SUMMARY OF COUNTERMEASURES AGAINST ASBESTOS IN JAPAN

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AIR ENVIRONMENT DIVISION
ENVIRONMENTAL MANAGEMENT BUREAU
MINISTRY OF THE ENVIRONMENT
JAPAN

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Preface

Asbestos-related health concerns were brought to public attention in June 2005 after the disclosure of asbestos-related deaths among the employees of asbestos manufacturers as well as residents in the vicinity of asbestos-processing factories.

Following this incident, the Japanese government devised comprehensive countermeasures against asbestos for the prevention of health hazards and the care of the victims of asbestos-related illnesses.

In some Asian countries, however, a large amount of asbestos is still being used. Similarly to Japan, the use of asbestos can have large repercussions in countries which do not exercise effective control and do not impose regulations.

Thus, for the purpose of contributing to the adequate promotion of effective countermeasures against asbestos in Asian countries, we prepared a report, "Summary of countermeasures against asbestos in Japan," in FY2007, documenting Japan's experience with asbestos-related problems, including developments regarding Japanese countermeasures and measures to prevent the dispersal of asbestos into ambient air, and started distributing the report to Asian countries in FY2008. Given changes made in asbestos-related laws and regulations in Japan, we have revised the report, also taking into account the present circumstances of Asian countries still using asbestos products.

We hope that this report will be useful for establishing a framework for the management of asbestos in countries in need.

This report has been approved by a technical committee consisting of experts on asbestos in Japan, who are listed below. We wish to express our sincere gratitude to the members of the committee for their support of this project.

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1 GENERAL INFORMATION REGARDING ASBESTOS

1.1 Definitions of Asbestos

Asbestos is a generic term given to fibrous minerals with silken glaze that occur naturally and possess high tensile strength and flexibility. The Convention concerning Safety in the Use of Asbestos (Convention: C162, Session of Conference: 72) defines asbestos as follows:

> "the term asbestos means the fibrous form of mineral silicates belonging to rock-forming minerals of the serpentine group, i.e. chrysotile (white asbestos), and of the amphibole group, i.e. actinolite, amosite (brown asbestos, cummingtonite-grunerite), anthophyllite, crocidolite (blue asbestos), tremolite, or any mixture containing one or more of these."

Due to its superior resistance to heat, friction, and acids and alkalis, as well as its physical durability, asbestos has been used in various applications including the manufacturing of construction materials (e.g. fireproof walls and ceilings) and automobile brake linings.

In Japan, asbestos is defined from mineralogical, industrial and environmental perspectives:

1.1.1 Mineralogical definition

Asbestos is a generic term for a group of fibrous minerals with silken glaze that occur naturally and possess high tensile strength and flexibility (called asbestiform). Thus, the term asbestos is not used in mineralogical classifications. Minerals which exist in asbestiform include:

A The serpentine family of chrysotile (white asbestos)

B The amphibole family of amosite (brown asbestos), crocidolite (blue asbestos) and several other types.

It should be noted that both the serpentine and the amphibole minerals also occur in non-asbestiform form. Minerals that are not in asbestiform at a macroscopic level are not usually called asbestos. The non-asbestiform minerals have the same single-grid physical and chemical properties as the asbestiform ones and often appear as tiny irregular bundles of fibers under the microscopic scale.

1.1.2 Industrial definition

Asbestos, though varied depending on type, is generally characterized by its remarkably high tensile strength, flexibility, electrical insulation property, heat resistance, superior spinnability as well as chemical resistance, compared with other fibrous minerals. Due to these unique properties, asbestos is being mined and exploited as industrial material in regions where it is produced in large quantities.

Asbestos in its industrial state usually refers to macroscopically asbestiform minerals mined and processed for industrial use.

1.1.3 Definition of asbestos in ambient air

Fibrils of minerals shown in Table 1-1 are extremely thin, with a single chrysotile fibril having a diameter of only 0.02-0.03μm. Asbestiform minerals are readily spilt into bundles of fine fibers 1-2μm in diameter, and are often released into the air and remain suspended in the state of minute fibers or fiber bundles. Thus, asbestos in ambient air may be defined as minerals in Table 1-1 that are suspended airborne in the state of minute fibers or fiber bundles.

Source: "Manual for Measures to Prevent Asbestos Dispersal Related to the Dismantling of Buildings, Etc. 2007" (in Japanese), Ministry of the Environment, March 2007.

(See Appendix I for more details and Table 1-1)

1.2 Asbestos-Containing Products

Definitions of asbestos-containing products subject to legal regulations vary among countries. In the European Union (EU), asbestos-containing products refers to any products to which asbestos is added intentionally, regardless of asbestos content, whereas in the United States, it refers to products containing more than 1% of asbestos by weight, regardless of whether asbestos has been added intentionally or unintentionally. In Japan, any products containing more than 0.1% of asbestos by weight (5% by weight in 1975, and 1% by weight in 1995) are subject to legal regulations, regardless of whether asbestos has been added intentionally or unintentionally.

As seen above, definitions of asbestos-containing products are varied, depending on country and on the point in time. In Japan, asbestos-containing products generally can be broadly divided into building products, industrial asbestos products, asbestos-containing friction products and others, of which building products use the largest amount of asbestos.

1.2.1 Building products

・Asbestos-containing spraying materials: steel beams of buildings sprayed for fireproofing protection, dew condensation prevention and sound absorption

・Asbestos-containing molded products, etc.: Interior materials, floorings, exterior materials, roofing and chimneys, etc. of buildings

1.2.2 Industrial asbestos products

・Joint sheets: sealants for equipment in chemical and electric power plants, and in pipework

・Gland packing: sealants for equipment in chemical and electric power plants, and in pipework

・Lagging materials: heat retention for equipment in chemical and electric power plants, and in pipework

・Asbestos textile products: raw materials in the production of gland packing and friction materials, and for sparking avoidance and sealants

・Millboards/asbestos paper: for heat-insulation materials, etc.

1.2.3 Asbestos-containing friction products

・Brake lining, clutch facing: for brakers for transporter vehicles and brakes for industrial machinery, etc.

1.2.4 Others

Other areas of application include water pipes, adhesives and coatings.

1.3 Asbestos Consumption

World asbestos consumption has declined from 5 million tons several decades ago to 2-2.5 million tons in the last decade. Figure 1-1 shows changes in asbestos imports into Japan. Imports increased after World War II to 100,000 tons in 1961 and to a peak of 350,000 tons in 1971, and then fluctuated between 200,000 tons and 300,000 tons a year until 1989. After decreasing in the interim period, imports fell sharply to about 110 tons in 2005 following the prohibition of the import, manufacture and use of asbestos-containing building materials, asbestos-containing friction materials and asbestos-containing adhesives under the Industrial Safety and Health Act in October 2004, and no imports were recorded since 2006 in terms of trade statistics of the Ministry of Finance.
(See Appendix II for more details.)

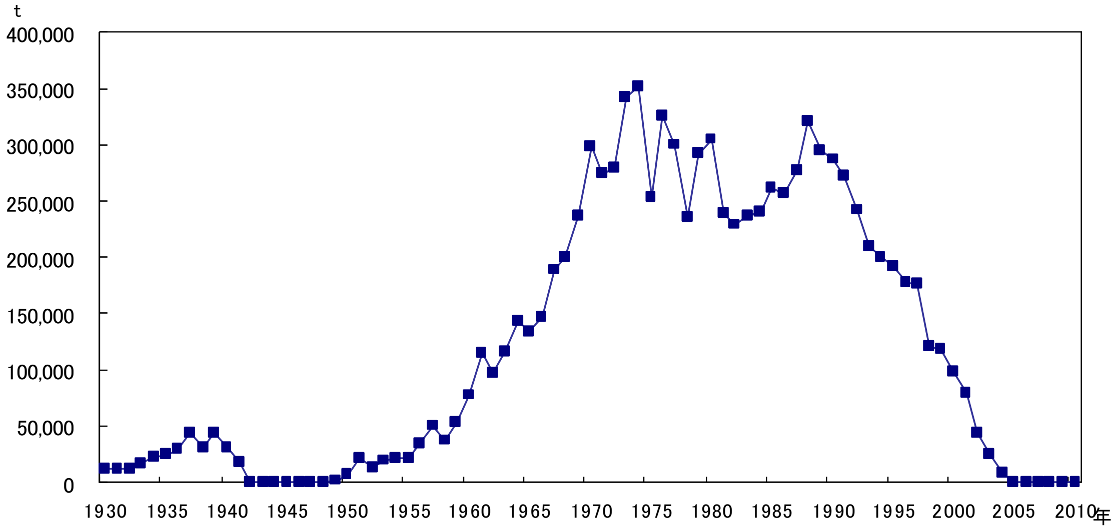

Figure 1-1 Changes in asbestos imports into Japan

Source: Trade Statistics, Ministry of Finance; and partly, "Manual for Management of Waste Asbestos, Etc.", Ministry of the Environment, 2005.

1.4 Health Effects of Asbestos

1.4.1 Health effects of asbestos

Asbestos has been classified as a Group I carcinogen (a known human carcinogen) by the International Agency for Research on Cancer (IARC). Health hazards confirmed to be related to exposure to asbestos include asbestosis, lung cancer and mesothelioma. The "Environment Health Criteria 53 : Asbestos and Other Natural Mineral Fibres," published by the World Health Organization (WHO) in 1986, describes the degree of influence of asbestos on respective asbestos-related diseases. The influence asbestos could have on human bodies is described below:

(a) Asbestosis

Asbestosis is the disease that came under the spotlight as a health hazard related to asbestos ahead of other diseases, and is a type of pneumoconiosis that has long been recognized to be caused by the inhalation of asbestos dust among workers with occupational exposure to asbestos of relatively high concentration or long-term exposure to asbestos.

When asbestos fibers enter the lungs, they cause irritation and inflammation in small bronchi and cells, gradually develop fibrosis in areas around the terminal pulmonary bronchus and alveolar interstitium, and eventually lead to lung function impairment. Asbestosis is rarely detectable at the state soon after exposure, and detection of even the early stage of asbestosis usually comes more than 10 years after the initial exposure. In the majority of cases, asbestosis appears to advance after the cessation of exposure, although early-stage cases do not show any appreciable radiographic change over many years.

Though there is no substantial evidence that the type of asbestos influences the incidence or severity of asbestosis, the risk of acquiring asbestosis appears to be higher at spinning factories than at mines, rock quarry or manufacturing plants for friction products. There are some cases in which pulmonary fibrosis due to asbestosis leads to death from respiratory failure. The mortality is related to the duration and intensity of exposure, but not to age, and the mortality appears to be higher among cigarette smokers. Among asbestos patients and in experiments on animals exposed to asbestos, there are cases where changes in numerical values of immunological test items have been observed. However, it is not clear to what extent these changes have influenced the onset of asbestosis.

(b) Lung cancer

Lung cancer as a complication of asbestosis was first reported by Lynch and Smith in 1935. Then in 1955, Doll found in an epidemiological study on workers at a spinning factory in Britain that the mortality from lung cancer in textile workers with 20 years or more of service at the factory was 13.7 times higher than that of the general population.

Asbestos exposure is known to increase the risk of lung cancer. The period of latency between exposure to asbestos and the onset of asbestos-related lung cancer is generally 15-40 years, and it has been confirmed that the risk of developing lung cancer increases with the degree of asbestos exposure.

(c) Mesothelioma

Mesothelioma is a malignant tumor (cancer) of very poor prognosis of the surface of the mesothelium, which covers the pleura, pericardium and peritoneum, and its underlying tissues. There is the latency period of 20-50 years between the initial asbestos exposure and development of mesothelioma. The incidence of mesothelioma has been increasing in recent years, as shown in Figure 3-1 (see Appendix III).

It is believed that about 80% of the onset of mesothelioma is caused by asbestos. It is also known that the incidence of mesothelioma is influenced by the type of asbestos. It is believed that the risk associated with exposure to crocidolite is the highest, followed by amosite, and that the risk associated with exposure to chrysotile is lower than crocidolite and amosite. However, there is no reliable data to support the relation between the onset of mesothelioma and the amount of exposure to asbestos.

(See Appendix III for more details)

2 OUTLINE OF COUNTERMEASURES AGAINST ASBESTOS

2.1 History of Asbestos-Related Problems and Countermeasures in Japan

Japan's imports of asbestos gradually increased since the mid-1960s in order to meet the growing demand for asbestos as building materials. Imports exceeded 300,000 tons a year by the early 1970s and continued until around 2000. The spraying of asbestos was prohibited in 1975, although the use of asbestos in building materials and other forms continued.

