9 Process 3-(2): Asbestos-containing brake lining (sprayed with water)

Measurement point	1st measurement		2nd measurement		3rd measurement		Average	
	Total fiber concentration (f/L)	Chrysotile fiber concentration (f/L)	Total fiber concentration (f/L)	Chrysotile fiber concentration (f/L)	Total fiber concentration (f/L)	Chrysotile fiber concentration (f/L)	Total fiber concentration (f/L)	Chrysotile fiber concentration (f/L)
1	537.8	21.5	43.0	10.8	107.5	21.5	229.4	17.9
2	613.1	10.8	21.5	28.4 or less	21.5	28.4 or less	218.7	22.5
3	580.8	21.5	21.5	28.4 or less	86.0	10.8	229.4	20.2
4	398.0	10.8	10.8	28.4 or less	107.5	28.4 or less	172.1	22.5
5	437.2	21.5	21.5	28.4 or less	32.3	28.4 or less	163.7	26.1
Geometric average	506.5	16.3	21.5	23.4	58.6	22.1	200.5	21.7
Arithmetic average	513.4	17.2	23.7	24.9	71.0	23.5	202.7	21.8
Individual	376.4	17.9	26.9	9.0	35.9	9.0	146.4	12.0

Water spraying condition: Approximately 73 mL of water was sprayed onto the brake lining each time.

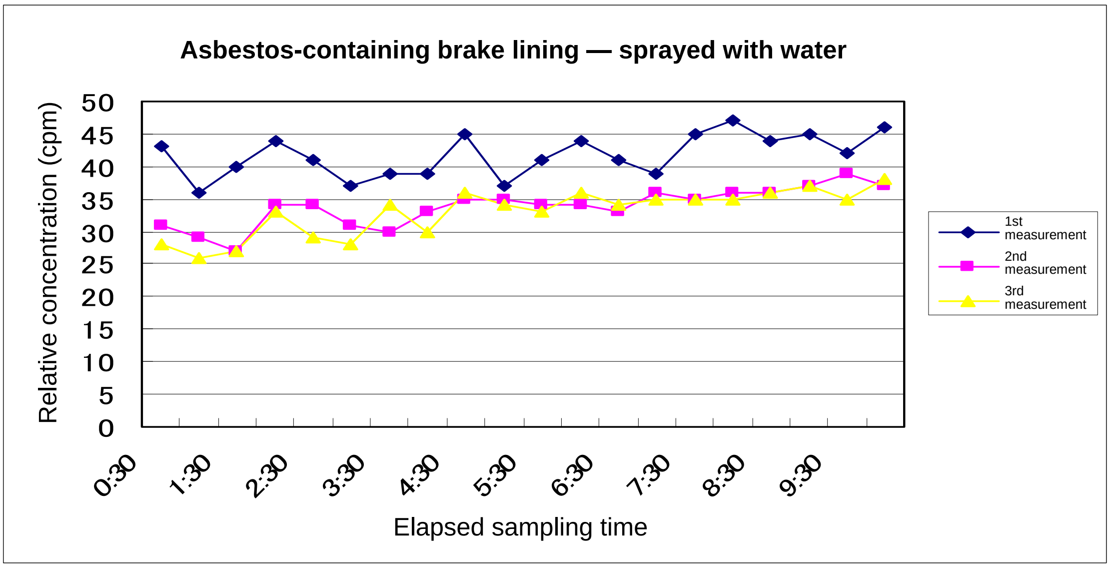


Fig. 10 Dust particle concentration measured with relative dust concentration detector (asbestos-containing brake lining sprayed with water)

(3) Material sprayed with asbestos scattering inhibitor

Table 10 shows the total fiber concentration and chrysotile concentration measurement results obtained in Process 3-(3).

Based on the three repeated Process 3-(3) measurements, the geometric average of fixed-point total fiber concentration was 127.1 (f/L) and the geometric average of chrysotile fiber concentration was 13.9 (f/L).

The average value of total fiber concentration for a given individual was 98.6 (f/L) and the average value of chrysotile fiber concentration for a given individual was 14.9 (f/L).

Fig. 11 shows the dust particle concentration in the chamber measured with a relative dust concentration detector during the work process. Among the three measurements, the relative concentration was the highest in the first measurement, recording a relative concentration of approximately 55 cpm. The dust particle concentration was slightly higher than in the results of measurement with dry material, as illustrated in Fig. 9.

Table 10 Process 3-(3): Asbestos-containing brake lining (sprayed with asbestos scattering inhibitor)

Measurement point	1st measurement		2nd measurement		3rd measurement		Average	
	Total fiber concentration (f/L)	Chrysotile fiber concentration (f/L)	Total fiber concentration (f/L)	Chrysotile fiber concentration (f/L)	Total fiber concentration (f/L)	Chrysotile fiber concentration (f/L)	Total fiber concentration (f/L)	Chrysotile fiber concentration (f/L)
1	75.3	21.5	172.1	21.5	118.3	21.5	121.9	21.5
2	107.6	10.8	86.0	10.8	129.1	10.8	107.6	10.8
3	129.1	10.8	129.1	10.8	387.2	21.5	215.1	14.4
4	86.0	10.8	118.3	10.8	258.1	21.5	126.3	14.4
5	53.8	10.8	129.1	10.8	96.8	10.8	93.2	10.8
Geometric average	86.5	12.4	123.9	12.4	171.4	16.3	127.1	13.9
Arithmetic average	90.4	12.9	126.9	12.9	197.9	17.2	132.8	14.4
Individual	107.6	17.9	107.6	17.9	80.7	9.0	98.6	14.9

Particle scattering inhibitor spraying condition: Approximately 20 mL of inhibitor was sprayed onto the brake lining each time.

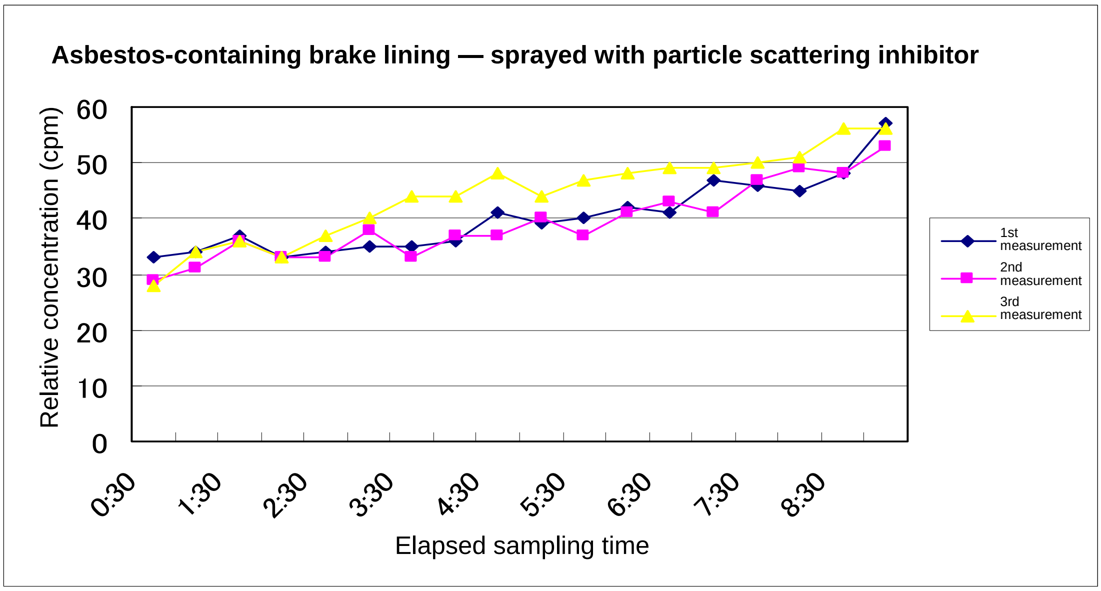


Fig. 11 Dust particle concentration measured with relative dust concentration detector (asbestos-containing brake lining sprayed with asbestos scattering inhibitor)

8. Considerations

8.1 Asbestos ribbon

Table 11 shows a comparative chart of the total fiber concentration and chrysotile concentration measurement results obtained in Process 1-(1) through Process 1-(4).