Concerns about pollution by asbestos in ambient air have become a growing issue since the latter half of the 1970s. The Japanese government conducted a few surveys to grasp the actual situation and collected the relevant information on asbestos-related issues. However, the findings were not fully reflected in the formulation of specific legal systems or concrete regulations. In 1987, the media reported health hazards related to asbestos sprayed in school buildings in the past. A subsequent nationwide survey conducted by the Ministry of Education found that sprayed asbestos had been used at approximately 1,500 school buildings. In 1989, the Air Pollution Control Act was amended from the standpoint of preventing ambient air pollution, and the standard asbestos content at the factory border of asbestos products manufacturing factories was established at 10f/L. Then, measures were taken to prohibit the manufacture, import, transfer, provision or use of crocidolite and amosite in 1995, the manufacture, import, transfer, provision or use of 10 asbestos-containing products including building materials, friction materials and adhesives in 2004, and the manufacture, import, transfer, provision or use of all asbestos-containing products in 2006. In 2005, Japan ratified the International Labour Organization's Convention concerning Safety in the Use of Asbestos (ILO Convention No. 162).

On June 29, 2005, a major industrial equipment manufacturer headquartered in Osaka publicly disclosed that 78 deaths among its workers and residents in the vicinity of plants were caused by asbestos-related lung cancer and mesothelioma. In response to the media report, a number of asbestos-related incidences were reported in railroad, shipbuilding and building-materials industries, as well as in the vicinity of their manufacturing plants. Public health concerns were once again raised over asbestos used in school buildings.

2.2 Laws and Regulations in Japan

Asbestos is regulated under a number of laws: for the protection of workers' occupational safety and health, the Pneumoconiosis Act, the Industrial Safety and Health Act, the Ordinance on Prevention of Hazards due to Specified Chemical Substances and the Ordinance on Prevention of Health Impairment due to Asbestos; for environmental protection purposes, the Air Pollution Control Act and the Waste Management and Public Cleansing Act; and for construction regulation and other purposes, the Building Standards Act, the Construction Material Recycling Act and the Act on Asbestos Health Damage Relief. The major laws and regulations pertaining to asbestos are summarized below.

The Pneumoconiosis Act was enacted in 1960 in order to help maintain the health and increase other welfare of workers engaged in work in dusty environments. The law requires employers to provide workers who were engaged in work in a dusty environment with periodic medical checkups for pneumoconiosis. Work in a dusty environment includes work to unravel asbestos and work to spray asbestos.

Enacted in 1972, the Industrial Safety and Health Act is designed to secure the safety and health of workers in the workplace by promoting comprehensive and well-planned measures for the prevention of occupational accidents and facilitate the establishment of comfortable working environments. The law's asbestos-related provisions include those on the prohibition of manufacture, etc., the labeling of products and the Asbestos Health Damage Medical Passbook.

The Ordinance on Prevention of Hazards due to Specified Chemical Substances is an ordinance issued by the Ministry of Health, Labour and Welfare for the purpose of setting out safety standards for specified chemical and standard chemical substances. It amended the former Ordinance on Prevention of Hazards due to Specified Chemical Substances in 1972 in conformity to the Industrial Safety and Health Act. In order to toughen measures focusing on the carcinogenicity of asbestos, the amendment of 1975 prohibits, in principle, the use of sprayed asbestos in buildings containing more than 5% asbestos by weight.

The Ordinance on Prevention of Health Impairment due to Asbestos was introduced in 2005 by separating asbestos-related provisions from the Ordinance on Prevention of Hazards due to Specified Chemical Substances as work is likely to focus on the dismantling of asbestos-containing products following the prohibition of the use of asbestos.

For the purpose of protecting the health of workers from lung cancer, mesothelioma and other health impairments resulting from asbestos, it encourages employers to improve work methods and the working environments, thereby minimizing exposure to asbestos. Any products containing more than 0.1% asbestos by weight are regulated under the ordinance. In order to prevent health hazards such as lung cancer and mesothelioma of workers exposed to asbestos dust due to dismantling and other work, employers are required to take measures, such as improvement in work methods and improvements to related equipment and facilities, necessary to minimize the inhalation of asbestos. The definition of asbestos-containing products was changed from products with asbestos in excess of 1% by weight to products with asbestos in excess of 0.1% by weight to substantially expand the scope of products subject to regulations.

The Air Pollution Control Act was enforced in 1968 for the purpose of protecting the public health and the living environments from air pollution, by controlling emissions of soot and smoke from operations of factories and business establishments. The law was amended in 1989 to introduce regulations on manufacturing plants of asbestos products, such as the mandatory notification of facilities that discharge specified dust (asbestos) (with size requirements) and the establishment of the maximum permissible concentration of asbestos on the border line between the grounds of factories or business establishments and any neighboring properties at 10f/L. The amendment of 1996 mandates the notification of work to demolish buildings.

Following the incidence of asbestos-related problems from late June, 2005, onward, the Enforcement Order and Enforcement Regulations of the Air Pollution Control Act were amended to abolish the size requirement for the mandatory notification of the dismantling of buildings and newly subject asbestos-containing insulation materials to regulations. In 2006, the law to partially amend the Air Pollution Control Act for the prevention of health impairment due to asbestos was enacted in order to make work on the dismantling of industrial products containing asbestos subject to the regulations just as work on the dismantling of buildings, and came into force in the same year.

The Waste Management and Public Cleansing Act was enacted in 1970 for the purpose of preserving the living environment and improving public health through the restriction of waste discharge, appropriate sorting, storage, collection, transport, recycling, disposal, or the like of waste and conservation of a clean living environment. The amendment of 1991 designated waste asbestos as "specially controlled industrial waste".

The Act on Asbestos Health Damage Relief was enacted in 2006 for the purpose of providing prompt relief to persons who suffer from asbestos health damage and their survivors in view of the special characteristics of asbestos health damage by taking measures for paying them medical expenses, etc.

Legal Framework for Asbestos Regulations

Aerial Environment Preservation

＜Laws and Regulations, etc.＞

①Air Pollution Control Law
- ■Enactment: Act No.97, 1968
- ■Amendments:
  - 1989 Classifies asbestos as “designated particulate”
  - 1996 Notifies the local government for activities that involve the spraying of asbestos and mandates the observance of the standards
  - 2005 Bans the spraying of asbestos regardless of building size
  - 2006 Mandates the notification of the local government for the dismantling of industrial products

② Waste Management and Public Cleansing Law
- ■Enactment: Act No.137, 1970
- ■Amendments:
  - 1991 Classifies materials containing asbestos as “specially controlled industrial waste”
  - 2006 Classifies any waste containing more than 1% asbestos by weight as asbestos-containing waste
  - The asbestos harmless treatment certification system launched

Occupational Safety and Health

③ Pneumoconiosis Act (provisions for medical checkups for pneumoconiosis)
- ■Enactment: Act No.30, 1960,
- ■Amendments of Enforcement Regulations:
  - 2003 Medical checkups for lung cancer

④ Industrial Safety and Health Act
- ■Enactment: Act No.57, 1972,
- ■Amendment of Enforcement Order:
  - 2004 Bans the manufacture of 10 products, including asbestos-containing building materials
  - 2006 Bans any products containing more than 1% asbestos by weight (with some exemptions)
  - 2008 Expands the scope of work subject to asbestos medical examinations and issuance of the Asbestos Health Damage Medical Passbook (With the amendment of the Enforcement Order, related regulations also amended)
  - 2009 Expands the scope of requirements for issuance of the Asbestos Health Damage Medical Passbook

⑤ Ordinance on Prevention of Hazards due to Specified Chemical Substances
- ■Enactment: Ministry of Labour Ordinance No.39, 1972
- ■Amendments:
  - 1975 Bans the spraying of asbestos coatings containing more than 5% asbestos by weight, in principle

⑥Ordinance on Prevention of Health and Impairment due to Asbestos
- ■Enactment: Ministry of Health, Labour and Welfare Ordinance No.21, 2005

(2005 Enacted by separating asbestos-related provisions from the Ordinance on Prevention of Hazards due to Specified Chemical Substances)

- ■Amendments:
  - 2006 Bans any material containing more than 0.1% asbestos by weight
  - 2009 Mandates the posting of preliminary survey results, improvement of isolation measures, and the use of powered air-purifying respirators; tougher regulations on work to dismantle steel ships

Regulations for Construction

⑦ Building Standards Act
- ■Enactment: Act No.201, 1950
- ■Amendments:

2006 mandates the removal of asbestos from buildings during renovation and orders the implementation of safety measures for preventing the release of asbestos fibers

⑧ Construction Material Recycling Act
- ■Enactment: Act No.104, 2000
- ■Last Amendment: Act No.147, 2004
  - Mandates original contractors to notify preliminary surveys and proactive measures concerning the confirmation of the presence of sprayed asbestos in specified construction materials

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⑨Act on Asbestos Health Damage Relief
- ■Enactment: Act No.4, February 10, 2006

Figure 2-1 Legal framework for asbestos regulations

2.3 Government Actions in Response to Recent Asbestos-related Problems in Japan

Asbestos-related health concerns were brought to the attention of the public in June 2005, when newspaper articles reported on a large number of asbestos-related deaths of workers at a major industrial equipment manufacturer.

The results of fact-finding surveys conducted by relevant government ministries and agencies on asbestos-caused health hazards as of September 2005 are described below. We quote the excerpts of "Survey on Health Hazards due to Asbestos (Overview)" (in Japanese), the material submitted to the third Cabinet Meeting on Asbestos-related Problems:

○ 743 compensated cases and 603 deaths in 482 companies to which the compensated employees belonged prior to 2004

○ 483 cases of health hazards (including 391 deaths) on the basis of information provided by 93 manufacturers of asbestos-containing products, and 74 cases of health hazards (including 60 deaths) on the basis of voluntary information disclosure by about 100,000 other companies

○ 170 cases of health hazards (including 129 deaths) on the basis of companies in the transportation industry

In response to the situation described above, it was decided that the government as a whole should take necessary measures urgently, including the holding of the Cabinet Meeting on Asbestos-related Problems.

2.3.1 Priority measures for asbestos-related problems

(Cabinet Meeting on Asbestos-related Problems held on July 29, 2005; revised on August 26, 2005; and revised again on September 29, 2005)

①Prevention of expansion of health hazards

- Take measures to prevent the dispersal of asbestos in the demolition of buildings
- Enforce an early total ban on the manufacture and new use of asbestos

②Measures for relieving public concern

- Offer information about asbestos-related health hazards to the general public
- Provide health consulting services, etc.

③Responses to health hazards in the past

- Make the worker's accident compensation system widely known
- Provide relief for workers who have died without receiving compensation as well as families of asbestos victims and residents in the vicinity of asbestos processing factories

④Evaluation of past government actions with regard to asbestos-related health hazards

- Evaluate government actions with regard to asbestos-related health hazards in the past and publicize the results
- Establish at an early date a liaison conference of relevant ministries and agencies for an

exchange of information on regulations under international conventions, etc.

⑤Extensive investigation of the current situation

- Look into the actual conditions regarding the use of sprayed asbestos in buildings

2.3.2 Comprehensive measures for asbestos-related problems

(Cabinet Meeting on Asbestos-related Problems held on December 27, 2005)

①Solid relief for people suffering from health impairment

- Enact a new relief law
- Make the worker's accident compensation system widely known
- Promote extensive researches

②Prevention of future asbestos-related health hazards

- Take adequate measures when removing asbestos from existing facilities
- Take adequate measures to prevent dispersal of and exposure to asbestos when demolishing buildings containing asbestos
- Enforce an early total ban on asbestos
- Promote proper management of waste containing asbestos

③Measures for relieving public anxiety

- Investigate the current situation and offer information to the general public
- Provide health consultation services

2.4 Countermeasures against Asbestos in the World

The International Labour Organization reported in 1972 that asbestos exposure is a risk factor for occupational cancer. The World Health Organization also identified the risk of developing lung cancer and mesothelioma in relation to asbestos exposure and evaluated asbestos as a human carcinogen in 1977 and 1987.