Where a value of 100% is given for total fiber concentration and chrysotile concentration levels measured with the material in a dry condition, the residual rates of total fiber concentration and chrysotile concentration measured with the material sprayed with water were 2.8% and 2.7%, respectively. Similarly, the residual rates of total fiber concentration and chrysotile concentration measured when the material was sprayed with a particle scattering inhibitor were 3.6% and 1.8%, respectively. The residual rates of total fiber concentration and chrysotile concentration measured when the material was sprayed with a particle scattering inhibitor and then dried were 15.5% and 13.3%, respectively.

The comparison of the total fiber concentration and chrysotile fiber concentration measured with the material in a dry condition against the results obtained with different processing methods showed that processing of material after applying an asbestos scattering inhibitor was most effective in the reduction of chrysotile fiber concentration, followed by the processing of material sprayed with water, and processing of material after applying an asbestos scattering inhibitor and then drying, in that order.

Processing of material sprayed with an asbestos scattering inhibitor and processing of material sprayed with water were both effective in suppressing asbestos scattering. In the case of water spraying, this effect is believed to last only while the material remains moist. If a material is processed after the sprayed water has evaporated and the material has nearly dried, the result is suspected to be about the same as that obtained with a dry material. Based on the results of this experiment, it can be concluded that working immediately after applying an asbestos scattering inhibitor is the most effective way to prevent asbestos from scattering.

However, if the work is conducted after the asbestos scattering inhibitor dries, the effectiveness of the inhibitor will decrease significantly. Therefore, it is important to process the material while it is still wet with the inhibitor.

Table 11 Processes 1-(1) through 1-(4): Asbestos scattering conditions in asbestos ribbon processing

Measurement point	Process 1-(1)		Process 1-(2)		Process 1-(3)		Process 1-(4)	
	Total fiber concentration (f/L)	Chrysotile fiber concentration (f/L)	Total fiber concentration (f/L)	Chrysotile fiber concentration (f/L)	Total fiber concentration (f/L)	Chrysotile fiber concentration (f/L)	Total fiber concentration (f/L)	Chrysotile fiber concentration (f/L)
1	1833.6	1484.3	53.8	21.5	50.2	23.8	304.7	154.2
2	1337.3	953.7	39.4	25.1	57.3	21.5	258.1	150.6
3	2011.5	1064.8	82.4	69.1	100.4	18.0	315.5	200.8
4	1610.1	1054.0	39.4	27.4	53.8	16.7	204.4	147.0
5	1534.5	1244.0	32.3	26.1	60.9	23.8	211.5	118.3
Geometric average	1648.8	1122.7	46.7	30.6	62.4	20.5	254.7	152.0
Arithmetic average	1665.4	1160.1	49.5	33.8	64.5	20.8	258.8	154.2
Residual rate (%)	100	100	2.8	2.7	3.8	1.8	15.5	13.3
Individual	1505.9	1055.3	44.8	24.8	92.6	28.8	170.3	116.5

Residual rate: Indicates a percentage of the value (100%) obtained in Process 1-(1) (dry condition)

8.2 Asbestos flange packing

Table 12 shows a comparative chart of the total fiber concentration and chrysotile concentration measurement results obtained in Process 2-(1) and Process 2-(2).

Where a value of 100% is given for total fiber concentration and chrysotile concentration levels measured with the material in a dry condition, the residual rates of total fiber concentration and chrysotile concentration measured with the material sprayed with water were 1,434.6% and 281.3%, respectively.

There was no suppression of dust particle scattering with the spraying of water in the processing of an asbestos flange packing; in fact, the spraying of water resulted in the scattering of more asbestos than when the material was processed in a dry condition. After water was sprayed, the flange packing repelled instead of absorbed the water. When a grinder was used on the flange packing in this condition, the heat generated by grinding caused the water to evaporate. It is suspected that the increased amount of scattered particles relative to dry material is attributable to the effects of the increased heat of vaporization and the rotating force of the grinder.

For the removal of flange packings by cutting with a grinder, it is deemed necessary to investigate new work standards, such as continuous spraying of water while using the grinder.

Table 12 Processes 2-(1) and 2-(2): Asbestos scattering conditions in asbestos flange packing processing

Measurement point	Process 2-(1)		Process 2-(2)	
	Total fiber concentration (f/L)	Chrysotile fiber concentration (f/L)	Total fiber concentration (f/L)	Chrysotile fiber concentration (f/L)
1	5096.7	4758.4	78276.5	12143.1
2	3920.4	3457.7	60410.4	10734.9
3	4948.2	4614.7	62100.5	10398.8
4	3423.4	3150.8	57455.2	11609.4
5	5230.7	3992.4	63756.5	10695.3
Geometric average	4462.9	3944.7	64023.0	11097.4
Arithmetic average	4523.9	3994.8	64399.8	11116.3
Residual rate (%)	100	100	1434.6	281.3
Individual	3692.7	3141.3	56914.8	9032.1

Residual rate: Indicates the percentage of the value (100%) obtained in Process 2-(1) (dry condition).

8.3 Asbestos-containing brake lining

Table 13 shows a comparative chart of the total fiber concentration and chrysotile concentration measurement results obtained in Process 3-(1) through Process 3-(3).

Where a value of 100% is given for the total fiber concentration and chrysotile concentration levels measured with the material in dry condition, the residual rates of total fiber concentration and chrysotile concentration measured with the material sprayed with water were 73.0% and 101.4%, respectively.

The residual rate of chrysotile fiber concentration in excess of 100% is attributable to the fact that the values obtained in the second and third measurements were in many cases based on the minimum determination limit value, and these were used in the calculation of an average value. This does not mean that the spraying of water is ineffective in suppressing particle scattering.

The residual rates of total fiber concentration and chrysotile fiber concentration measured with the material sprayed with an asbestos scattering inhibitor were 46.3% and 69.5%, respectively.

In the processing of an asbestos lining, holes were drilled with an electric drill, but the amount of particles generated from the material in a dry condition was small in comparison to other processing methods. Therefore, any enhanced suppression of particle scattering provided by spraying of water or an asbestos scattering inhibitor was not significant.

Nevertheless, because the asbestos brake lining was sufficiently wet with water or asbestos scattering inhibitor, the particle scattering suppression effect was greater than when the material was dry.

Table 13 Processes 3-(1) through 3-(3): Asbestos scattering conditions in asbestos-containing brake lining processing

Measurement point	Process 3-(1)		Process 3-(2)		Process 3-(3)	
	Total fiber concentration (f/L)	Chrysotile fiber concentration (f/L)	Total fiber concentration (f/L)	Chrysotile fiber concentration (f/L)	Total fiber concentration (f/L)	Chrysotile fiber concentration (f/L)
1	233.0	17.9	229.4	17.9	121.9	21.5
2	268.9	17.9	218.7	22.5	107.6	10.8
3	354.9	10.8	229.4	20.2	215.1	14.4
4	301.2	32.3	172.1	22.5	126.3	14.4
5	233.0	28.7	163.7	26.1	93.2	10.8
Geometric average	274.6	20.0	200.5	21.7	127.1	13.9
Arithmetic average	278.2	21.5	202.7	21.8	132.8	14.4
Residual rate (%)	100	100	73.0	101.4	46.3	69.5
Individual	332.4	20.9	146.4	12.0	98.6	14.9

Residual rate: Indicates the percentage of the value (100%) obtained in Process 3-(1) (dry condition).