Regarding asbestos-related developments at international organizations, the International Agency for Research on Cancer (IARC) in 1972 pointed to the link between exposure to asbestos and lung cancer and mesothelioma, and in the same year, the International Labour Organization (ILO) called a meeting of experts on occupational cancer and recognized that asbestos exposure is a risk factor for occupational cancer. In 1987, the LARC, based on its research on carcinogenicity of asbestos in humans and animals, concluded that there is sufficient evidence of carcinogenicity and classified asbestos as a Group I carcinogen (a known human carcinogen). In 1987, the ILO adopted the Convention concerning Safety in the Use of Asbestos (ILO No. 162 Convention), commonly known as the Asbestos Convention. The key points of the convention include: ① prohibition of the use of crocidolite and products containing this fiber; ② prohibition of the spraying of all forms of asbestos; ③ the fixing and periodical review and update of the exposure limits or other exposure criteria in the light of technological progress and advances in technological and scientific knowledge; ④ replacement of asbestos or of certain types of asbestos or products containing asbestos by other materials or products or the use of alternative technology; ⑤ undertaking of demolition of plants or structures containing friable asbestos insulation materials, and removal of asbestos from buildings or structures in which asbestos is liable to become airborne by qualified by employers or contractors; ⑥ measurement of concentrations of airborne asbestos dust in workplaces; ⑦ monitoring of the exposure of workers to asbestos at intervals and using methods specified by the competent authority; ⑧ dissemination of information on health hazards due to exposure to asbestos and on methods of prevention and control; and ⑨ education and periodic training of workers on asbestos hazards and methods of prevention and control. Further, in 1989, the World Health Organization (WHO) came up with the view that occupational groups face the risk of developing asbestosis, lung cancer and mesothelioma due to exposure to asbestos and recommended that the use of crocidolite and amosite be banned and the exposure limit be set at 2f/cm^3 for the time being. Meanwhile, as an international convention on disposal of hazardous chemicals, the Rotterdam Convention on the Prior Informed Consent Procedure for Certain Hazardous Chemicals and Pesticides in International Trade, commonly known as the Rotterdam Convention or the PIC Convention, covers five forms of asbestos, namely crocidolite, amosite, remolite, actinolite and anthophyllite.

2.4.1 Europe

Regarding asbestos regulations in major European countries, Britain imposed a total ban on the manufacture, use and import of crocidolite, amosite and products containing these two forms of asbestos in 1986, and in 1999 prohibited the manufacture and use of all asbestos and asbestos-containing products. Germany (then West Germany) prohibited the spraying of asbestos in 1979, banned the manufacture and use of crocidolite and crocidolite-containing products, in principle, in 1986, and placed a total ban on the amphibole family of asbestos like crocidolite and amosite and prohibited, in principle, the manufacture and use of asbestos-containing products in 1993. France prohibited the use of asbestos for spraying in 1978, banned the use of crocidolite, in principle, in 1988, placed a total ban on the import, sale and use of the amphibole family of asbestos in 1994, and prohibited the manufacture, processing, sale, import and export of all asbestos in 1996. The European Union (EU), which now has 27 member states, instructed its members to prohibit the marketing and use of crocidolite with Council Directive 83/478/EEC (1983), prohibit the marketing and use of the amphibole family of asbestos with Council Directive 91/659/EEC (1991), and totally prohibit the marketing and use of all asbestos from January 1, 2005, with Council Directive 1999/77/EEC (1999).

2.4.2 The United States and Canada

The United States enforces control of environmental pollution by asbestos under the two different federal laws, the Clean Air Act (CAA) and the Toxic Substances Control Act (TSCA).

Under the 1990 revision of the National Emission Standards for Hazardous Air Pollutants (NESHAP) of the CAA, the spray-on application of materials containing more than 1% asbestos to buildings, structures, pipes, and conduits was prohibited (however, the prohibition is not applicable if the material is encapsulated with a bituminous or resinous binder during spraying and the materials are not friable after drying. The prohibition is not applicable either to friable materials, where either no visible emissions are discharged to the outside air from spray-on application, or specified methods are used to clean emissions containing particulate asbestos material before they escape to, or are vented to, the outside air). For thermal system insulation, the use of asbestos is partially prohibited for pipes, boilers and hot water tanks.

Under the TSCA, the Environmental Protection Agency (EPA) in 1989 issued the rule commonly known as the "Asbestos Ban and Phaseout Rule," for the ban on the manufacture, importation, processing, or distribution in commerce of almost all asbestos-containing product categories. In 1991, however, the U.S. Fifth Circuit Court of Appeals found that much of the EPA's original rule for the phaseout of asbestos under the TSCA to be invalid, and as a result, six asbestos-containing product categories that are still subject to the asbestos ban include: ① corrugated paper, ② rollboard, ③ commercial paper, ④ specialty paper, ⑤ flooring felt, and ⑥ new uses of asbestos for which the manufacture, importation or sale is deemed not to have been undertaken as of July 1989. Asbestos-containing products that are not banned under the TSCA include: asbestos-cement corrugated sheet, asbestos-cement flat sheet, asbestos clothing, pipeline wrap, roofing felt, vinyl-asbestos floor tile, asbestos-cement shingle, millboard, asbestos-cement pipe, automatic transmission components, clutch facings, friction materials, disc brake pads, drum brake linings, brake blocks, gaskets, non-roofing coatings, and roof coatings. While the Occupational Safety and Health Administration (OSHA) does not prohibit the handling of asbestos, it has put a number of regulations in place for the prevention of workers' exposure to asbestos, including safety and health regulations for shipyard employment, safety and health regulations for construction, work health and safety regulations, general industry safety standards, safety standards for shipyard workers and safety standards for the construction industry.

Canada, a major producer of chrysotile, has suspended work with the risk of high-level exposure to asbestos since the 1970s and has adopted the "controlled use" approach for chrysotile and all other asbestos since 1982. This approach represents the stance that the use of asbestos is safe if exposure to it is managed adequately. Based on this, Canada has not placed a total ban on the use of asbestos, though it still has a variety of regulations and banned the sale of some asbestos-containing products.

3 MEASURES TO PREVENT ASBESTOS DISPERSAL AND AMBIENT CONCENTRATION

3.1 Measures to Prevent Asbestos Dispersal

Though there could be a variety of measures to prevent the dispersal of asbestos into ambient air, this section, from the perspective of preventing the dispersal of asbestos from its sources into surrounding environments, covers the current status of measures being taken at facilities to manufacture asbestos-containing products, at sites of the demolition of buildings and other structures and for the replacement of asbestos by other materials.

(See Appendix V for measures to prevent dispersal of and exposure to asbestos at the workplace, and Appendix VI for measures to prevent asbestos dispersal into ambient air.)

3.1.1 Measures at asbestos-containing product manufacturing facilities

Figure 3-1 shows an example of measures to control asbestos dust in the process of manufacturing asbestos-containing products.

The manufacturing process involves opening bags of raw asbestos, mixing materials containing asbestos with cement, as well as grinding and sawing such materials, all of which poses the risk of releasing asbestos fibers. Thus, the installation of dust collectors at each stage of the process is essential in order to ensure that asbestos dust is not released outside the manufacturing facilities. Tailings generated during sawing are reused as raw material.

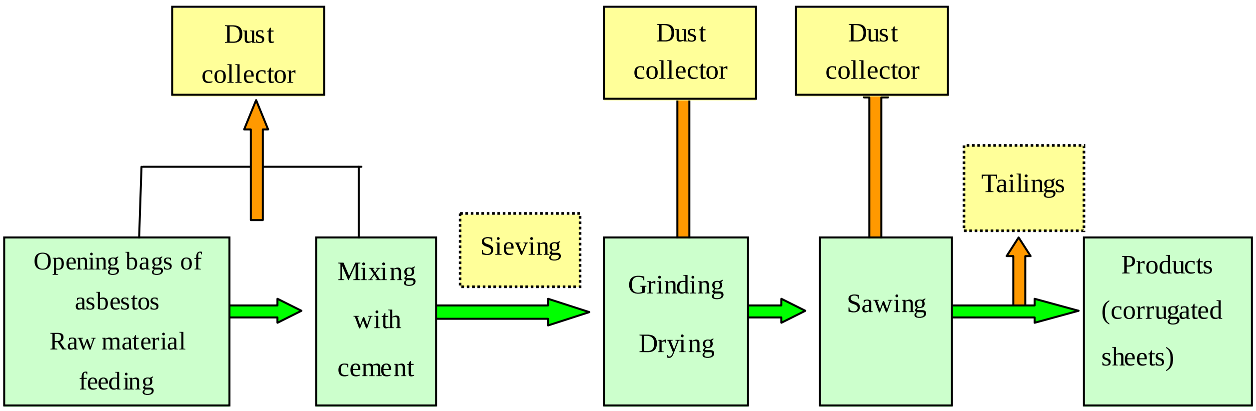


Figure 3-1 Example of dust emission control at designated particulate discharging facilities (asbestos-containing product manufacturing facilities)

3.1.2 Measures at sites of demolition of buildings and other structures

There is a high risk of significant dispersal of asbestos dust in work areas in association of the work to remove friable building materials such as asbestos-containing spray materials and lagging materials. As there also is the risk of ambient air pollution by asbestos, special precautions should be taken to prevent this, including the installation of security zones and negative pressure/dust-collecting exhaust ventilation equipment, and the use of wetting agents. At the same time, it is imperative to secure the safety of workers engaged in removal work. Regarding the work to dismantle relatively hard materials such as asbestos-containing slates and other asbestos-containing molded products, manual dismantling is required, in principle. Though the risk of ambient air pollution by asbestos from these materials is relatively low, the use of wetting agents and sufficient care for areas near work sites are necessary.

Regulated demolition work is operations to demolish, remodel or repair buildings and other structures as well as industrial products that use materials containing sprayed and other asbestos. Contractors undertaking these operations are required to notify local governments concerned and abide by work standards.

3.2 Management of Asbestos Waste

Asbestos waste is broadly categorized as “waste asbestos, etc.” and “asbestos-containing waste.” Asbestos-containing waste is classified either as “municipal solid waste containing asbestos” or “industrial waste containing asbestos.” They are defined as follows.

The 1991 amendment of the Waste Management and Public Cleansing Act designates waste asbestos, etc. as “specially controlled industrial waste.”

3.2.1 Waste asbestos, etc.

Waste asbestos, etc. are defined as 1 to 5 below:

1. Asbestos removed in the work to remove asbestos-containing building materials from materials sprayed with asbestos used in buildings, etc.;
2. Of asbestos-containing materials used in buildings, etc., those removed in the work to remove asbestos-containing building materials are listed below:
   (1) asbestos lagging material, (2) diatomite lagging material, (3) perlite lagging material, and (4) any lagging material, heat-insulating material and refractory covering material that may be as much or more friable as (1) to (3) due to contact with humans, aerial current and oscillation, etc.;
3. Plastic sheets, dust protective masks, workwear and other tools or instruments used in and discarded after the work to remove asbestos-containing building materials that may be contaminated with asbestos;
4. Asbestos collected by dust-collecting equipment at workplaces where designated particulate discharging facilities are installed; and
5. Dust protective masks, dust-collecting filters and other tools or instruments used and then discarded at plants or workplaces where there are designated particulate discharging facilities or dust-collecting equipment that may be contaminated with asbestos.

3.2.2 Asbestos-containing waste

1. Municipal solid waste containing asbestos

Municipal solid waste containing asbestos refers to municipal solid waste generated during the building, remodeling or removal of industrial products that contain more than 0.1% asbestos by weight.

2. Industrial waste containing asbestos

Industrial waste containing asbestos refers to industrial waste generated during the building, remodeling or removal of industrial products other than waste asbestos, etc. that contain more than 0.1% asbestos by weight.

3.2.3 Disposal standards

Disposal of waste asbestos, etc. and asbestos-containing waste should comply with regulations for the following items:

・Collection/Transportation/Intermediate Treatment/Ocean dumping

・Landfill disposal of waste asbestos, etc. should comply with disposal standards set for specially controlled industrial waste.

・Asbestos-containing waste should be disposed in designated landfills at final disposal sites.

Final disposal site manages should maintain records of the disposal locations and disposed quantities of asbestos-containing waste.

References: Manual for Disposal of Asbestos-Containing Waste, Etc. (Second Version), Ministry of the Environment, 2011; Enforcement Regulations for the Waste Management and Public Cleansing Act (Ministry of Health, Labour and Welfare Ordinance No. 35, 2971)

(See Appendix VII for more details.)

3.3 Asbestos Concentration in Ambient Air

The results of monitoring the air for asbestos concentrations in recent years are shown in Table 3-1. Airborne asbestos concentrations were low in all monitored areas, including areas at high risk of asbestos dispersal. In addition, comparison with the past monitoring results does not show any particular trends in the asbestos concentration, which may be taken to indicate that the asbestos concentration remains low.

(See Appendix VIII for an explanation of the methodology of asbestos concentration monitoring.)