2. Main Asbestos-containing Sections in Products and Suspected Usage Period in Ships

Product category	Asbestos-containing section	Suspected usage period
Propeller shaft systems		
	Low-pressure hydraulic pipe flange packings	Until 2005
	Equipment cover packings	Until 2005
	Clutches	Until 1995
	Brake linings	Until 1995
Diesel engines		
	Flange packings	Until 2005
	Fuel pipe heat insulator	Until 1988
	Exhaust pipe heat insulator	Until 2002
	Supercharger heat insulator	Until 1989
Turbine systems		
	Interior heat insulator	Until 1980
	Flange packings for steam pipes (valves), exhaust pipes (valves), and drain pipes (valves)	Until 2003
	Heat-insulating material for steam pipes (valves), exhaust pipes (valves), and drain pipes (valves)	Until 1987
Boilers		
	Heat insulator inside combustion chambers	Until 1987
	Casing door packings	Until 2005
	Exhaust pipe heat-insulating material	Until 1999
	Manhole packings	Until 1990
	Hand hole packings	Until 1990
	Gas sealing packings for soot blowers, smoke check pipes, etc.	Until 2005
	Flange packings for steam pipes (valves), exhaust pipes (valves), drain pipes (valves), and fuel pipes (valves)	Until 2005
	Heat-insulating material for steam pipes (valves), exhaust pipes (valves), drain pipes (valves), and fuel pipes (valves)	Until 1998
Exhaust gas economizers		
	Casing door packings	Until 2005
	Manhole packings	Until 1990
	Hand hole packings	Until 1990
	Soot blower gas sealing packings	Until 2005
	Flange packings for steam pipes (valves), exhaust pipes (valves), and drain pipes (valves)	Until 2005
	Heat-insulating material for steam pipes (valves), exhaust pipes (valves), and drain pipes (valves)	Until 1988

Product category	Asbestos-containing section	Suspected usage period
Incinerators		
	Casing door packings	Until 2005
	Manhole packings	Until 1990
	Hand hole packings	Until 1990
	Exhaust pipe heat insulator	Until 1988
Auxiliary equipment (pumps, compressors, oil cleaners, crane winches, windlasses, etc.)		
	Casing packings, valve packings, etc.	Until 2005
	Gland packings	Until 1988
	Brake linings	Until 2002
Heat exchangers		
	Cover packings	Until 1994
	Valve gland packings	Until 1992
	Heat-insulating material, heat-retaining material	Until 1989
Valves		
	Valve gland packings, pipe flange sheet packings, etc.	Until 2005
	High-pressure/high-temperature flange gasket packings, etc.	Until 2003
Pipes, ducts		
	Heat-insulating material, heat-retaining material	Until 1990
Tanks (fuel tanks, hot water tanks, steam separator tanks), devices (fuel strainers, lubricating oil strainers)		
	Heat-insulating material, heat-retaining material	Until 1990
Electrical equipment		
	Electrical insulators	Until 2004
Sprayed-on material		
	Walls, ceilings	Until 1975
Ceiling material, floor material, wall material in accommodation spaces		
	Ceilings, floors, walls	Until 1987
Fire doors		
	Packing material	Until 1981
Inert gas generators		
	Casings, packings	Until 1987

Product category	Asbestos-containing section	Suspected usage period
Air conditioning systems		
	Sheet packings, pipe insulators, flexible joints	Until 2005

Source: Survey by Japan Ship Technology Research Association

Cooperation: Japanese Marine Equipment Association

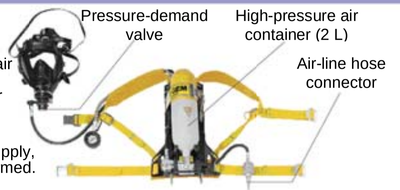
3. Protective Gear

For Work Grades 1, 2, 3 — Full-face pressure-demand-type combination air-line mask (JIS T 8153)

L30-AL-CMP

- For ordinary work, air is supplied from an external air source.
- Equipped with a 2-L high-pressure air container (air cylinder).

The air in the air cylinder is used in the event of an emergency, such as the stoppage of an external air supply, or generally in accordance with the type of work performed.
* The air supply source does not switch automatically.



For Work Grades 1, 2, 3 — Full-face pressure-demand-type air-line mask (JIS T 8153)

Combination respiratory protective equipment
Z-ALD

Option parts for Z-ALD
For work in high places — Rope with large hook

Chemical protection gloves (in compliance with JIS T 8116)
GL-11-37

Disposable chemical protection clothes (in compliance with JIS T 8115)
Microguard 1500

Chemical protection boots (in compliance with JIS T 8117)
RS-2

Packaged fresh air supply unit
KAU037C2
Manufactured by Kawasaki Safety Service Industries, Ltd.