Table 3-1 Comparison of the monitoring results of asbestos concentrations in ambient air in the same area*

(FY1995 and FY2005-FY2009)

Area category	Geometric mean (fiber/L)					
	FY1995	FY2005	FY2006	FY2007	FY2008	FY2009
Former manufacturing site of asbestos products	1.74	0.54	0.16	0.32	0.06	0.06
Waste disposal site	0.47	1.16	0.35	0.33	0.05	0.06
Serpentine area	0.64	0.30	0.28	0.42	0.06	0.06
Highway & main road	0.34	0.53	0.39	0.52	0.06	0.07
Residential	0.11	0.30	0.22	0.33	0.06	0.06
Commercial	0.19	0.22	0.27	0.26	0.06	0.06
Agricultural	0.47	0.13	0.40	0.40	0.06	0.06
Inland mountainous	0.24	0.20	0.36	0.42	0.06	0.06
Remote island	0.21	0.11	0.31	0.40	0.06	0.06

Source: Ministry of the Environment Press Release (July 16, 2010), "Monitoring Results of Asbestos Concentration in Ambient Air in FY 2009"

*The collection and analysis of samples is based on the "Asbestos Monitoring Manual." Basically, optical microscopes were used for the analysis of asbestos.

4 ASBESTOS REPLACEMENT

Since the number of types of asbestos-containing products runs to several thousands, the replacement began with products containing the amphibole family of asbestos (crocidolite and amosite) and products with a relatively low density of asbestos, followed by the replacement of building materials (asbestos cement products, etc.) and some industrial products containing the serpentine family of asbestos such as chrysotile. What remained difficult to be replaced to the end were seal materials used in chemical plants and other facilities, because the replacement by alternative products without careful consideration could result in leakage of hazardous chemical substances. Thus, the replacement of seal materials was phased in while confirming safety. The replacement of all asbestos-containing products has now been completed.

(See Appendix IX for more details.)

Appendices

Appendix I Definitions

1.1 Definitions and Types of Asbestos (Physical Properties of Asbestos)

In Japan, definitions of asbestos are categorized as follows depending on the state of its existence. Different definitions are described below, by referring mainly to “Manual for Measures to Prevent Asbestos Dispersal Related to the Dismantling of Buildings, Etc. 2007” (in Japanese), Ministry of the Environment, 2007.

1.1.1 Mineralogical definition

Asbestos is a generic term for a group of fibrous minerals with silken glaze that occur naturally and possess high tensile strength and flexibility (called asbestiform). Thus, the term asbestos is not used in mineralogical classifications. Minerals which exist in asbestiform include:

A The serpentine family of chrysotile (white asbestos)

B The amphibole family of amosite (brown asbestos), crocidolite (blue asbestos) and several other types.

It should be noted that both the serpentine and the amphibole minerals also occur in non-asbestiform form. Minerals that are not in asbestiform at a macroscopic level are not usually called asbestos. The non-asbestiform minerals have the same single-grid physical and chemical properties as the asbestiform ones and often appear as tiny irregular bundles of fibers under the microscopic scale.

1.1.2 Industrial definition

Asbestos, though varied depending on type, is generally characterized by its remarkably high tensile strength, flexibility, electrical insulation property, heat resistance, superior spinnability as well as chemical resistance, compared with other fibrous minerals. Due to these unique properties, asbestos is being mined and exploited as industrial material in regions where it is produced in large quantities.

Asbestos in its industrial state usually refers to macroscopically asbestiform minerals mined and processed for industrial use. At present, chrysotile is the only asbestos used for industrial applications.

1.1.3 Definition of asbestos in ambient air

Fibrils of minerals shown in Table 1-1 are extremely thin, with a single chrysotile fibril having a diameter of only 0.02-0.03μm. Asbestiform minerals are readily spilt into bundles of fine fibers 1-2μm in diameter, and are often released into the air and remain suspended in a state of minute fibers or fiber bundles. Thus, asbestos in ambient air may be defined as minerals in Table 1-1 that are suspended airborne in a state of minute fibers or fiber bundles.

Table 1-1 Types of asbestos and related minerals

Type of mineral		Generic name of industrial asbestos	
Name	Chemical formula	English	日本名
Serpentine Group			
Chrysotile	$Mg_6Si_4O_{10}(OH)_8$	Chrysotile asbestos	クリソタイル、 温アスベスト、 白アスベスト
Amphibole Group			
Anthophyllite	$(Mg,Fe^{2+})_7Si_8O_{22}(OH,F)_2$	Anthophyllite asbestos	アンソフィライト、 直閃アスベスト
Cummingtonite grunerite Series	$(Mg,Fe^{2+})_7Si_8O_{22}(OH)_2$	Amosite	アモナイト、 茶アスベスト
Tremolite actinolite Series	$Ca_2(Mg,Fe^{2+})_5Si_8O_{22}(OH,F)_2$	Tremolite asbestos Actinolite asbestos	トレモライト、 透角閃アスベスト アクチノライト、 陽起アスベスト
Riebeckite	$Na_2Fe_3^{2+}Fe_2^{3+}Si_8O_{22}(OH,F)_2$	Crocidolite	クロシドライト、 青アスベスト

Source: Carcinogenic Substances in the Air - Asbestos - (March, 1980)

1.2 Chemical Composition and Morphology of Asbestos

1.2.1 Chrysotile

Chrysotile consists of hydrated magnesium silicate, expressed with the chemical formula of $Mg_6Si_4O_{10}(OH)_8$, and often contains moderate amounts of aluminum and iron as impurities.

Chrysotile in the serpentine family is one of principal minerals that constitute serpentine, which was formed in the process of serpentinization of ultrabasic igneous rock (dolomite in rare cases). Chrysotile is found in reticulated form in serpentine.

1.2.2 Various amphibole asbestos

Generalized formulas are as shown in Table 1-1. Cummingtonite and grunerite are minerals of the same chemical structure, with cummingtonite being richer in magnesium than in iron, and grunerite being richer in iron than in magnesium. As they show a continuous variation in the ratio between magnesium and iron, they can be considered to belong to the same mineral group. Tremolite and actinolite have a similar relationship.

While members of the amphibole group are important rock-forming minerals, the amphibole family of asbestiform asbestos are often found in metamorphic rocks.

1.2.3. Accessory minerals

Asbestos ore may contain a range of other accessory minerals, such as talc ($Mg_3Si_4O_{10}(OH)_2$) and brucite ($Mg(OH)_2$).

Talc is mined as an industrial material, but talc processed as commercial products often contains minute fibers such as chrysotile and tremolite.

1.3 Chemical and Physical Properties of Asbestos

Asbestos is characterized by ① being fibrous and spinnable, ② superior resistance to heat, ③ high tensile strength, ④ chemical resistance, and ⑤ heat insulation properties.

Each type of asbestos has different chemical and physical properties, which can be summed up as follows, and are shown in Table 1-2.

1.3.1 Fibrous structure

Asbestos, even when separated into very thin fibers, is still a collection of bundles of minute fibers under an electron microscope. In chrysotile, a fibril, the smallest unit of these bundles of fibers, is said to be a hollow tube 0.02-0.03μm in diameter, whose cross-section surface is mostly circular. The smallest separable bundle of fibers is usually 1-2μm in diameter but has a very large surface area of 20-30m^2/g.

1.3.2 Heat resistance

Asbestos is highly resistant to heat, and this advantage determines the fact that it is preferred over organic fibers in industrial applications.

The structure of chrysotile asbestos is stable up to approximately 500°C, above which chrysotile begins to release crystallization water. This process is completed at around 800°C, with an ignition weight loss of 13-16%. The amphibole varieties of asbestos are usually more stable at high temperatures than chrysotile. Their fibers become brittle with the release of crystallization water and lose the properties of asbestos.

1.3.3 Tensile strength and flexibility

The high tensile strength is another important property of asbestos that enhances its industrial utility value. The flexibility of asbestos is influenced mainly by the thinness of fibers and the size of crystallization water.

Chrysotile, which has the thinnest fibers and a larger content of crystallization water, exhibits the highest flexibility among all asbestos types.

1.3.4 Chemical resistance

Chrysotile is generally weak in acid resistance but strong in alkali resistance. For instance, chrysotile experiences a weight loss of only 2% when exposed to a 25% solution of caustic soda at 100-105°C for 5 hours.

Among varieties of asbestos, anthophyllite has the strongest acid and alkali resistance and chrysotile the weakest, with the rest of asbestos standing in the middle of these two. Asbestos also has relatively strong resistance to chemicals, on top of acids and alkalis.

1.3.5 Heat insulation properties

Asbestos in general has strong heat insulation properties, which, together with its high resistance to heat, is an important property when used as lagging material. The heat insulation property is influenced by the component materials and composition state of asbestos.

Table 1-2 Chemical/physical properties of various asbestos

	Chrysotile	Anthophyllite	Amosite	Tremolite	Actinolite	Crocidolite
Hardness	2.5-4.0	5.5-6.0	5.5-6.0	5.5	around 6	4
Specific gravity	2.4-2.6	2.85-3.1	3.1-3.25	2.9-3.2	3.0-3.2	3.2-3.3
Specific heat	0.266	0.210	0.193	0.212	0.217	0.201
Tensile strength, kg/cm^2	30,000	2,800	25,000	70-560	70	35,000
Temperature at maximum ignition loss, °C	982	982	871-982	982	N.A. (Note 1)	649
Filtration properties	Slow	Medium	Fast	Medium	Medium	Fast
Electric charge	Positive	Negative	Negative	Negative	Negative	Negative
Fusion point,°C	1521	1468	1399	1316	1393	1193
Spinnability	Good	Poor	Fair	Poor	Poor	Fair
Flexibility	Very Good	Poor	Good Fair	Poor	Poor	Fair Poor
Resistance to heat	Brittle at high temperature	Very good	Brittle at high temperature	Good	N.A.	Fuses at high temperature
Resistance to acids	Poor	Fair	Fair	Very good	Very good	Good
Resistance to bases	Very good	Good	Good	Very good	Good	Good
Decomposition temperature, °C (Note 2)	450–700	620–960	600–800	600–850	950–1040	400–600

Note 1: N.A.: not available

Note 2: Decomposition temperature refers to the temperature at which dehydration dehydrogenating occurs, leading to a decrease in tensile strength

Source: Carcinogenic Substances in the Air – Asbestos - (March, 1980) (in Japanese); Meetings on the Countermeasures for Preventing the Release of Asbestos from Known Sources (June, 1980) (in Japanese)

1.3.6 Hygroscopicity

Hygroscopicity and absorbency are properties that need to be considered in lagging materials. Asbestos has a low moisture hygroscopicity and water absorbency relative to organic fibers. For instance, although the moisture hygroscopicity of chrysotile is the highest among all types of asbestos, it is still much lower than that of organic fibers. The reason for the high hygroscopicity and water absorbency of chrysotile relative to other types of asbestos is that chrysotile fibers have larger surface areas because they are thinner than those of other asbestos and hollow.

1.3.7 Stability and environmental accumulation

The stability and the environmental accumulation of asbestos in the environment pose problems. Under normal environmental conditions, the lifetime of all types of asbestos is known to be long, as they do not break down or metamorphose almost permanently and asbestos dust that settles down on surface soil layers can be released into the air again.

1.4 Asbestos as an impurity

Vermiculite, talc, sepiolite and natural brucite may contain asbestos as impurities.

Appendix II　Production of Raw Asbestos in Asian Countries and the World

The following section describes the production and consumption of raw asbestos in Asian countries, based data in "U.S. Geological Survey World asbestos supply and consumption trends from 1900 through 2003" "WORLD ASBESTOS CONSUMPTION FROM 2003 THROUGH 2007." Figures 2.1 to 2.4 show the patterns of production, imports, exports and consumption of six countries (China, India, Japan, Indonesia, Korea and Thailand) that consumed 30,000 tons a year or more of raw asbestos in 1985.

2.1　Raw Asbestos Production by Six Asian Countries

Figure 2-1 shows the production of raw asbestos in six principal countries in Asia. Production in China began to increase from around 1960, while India, Japan and Korea were producing relatively small amounts. Indonesia started production in 1985 to join four other producers. Production ceased in Indonesia in 1990, bringing the number of producing countries to four again, and then in 1995, Korea stopped production. Subsequently, between 1999 and 2005, only China and India produced raw asbestos. China remained the major producer, with output of some 450,000 tons each year between 1995 and 1997. India retained its production levels at about 30,000 tons a year since around 1980.

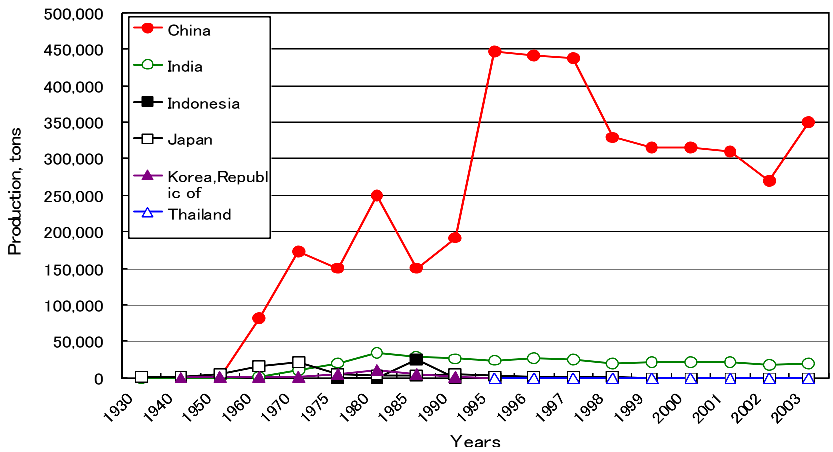


Figure 2-1　Production of raw asbestos by 6 Asian countries

2.2.　Raw Asbestos Imports by Six Asian Countries

Figure 2-2 shows imports of raw asbestos by six Asian countries. In 1930, only Japan imported asbestos in Asia, followed by China and India in 1940. China ceased its imports between 1950 and 1980, but resumed the trade in 1985. Japan began to increase its imports in 1960 and its imports peaked at some 400,000 tons in 1980. Then, Japan's imports began to decline gradually and slipped to about 20,000 tons in 2003. Japan was replaced by India in 1999 as the leading asbestos importer among these six countries in Asia. China was a relatively small importer, as sizeable amounts of domestic production appeared to satisfy its own market. Since 1999, India stayed as the largest importer. Thailand began to increase its imports rapidly from around 1985 and its imports reached around 180,000 tons a year, about the same amount as Japan, between 1995 and 1997.

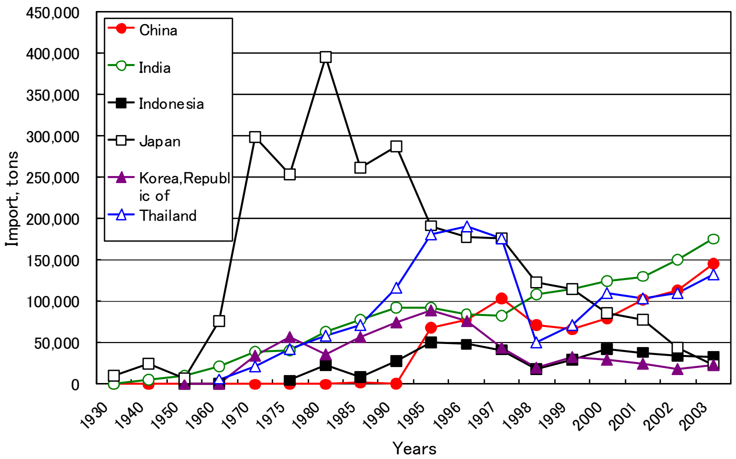


Figure 2-2 Imports of raw asbestos by 6 Asian countries

2.3. Raw Asbestos Exports by Six Asian Countries

As shown in Figure 2-3, of the six countries in Asia, only China, India and Japan exported asbestos until 1997. China's exports kept increasing since around 1980 in tandem with its production, shown in Figure 2-1. China's exports reached a peak level of 18,000 tons in 1998, and again in 2001. But exports by China fell sharply to around 4,000 tons in 2002 and 2003. India is also exporting raw asbestos, albeit only in small amounts.

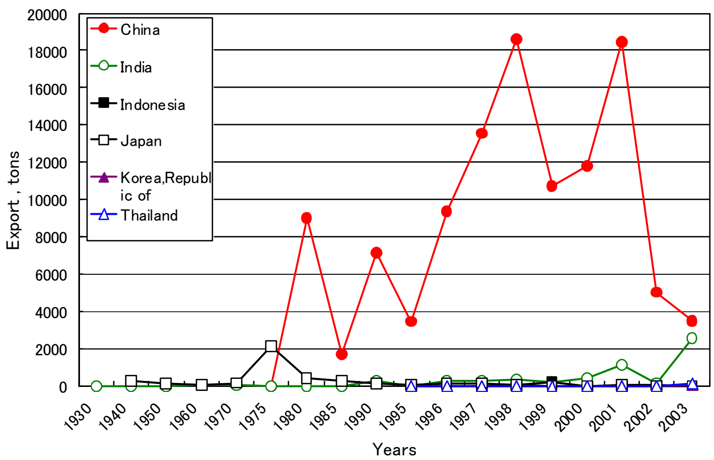


Figure 2-3 Exports of raw asbestos by 6 Asian countries

2.4 Raw Asbestos Consumption by Six Asian Countries

Figure 2-4 shows consumption patterns of six countries in Asia. Around 1930, raw asbestos was consumed by only three countries: China, India, and Japan. Consumption in Japan began to increase in the 1960s, peaked at about 400,000 tons in 1980, and then declined gradually to only about 58 tons in 2007. China's consumption started expanding around 1990, reaching at over 500,000 tons a year in the period between 1995 and 1997. Following a decline to about 400,000 tons a year between 1998 and 2002, the consumption turned upward again in 2003 and rose to about 620,000 tons in 2007. After reaching a level of some 100,000 tons around 1980, India's consumption of raw asbestos followed a mild rising curve and reached a little over 300,000 tons in 2007. Thailand's consumption began to increase around 1970 and reached nearly 200,000 tons, roughly the same amount as Japan, in 1995. The country's consumption rose after a sharp decline in 1998, but turned down again since 2005. In Korea, consumption gradually rose and peaked in 1995, and then declinedgradually thereafter, while Indonesia retained its consumption of around 20,000-50,000 tons a year since around 1980.

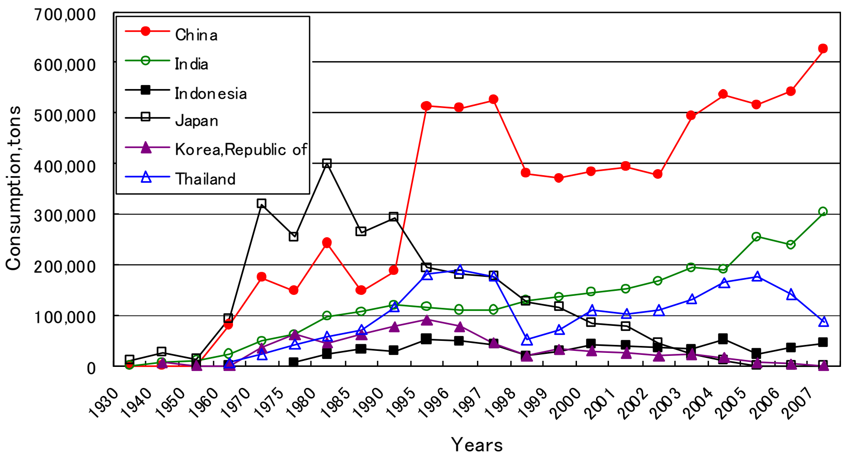


Figure 2-4 Consumption of raw asbestos by 6 Asian countries

2.5 Raw Asbestos Consumption Patterns of Six Asian Countries

With asbestos being used principally as building materials since 1990, consumption of raw asbestos tends to grow during periods of economic growth when demand for road development and construction increases [(1)-(3)].

As shown in Figure 2-4, Japan's consumption appears to have increased between 1970 and 1990 in tandem with the economic growth in that period [(4)]. The subsequent decrease in consumption came apparently because health impairment due to asbestos became a major social issue [(1)]. Meanwhile, asbestos consumption in China increased rapidly in association with the economic growth from around 1995, and the uptrend continued until 2003. The sudden decrease in consumption in Thailand in 1998 from 1997 is likely to have been related to the country's negative economic growth in 1997 and 1998 (5).

2.6 Production, Imports, Exports and Consumption of Other Asian Countries

Figures 2-5, 2-6, 2-7 and 2-8 show production, imports, exports and consumption of raw asbestos, respectively, by countries other than the six principal countries. As the scale of Figure 2-5 is adjusted to that of Figure 2-1 for consistency, production of raw asbestos in those countries is so little that it appears almost zero in Figure 2-5. As shown in Figure 2-6, Malaysia began importing asbestos around 1960, and its imports remained at 20,000-30,000 tons a year with the peak in 1980. Malaysia's imports continued at 10,000-20,000 tons a year until 2003. Vietnam began asbestos imports in 1997 and purchased nearly 50,000 tons in 2003. Sri Lanka also imported nearly 15,000 tons a year. As for exports shown in Figure 2-7, Singapore exported about 10,000 tons at the peak, while Malaysia also exported some 6,000 tons in 2001. Exports by other countries were almost zero as they do not produce raw asbestos. Looking at consumption shown in Figure 2-8, Malaysia consumed about 20,000 tons of raw asbestos from 1975 to around 1997, but its consumption has steadily declined since then. Vietnam consumed several tens of thousands of tons from 1998, and its consumption stood at a little over 100,000 tons in 2005. Sri Lanka's consumption topped 10,000 tons between 1998 and 2001, and in 2004, 2005 and 2007, but was low in other years. Other countries showed no significant changes in graphs.