- Dimensions: 750 (W) x 960 (D) x 1,425 (H) mm
- Air discharge volume: 405 L/min (at 0.93 MPa)
- Power source: 3-phase 200 V 5-m hose

Type KB hose reel

For Work Grades 1, 2, 3 — Air-supplied respirator (constant-flow-type air-line mask, blower-equipped hose mask) (JIS T 8153)

For improved safety

Face piece
CS-1

Waist band
AL-2NSB
- Equipped with air cleaner

Medium-pressure hose (inside diameter: 8 mm)
Pressure-proof rubber hose (20 m)

Constant-flow-type air-line mask
AS-2N series waist band
- Uses compressed air supplied by an air compressor, etc.

For simultaneous use by up to four persons

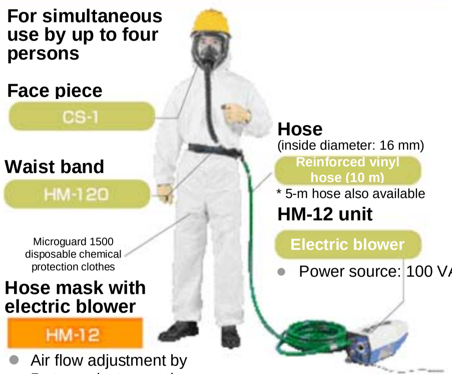
Face piece
CS-1

Waist band
HM-120

Hose mask with electric blower
HM-12
- Air flow adjustment by 5-step selector notches

Hose (inside diameter: 16 mm)
Reinforced vinyl hose (10 m)
* 5-m hose also available

HM-12 unit
Electric blower
- Power source: 100 VAC



For Work Grades 1, 2, 3 — Respiratory protective equipment with electric fan (JIS T 8157)

■ Filter with Class-A dust collection efficiency
■ Class-S protection

Easy to breathe! Comfortable to work in! Electric fan and filter provide clean air.

Direct type Electric fan, battery, and filter are built into the face piece.

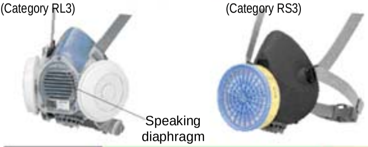
Full-face type
AP-03N

Half-face type
AP-08S4N (set)

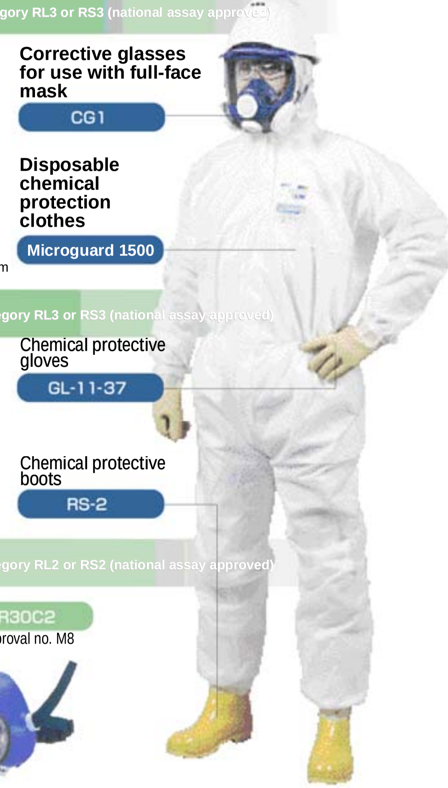
* Be sure to wear protective goggles, etc.

For Work Grades 1, 2, 3 — Full-face dust protective mask — Category RL3 or RS3 (national assay approved)

For Work Grades 2,3 — Half-face dust protective mask — Category RL3 or RS3 (national assay approved)



For Work Grades 3 — Half-face dust protective mask — Category RL2 or RS2 (national assay approved)



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