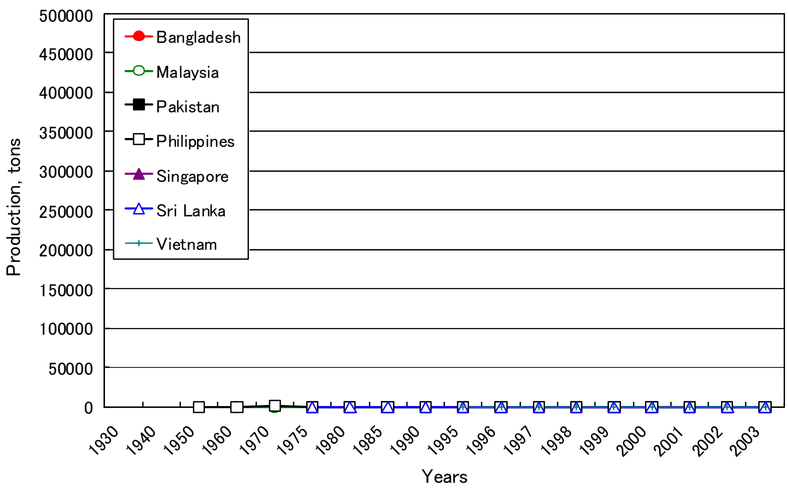


Figure 2-5 Production of raw asbestos by other Asian countries

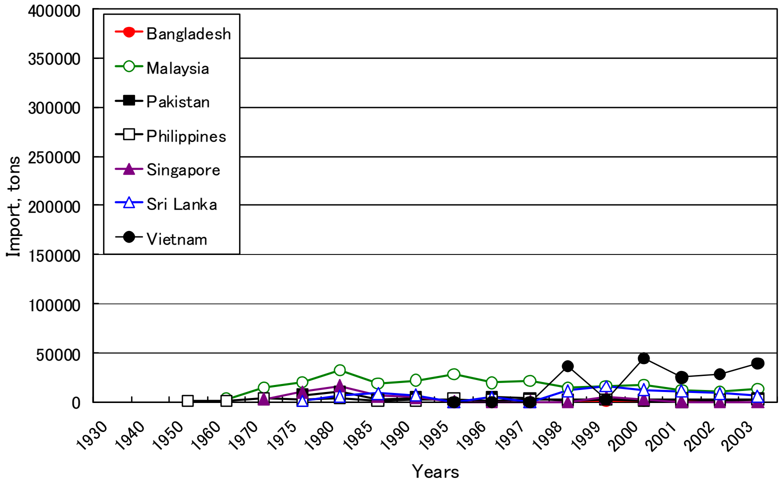


Figure 2-6 Imports of raw asbestos by other Asian countries

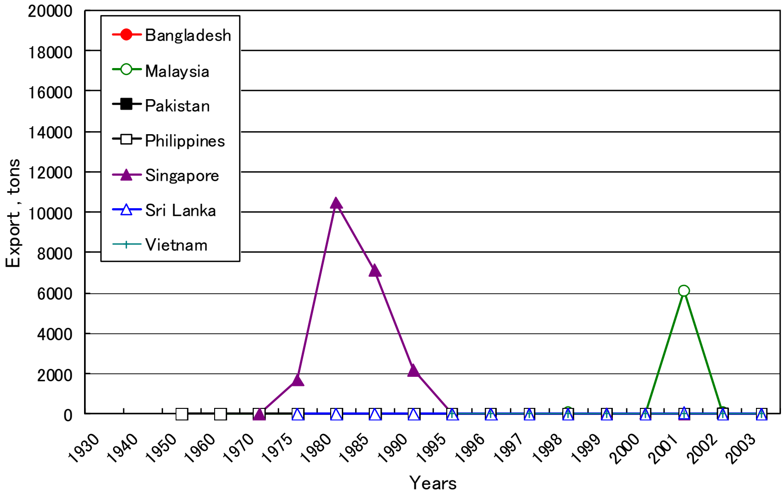


Figure 2-7 Exports of raw asbestos by other Asian countries

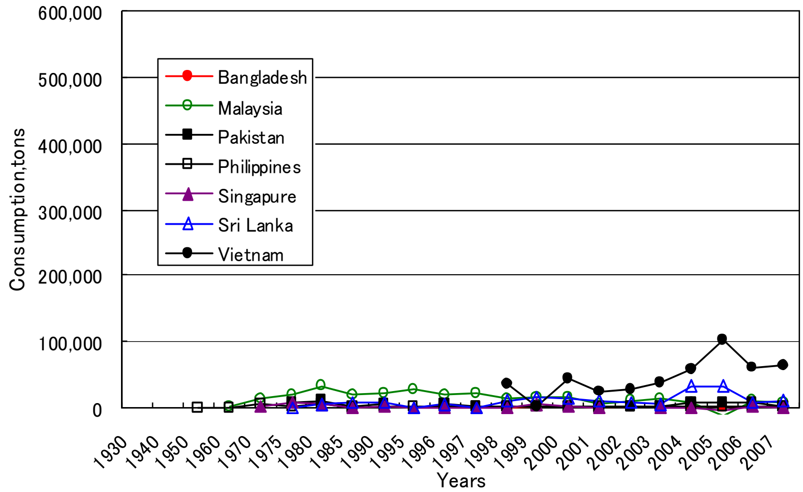


Figure 2-8 Consumption of raw asbestos by other Asian countries

References

(1) USGS World asbestos supply and trends from 1900 through 2003. 80pp

(2) Virta, R.L.1998.Asbestos.U.S.Geological Survey. 2pp

(3) Perron, L. 2003. Chrysotile, Canadian Minerals Yearbook, Natural Resources, Canada.

(4) Morinaga, K.2003. Asbestos in Japan. European Asbestos Conference, Dresden

(5) Ministry of Economy, Trade and Industry website
http://www.meti.go.jp/policy/trade_policy/asia/thai/index.html

2.7 Production in the World

Asbestos as industrial materials can be obtained by mining ores that contain mineralogically-defined asbestos mostly from open-pit mines and concentrating them after processing. The asbestos content in raw ores ranges from 2% to 20%, and is generally between 4% and 9%.

Production of asbestos as industrial materials in the world has declined from 5 million tons several decades ago to 2-2.5 million tons in the last decade, as shown in Table 2-1.

Today, Russia is the leading producing country, with some one million tons in 2009, accounting for nearly 50% of global production, followed by such countries as China, Kazakhstan, Canada, Brazil and Zimbabwe.

Asbestos deposits are found throughout Japan, though only in small amounts sufficient as mineral samples, and small-scale mining was conducted before World War II. Domestic production of some 5,000 tons a year in the postwar period accounts for the recovery from tailings at former mines. However, such production has been discontinued now.

Table 2-1 Changes in asbestos production in the world (in thousand tons)

	Russia	Canada	China	Brazil	Zimbabwe	Kazakhstan	South Africa	United States	Others	Total
1994	800	518	240	175	150	300	95	10	122	2,410
1995	800	511	240	190	150	250	95	9	155	2,400
1996	720	521	250	170	165	225	90	10	139	2,290
1997	700	447	245	170	160	125	60	7	156	2,070
1998	650	330	250	170	140	125	20	6	149	1,840
1999	700	337	300	170	135	125	20	7	136	1,930
2000	750	340	260	170	110	125	19	5	121	1,900
2001	750	340	360	170	120	235	16	5	54	2,050
2002	750	272	360	209	130	291		3	120	2,130
2003	878	241	260	195	130	353		-	93	2,150
2004	875	200	355	195	150	347		-	110	2,230
2005	925	200	520	195	122	355		-	84	2,400
2006	925	244	350	236	100	355		-	90	2,300
2007	925	185	380	230	100	300		-	80	2,200
2008	1020	180	280	255	50	230		-	75	2,090
2009	1000	150	380	288		230		-	19	2,070
2010 Estimated	1,000	100	350	270		230		-	20	2,070

Source: U.S. Geological Survey, Mineral Commodity Summaries (1996-2011)

Appendix III Incidence of Diseases in Japan

3.1 Health Effects of Asbestos

3.1.1. Asbestosis

Asbestosis is the disease that came under the spotlight as a health hazard related to asbestos ahead of other diseases, and is a type of pneumoconiosis that has long been recognized to be caused by the inhalation of asbestos dust among workers with occupational exposure to asbestos of relatively high concentration or long-term exposure to asbestos. When asbestos fibers enter the lungs, they cause irritation and inflammation in small bronchi and cells, gradually develop fibrosis in areas around the terminal pulmonary bronchus and alveolar interstitial, and eventually lead to lung function impairment. Asbestosis is rarely detectable at the state soon after exposure, and detection of even the early stage of asbestosis usually comes more than 10 years after the initial exposure. In the majority of cases, asbestosis appears to advance after the cessation of exposure, although early-stage cases do not show any appreciable radiographic change over many years.

Though there is no substantial evidence that the type of asbestos influences the incidence or severity of asbestosis, the risk of acquiring asbestosis appears to be higher at spinning factories than at mines, rock quarry or manufacturing plants for friction products. There are some cases in which pulmonary fibrosis due to asbestosis leads to death from respiratory failure. The mortality is related to the duration and intensity of exposure, but not to age, and the mortality appears to be higher among cigarette smokers.

3.1.2 Lung cancer

Asbestos exposure is known to increase the risk of lung cancer. The period of latency between exposure to asbestos and the onset of asbestos-related lung cancer is generally 15-40 years, and it has been confirmed that the risk of developing lung cancer increases with the degree of asbestos exposure. Table 3-1 shows the carcinogenicity of asbestos, while Table 3-2 shows the relationship between asbestos and smoking.

Table 3-1 Carcinogenicity of asbestos

Type of fiber	Immunology	in vitro (**)	Evaluation (WHO*)
Chrysotile	＋	± ＋＋	Carcinogen
Amosite	＋＋	± ＋＋	Carcinogen
Crocidolite	＋＋	± ＋＋	Carcinogen

*: Wor1d Health Organization, Environmental Health Criteria vol. 53, vol. 77

**: November 1990, Air Pollution Control Society (Takeout, Adachi) (in Japanese)

Source: Tokyo Metropolitan Government, March 1996, Basic Knowledge and a Guidance Manual of Asbestos (in Japanese)

Table 3-2 Mortality ratio for lung cancer due to asbestos exposure in relation to cigarette smoking

Hammond 1979	Asbestos exposure		McDonald 1980	Level of asbestos exposure		
	No	Yes		None	Moderate	High
Nonsmoker	1.0	5.17	Nonsmoker	1.0	2.0	6.9
			Moderate smoker	6.3	7.5	12.8
Smoker	10.85	53.24	Heavy smoker	11.8	13.3	25.0

Source: Nakadate, 1988, Health Effects of Asbestos, Journal of Clinical Epidemiology, p.147, pp. 527-529 (in Japanese)

3.1.3 Mesothelioma

Mesothelioma is a malignant tumor (cancer) of very poor prognosis of the surface of the mesothelium, which covers the pleura, pericardium and peritoneum, and its underlying tissues. There is the latency period of 20-50 years between the initial asbestos exposure and development of mesothelioma. The incidence of mesothelioma has been increasing in recent years, as shown in Figure 3-1.

It is believed that the onset of mesothelioma is caused by asbestos. It is also known that the incidence of mesothelioma is influenced by the type of asbestos. It is believed that the risk associated with exposure to crocidolite is the highest, followed by amosite, and that the risk associated with exposure to chrysotile is lower than crocidolite and amosite. However, there is no reliable data to support the reaction relation between the onset of mesothelioma and the amount of exposure to asbestos.

3.2 Asbestos-Related Diseases in Japan

Figure 3-1 shows the number of compensated occupational diseases (lung cancer and mesothelioma) and the number of deaths from mesothelioma (vital statistics). This is because there is a latency period of 20-50 years between the initial asbestos exposure and development of mesothelioma and the incidence of mesothelioma has been increasing in recent years. Figure 3-2 shows both changes in asbestos imports and the number of deaths from mesothelioma.

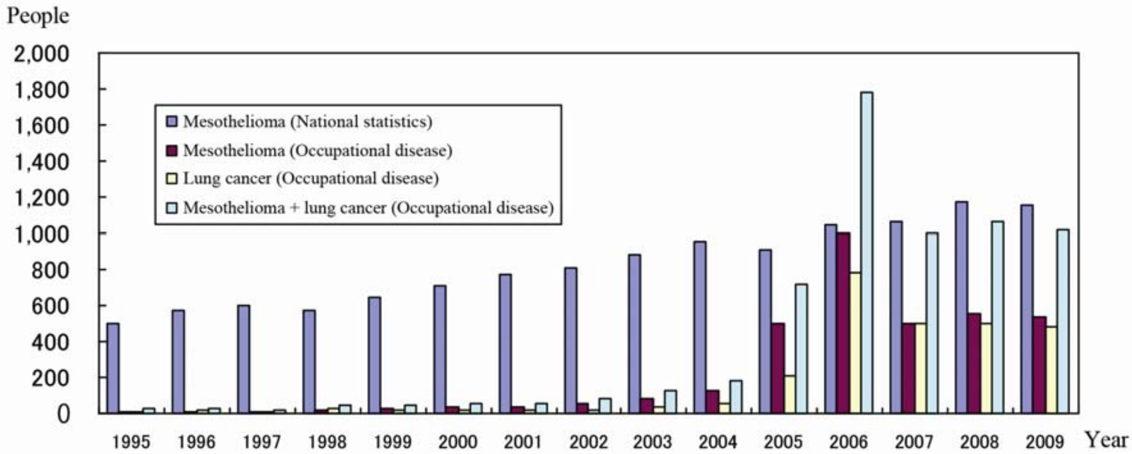


Figure 3-1 The number of deaths from mesothelioma and compensated occupational diseases

Source: Compiled based on Ministry of Health, Labour and Welfare material, Yearly Changes in the Number of Deaths from Mesothelioma by Prefecture (1995-2009) Vital Statistics (Fixed Numbers) and Claims and Determinations of Insurance Benefits Concerning Diseases (Lung Cancer, Mesothelioma, Benign Asbestos Effusion and Diffuse Pleural Thickening.

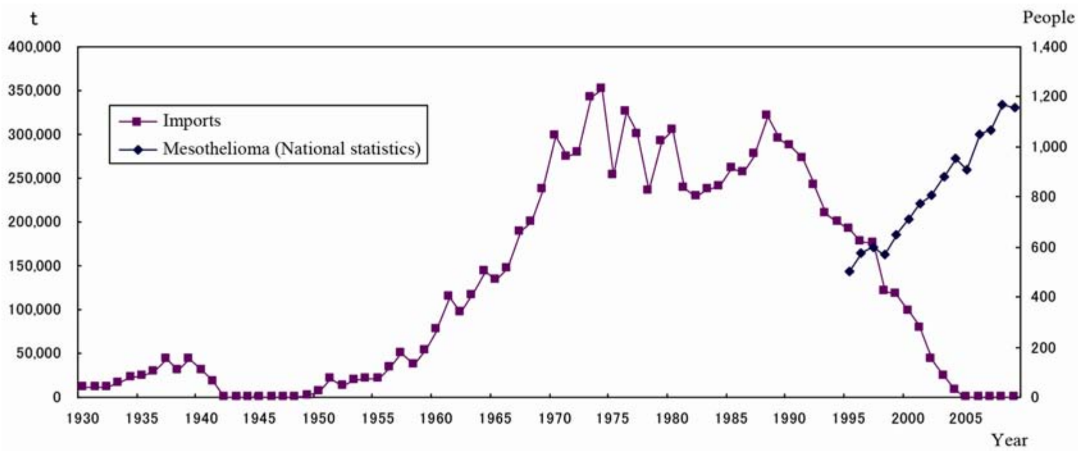


Figure 3-2 Changes in asbestos imports and the number of deaths from mesothelioma

Source: Compiled based on Trade Statistics, Ministry of Finance, and Ministry of Health, Labour and Welfare material, Yearly Changes in the Number of Deaths from Mesothelioma by Prefecture (1995-2009) Vital Statistics (Fixed Numbers).

Appendix IV Definitions and Applications of Asbestos-Containing Products

4.1 Applications and Products

As asbestos has high spinnability, heat resistance and many other superior properties, it has been widely used in industrial applications by leveraging its unique properties. It would be no exaggeration to say that asbestos-containing products have spread to every corner of the living territory. It is said that there were once more than 3,000 types of such products, a considerable number of which were manufactured to comply with the Japanese Industrial Standards (JIS).

The major spheres of application for asbestos in Japan were industrial products and building materials. Building materials accounted for about 90% of the domestic consumption of asbestos in FY1995, and building materials also accounted for about 90% of fields of use of asbestos, followed by automotive parts at 4%. In the automobile industry, asbestos in automotive parts of new vehicles had been steadily replaced by newly developed substitute materials under Japanese automakers' self-imposed restraint on the use of asbestos, with the replacement completed for passenger cars, light commercial vehicles and mini-vehicles by the end of FY1994, and the substitutes also have almost entirely replaced asbestos in trucks, buses and motorcycles.

As of October 1, 2004, the Industrial Safety and Health Act placed a ban on the import, manufacture and use of building materials, friction materials and adhesives containing asbestos. The replacement of asbestos in these products proceeded steadily and has run its course by now.

4.2 Use of Asbestos in Buildings

A considerable amount of asbestos has been used in such structures as steel-reinforced concrete, reinforced concrete, steel and concrete block buildings. Asbestos was used as spray-on asbestos applied directly to walls, ceilings, columns and joists, and was also used in flooring, walling, ceiling materials, ceiling eaves and fireproofing wall materials such as corrugated asbestos slates and asbestos cement boards.

Crocidolite or amosite were often used as spray-on asbestos, sprayed by spraying machines after being mixed with bonding materials.

The use in spray-on applications began around 1955. Starting in 1964, asbestos was sprayed for soundproofing purposes in buildings in the vicinity of air bases, and its use was later expanded to residential and industrial applications.

The demand for asbestos as light refractory covering materials became significant from around 1967 with technological developments allowing the construction of skyscrapers and steel framed buildings. It reached a peak in Japan's high growth period of 1970-1972, when capital spending was robust.

In order to prevent health impairment of workers engaged in spraying work, the spraying of over 5% asbestos by weight was prohibited, in principle, under the Ordinance on the Prevention of the Hazard due to Specified Chemical Substances in 1975. The spraying of over 1% asbestos by weight was banned, in principle, in 1995, and then with the enactment of the Ordinance on Prevention of Health Impairment due to Asbestos, the spraying of 0.1 % asbestos by weight was entirely prohibited in 2006.

It is known that the use of rockwool containing asbestos less than 5% by weight continued until 1989. It is, however, not certain when the practice of using spray-on asbestos without rockwool (containing asbestos less than 5% by weight) actually ceased.

Figure 4-1 shows statistics about the production of spray-on asbestos and spray-on rockwool containing asbestos.

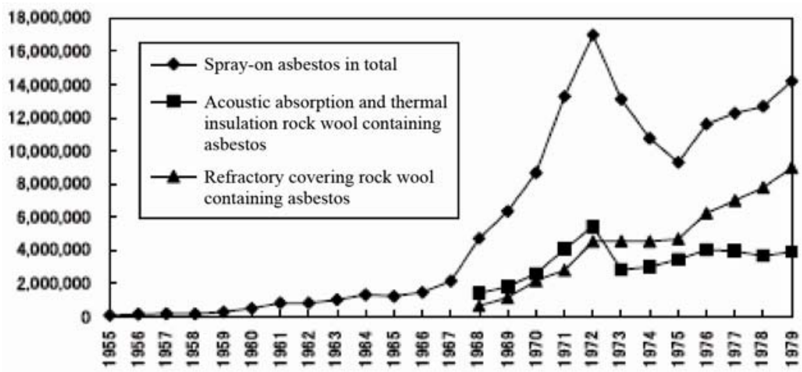


Figure 4-1 Trends of production of spray-on asbestos and asbestos-containing spray-on rockwool

Source: Report of the Study Group on the Prevention of Dispersal of Asbestos in the Demolition of Buildings (in Japanese), Ministry of the Environment, November 2005.

Note: Based on production in tonnage, the area is calculated assuming that spray-on asbestos, acoustic absorption and thermal insulation rockwool containing asbestos and refractory covering rockwool containing asbestos have respective densities and thicknesses of 0.3, 10mm; 0.3, 45mm; and 0.3, 15mm.

Spray-on asbestos in total is the sum of spray-on asbestos and rockwool containing asbestos between 1968 and 1974, and was rockwool containing asbestos (for acoustic absorption and thermal insulation and for refractory covering).

Appendix V Measures to Prevent Asbestos Dispersal/Exposure in the Working Environment

5.1 Overview

Given the extreme seriousness of health impairment caused by asbestos, it is important to take adequate measures against the dispersal of and exposure to asbestos in the working environment. Generally, there are production technology, occupational health engineering and work management approaches to dispersal/exposure prevention measures. It is more effective to combine several methods instead of relying on a single approach.

Below, the common principles of production technology, occupational health engineering and work management approaches are described, and then occupational health engineering and work management approaches are outlined. The general ventilation (dilution ventilation), in which hazardous substances that emanate and are dispersed from the source of emanation are discharged from a roof light window after being diluted by unpolluted air coming in from windows, etc., is not an appropriate method to be adopted at workplaces that handle extremely hazardous substances like asbestos. Therefore, it should be positioned as a complementary ventilation method at workplaces.

Production technology approach	① Halt to the manufacture and use of hazardous substances; switchover to less hazardous materials
	② Prevention of emanation of hazardous substances through improvements to hazardous production processes and work methods
	③ Sealing-up and automatization of facilities handling hazardous substances
	④ Isolation and remote-control operation of hazardous production processes
Occupational health engineering approach	⑤ Installation of local ventilation equipment
	⑥ Installation of push-pull ventilation equipment
	⑦ Installation of general ventilation equipment
Work management approach	⑧ Improvement in work methods, such as limits on working hours
	⑨ Prevention of infestation with the use of respiratory protective equipment
	⑩ Prevention of secondary generation of dust through improvements in work behaviors

5.2 Occupational Health Engineering Approach

5.2.1 Configuration of local ventilation equipment/air cleaning equipment

Local ventilation equipment, with a hood installed close to the source of emanation of hazardous substances to suck in hazardous substances, is designed to suck in highly-concentrated hazardous substances without dispersing them by creating a constant flow of air current locally.

The equipment consists of hoods, ducts, air cleaning equipment (dust removal equipment), exhaust fans and the exhaust outlet, and the cleaned air is released into the atmosphere through the air cleaning equipment. The local ventilation equipment/air cleaning equipment requires periodical checkups. The checkup of the local exhaust equipment is described in Section 5.3.

An example of the configuration of the local exhaust equipment/air cleaning equipment is shown in Figure 5-1.

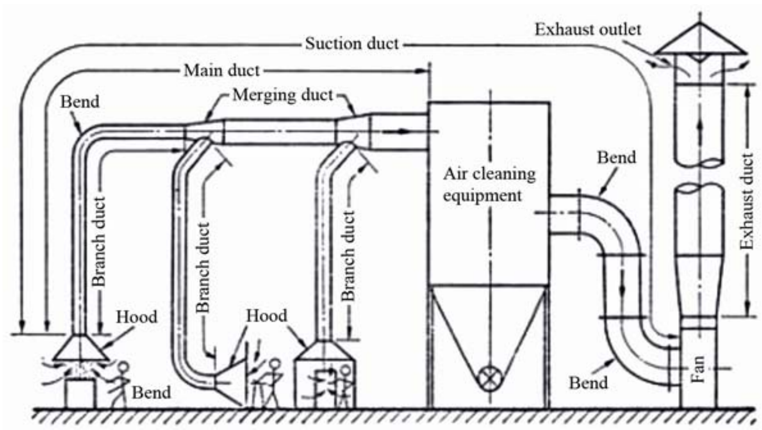


Figure 5-1 Example of the configuration of local ventilation equipment/air cleaning equipment

Source: Japan Industrial Safety and Health Association, Standard Design and Maintenance Management of Local Ventilation/Air Cleaning Equipment

5-2-2 Components of the local exhaust equipment/air cleaning equipment

5.2.2.1 Hood

The hood, installed close to the source of dust as an inlet to suck in air, sucks in and captures dispersed dust together with air. The performance of the local exhaust equipment is shown by the velocity of the air current sucked into the hood, called the control velocity. In Japan, the Ministry of Health, Labour and Welfare has set in its notifications a control velocity of at least 0.5 m/s for gaseous substances and at least 1.0 m/s for particulate substances.

The choice of the hood requires sufficient consideration since the shape of the hood and the location of installation greatly influence the capacity of dust-collecting equipment, pollution in the surrounding environment and workability. Generally, there are four basic rules about the installation of the hood.

1. The installation location of the hood should be determined to position work areas on the windward side of the source of dust to prevent workers from being exposed to dust.

2. When the direction of dust dispersal is constant, the hood should be installed to cover that direction.

3. The hood should be installed as close as possible to the source of dust.

4. Enclose the source of dust as much as possible and make the hood opening as small as possible in order to secure an adequate air current for suction and reduce an air volume to be treated by the dust removal equipment.

Broadly speaking, hoods are installed for ordinary sources of dust or for dust generated by rotating bodies like grinders.

① For ordinary sources of dust

Hoods are classified into enclosure-type hoods to enclose the sources of dust and external hoods installed outside the sources of dust. Depending on where they are installed, external hoods are further classified into lateral suction hoods that suck in air laterally from the sources of dust, downward suction hoods that suck in air downward and upward suction hoods that suck in air upward. Representative examples of these types of hoods are shown in Figure 5-2.

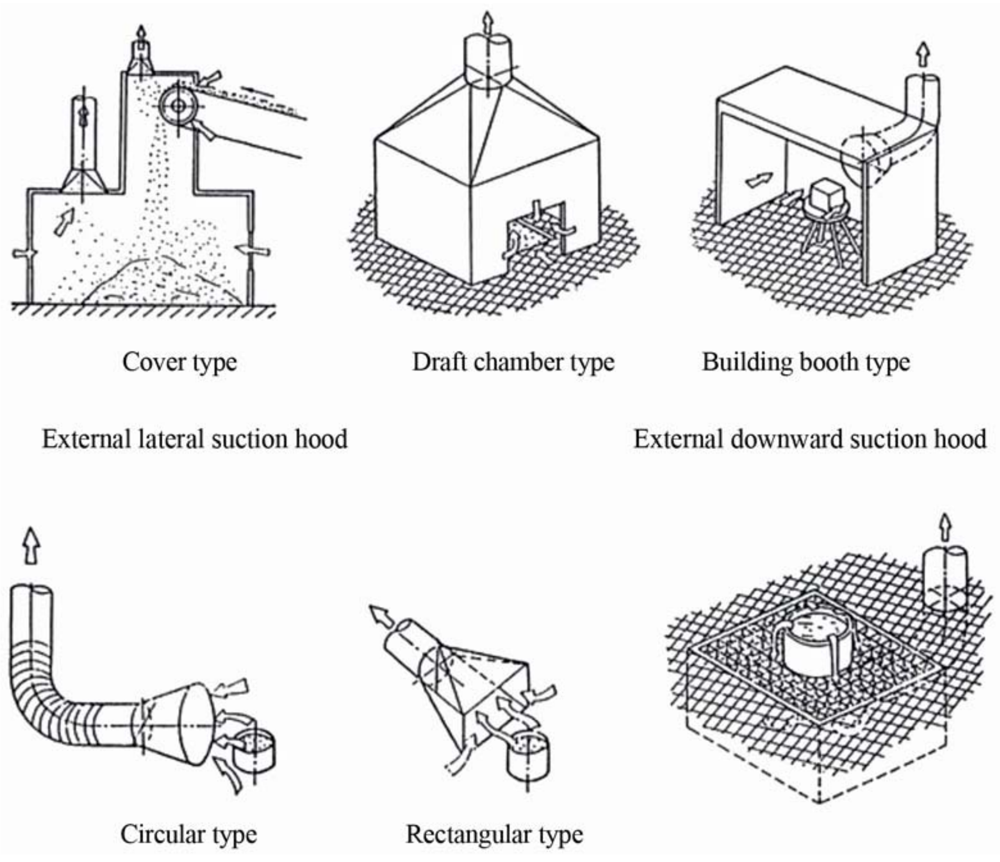


Figure 5-2 Hoods for fixed sources of dust

Source: Japan Industrial Safety and Health Association, Standard Design and Maintenance Management of Local Ventilation/Air Cleaning Equipment

② For dust generated from rotating bodies

Since modes of the generation of dust from grinders and other rotating bodies are different from ordinary sources of dust, the three ways of installation shown in Figure 5-3 are appropriate.

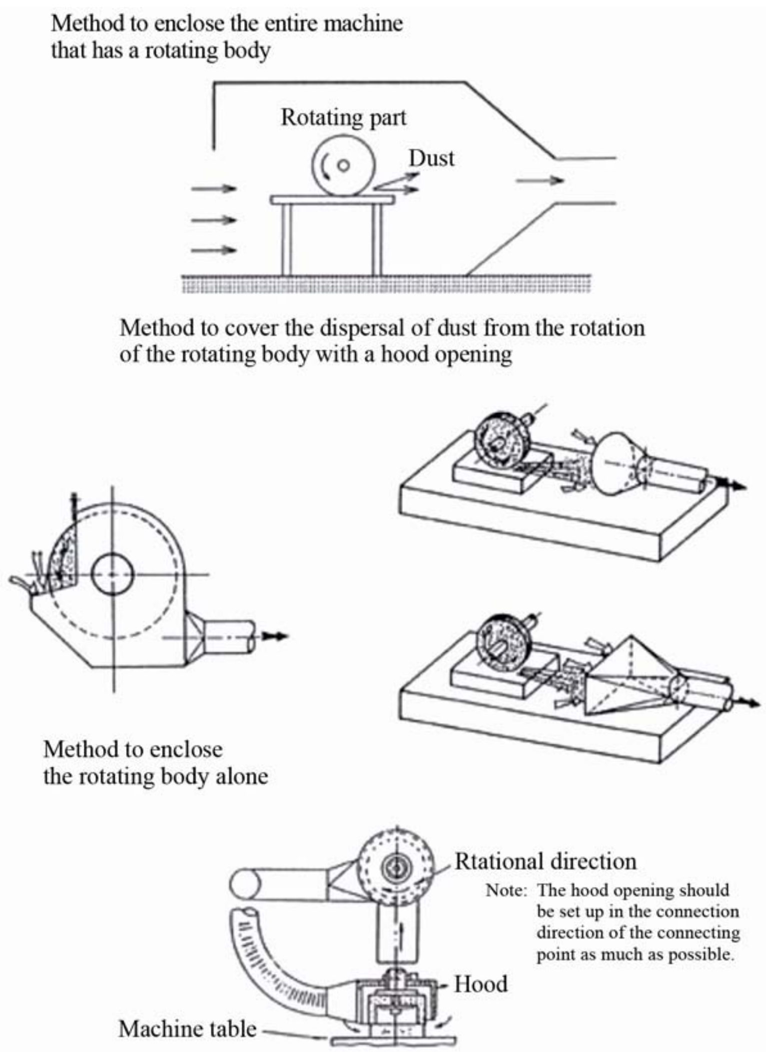


Figure 5-3 Example of hoods for rotating bodies

Source: Japan Industrial Safety and Health Association, Standard Design and Maintenance Management of Local Ventilation/Air Cleaning Equipment

5.2.2.2. Ducts

Ducts are tubes that carry air sucked in by hoods, and there are two types of ducts: suction ducts and exhaust ducts. It is necessary to pay attention to the following points in installing ducts:

1. Make ducts as short as possible and reduce the number of bends to as few as possible.
2. Ensure an adequate wind velocity in order to prevent dust from accumulating within ducts and keep ducts from wearing.
3. Make cleaning holes at appropriate places to make the cleaning of ducts easier.

5.2.2.3 Air cleaning equipment (dust removal equipment)

① Overview

There are a number of types of dust removal equipment that leverage a variety of the mechanisms, including gravity dust removal equipment based on gravitational sedimentation, inertia force dust removal equipment based on inertial collision, centrifugal force dust removal equipment based on centrifugal force (cyclone, multi-cyclone), cleansing dust removal equipment based on humidification, filter dust removal equipment based on filtration, and electric dust removal equipment based on static electricity.

It is necessary to select types of dust removal equipment by sufficiently considering the types, particle diameters and physical properties of dust to be removed as well as generated amounts and concentrations of dust to be removed. The selection should be made by paying particular attention to the following points. Table 5-1 shows an overview of dust removal methods in accordance with particle diameters of dust.

1. Take full account of the particle diameter distribution.
2. If dust to be removed has a particle diameter of a few μm or smaller, select cleansing, filter or electric dust removal equipment.
3. If the use of water is restricted, avoid cleansing dust removal equipment. If there is no choice but to select cleansing dust removal equipment, select the water-circulation type.
4. If waste liquids from cleansing are either strongly acid or strongly alkaline, select the dry-type dust removal equipment to avoid problems related to sewage treatment and equipment corrosion.
5. Take waste liquid treatment into consideration when selecting cleansing dust removal equipment.
6. When coarse-particle dust generated in large quantities is to be removed, install inertia force dust removal equipment or centrifugal force dust removal equipment in front of other types of dust removal equipment.

Table 5-1 Case examples of dust particle diameters and corresponding dust removal methods

Dust particle diameter (μm)	Dust removal method
Less than 5	・Filtration ・Electrostatic precipitation
5 or more but less than 20	・Liquid scrubbing ・Filtration ・Electrostatic precipitation
20 or over	・Multi-cyclone dust shields ・Scrubber removal ・Filtration ・Electrostatic precipitation

② The workings of filter dust removal equipment

Though there are a variety of types of air cleaning equipment, the most suitable for removal of asbestos dust is filter dust removal equipment (bag filters). Filter dust removal equipment uses woven cloths, paper-based devices (bag filters) and air filters that use filled layers (glass fibers and sand, etc.) to filter and separate air contaminated with dust. Figures 5-4 and 5-5 outline the workings of bag filters. The separating diameter is varied depending on types of filter, with the separating diameter (particle diameter of removable dust) being about >5μm for rough cloth and about >1μm for extra fine cloth. The dust removal efficiency is 90-99%, while the pressure loss is 10-20hPa. The bag filter can remove fine dust with a particle diameter of around 1μm when a certain amount of dust is attached to the surface of the filter cloth to form a layer.

The widely-used type of bag filter (see the right-hand side of Figure 5-4) has multiple hanging cylindrical bags with a diameter of 15-50cm and length of 100-500cm inside and dust-containing air is fed from underneath into these bags. Previously, the vibration mechanism was adopted to brush off dust in the bags, but in recent years, the backwashing brush-off mechanism using pulse jet has become mainstream. If bag filters are structured to allow the replacement of filter cloths from inside the clean room from which post-filtration cleaned air is discharged, the replacement of ruptured filter cloths is easily done.

Filters are usually made of cotton, wool, glass fiber, polyvinylidene chloride fiber (saran), polyvinyl chloride fiber (Tebiron), polyvinyl fiber (vinylon), polyacrylonitrile fiber (Kanekalon, Orlon), polyamide fiber (nylon), and polyester fiber (tetoron).

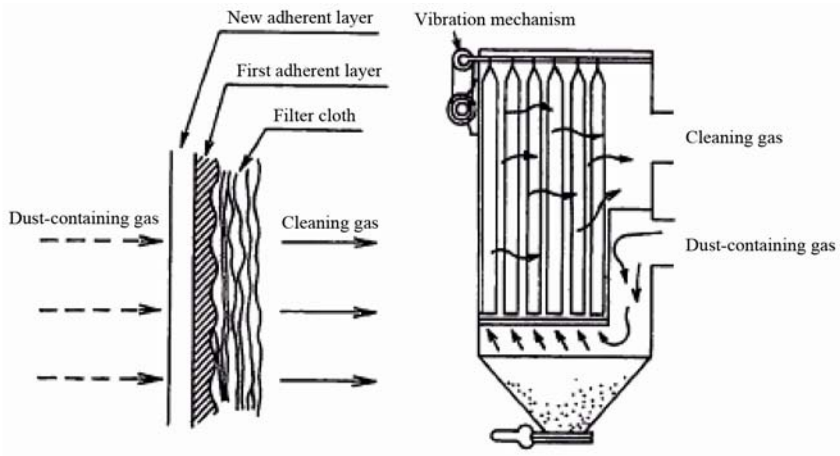


Figure 5-4 Overview of the workings of the bag filter

Source: Japan Industrial Safety and Health Association (2009), Text for Foremen for Asbestos-Related Work

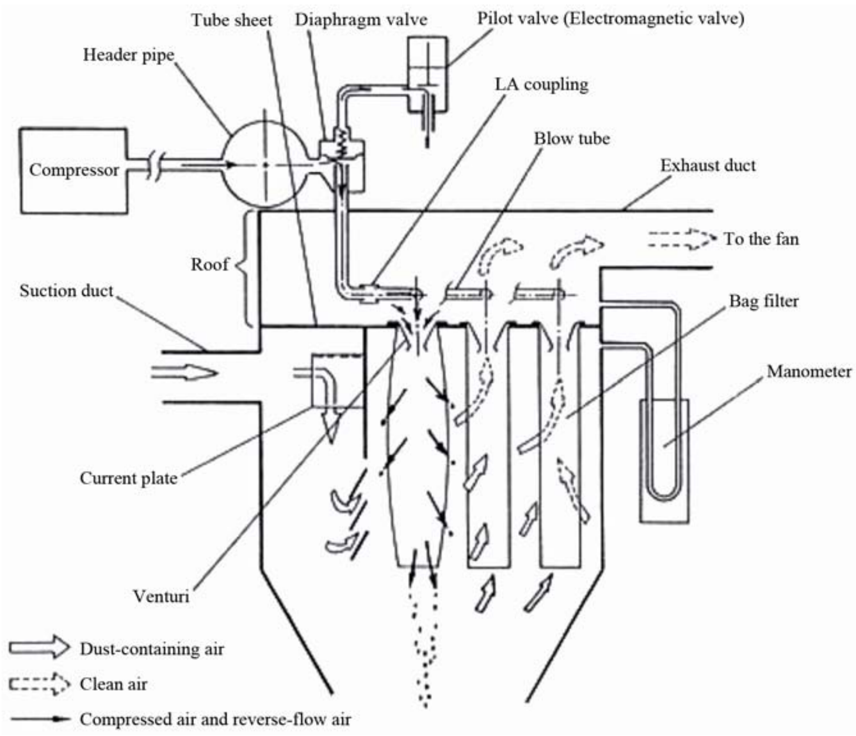


Figure 5-5 Overview of the workings of the pulse-jet bag filter

Source: Japan Industrial Safety and Health Association, Standard Design and Maintenance Management of Local Ventilation/Air Cleaning Equipment

5.2.2.4 Fans (Exhaust fans)

Fans serve as the power sources to suck in and discharge air, and are usually installed behind the dust removal equipment to prevent the wear of impellers.

5.2.2.5 Exhaust outlets

The exhaust outlet is an opening to discharge air sucked in, and it has to be installed outside.

5.2.3 Push-pull ventilation equipment

Push-pull ventilation equipment is composed of a blow-side hood (push hood) that blows in uniform air to capture emanating hazardous substances and the trap-side hood (pull hood) that sucks in air that captures hazardous substances within the trap surface. The ventilation equipment blows in slow and uniform blow-off air (push velocity) from the push hood, takes in hazardous substances dispersed in the air within the trap surface and sucks them in from the trap-side hood (pull velocity).

The equipment is composed of hoods, ducts, dust removal equipment, fans, exhaust fans and exhaust outlets, etc. The push-pull ventilation equipment can be generally classified into closed push-pull ventilation equipment and open push-pull ventilation equipment. For the open-type ventilation equipment, the ventilation area refers to the entire area where a uniform air current is generated. Figure 5-6 shows a representative example of push-pull ventilation equipment.

The notification of the Ministry of Health, Labour and Welfare has it that for push-pull ventilation equipment the trap surface in a direction perpendicular to the flow of air current should be divided into at least six portions of equal area with the wind velocity controlled such that the capture velocity at each intersection point is at at least 0.2 m/s and within ±50% of the average capture velocity. This capture velocity is with no influence from external airflow, and therefore it is necessary to set the capture velocity at higher levels, depending on the dispersal conditions of hazardous substances and the conditions of the external airflow.

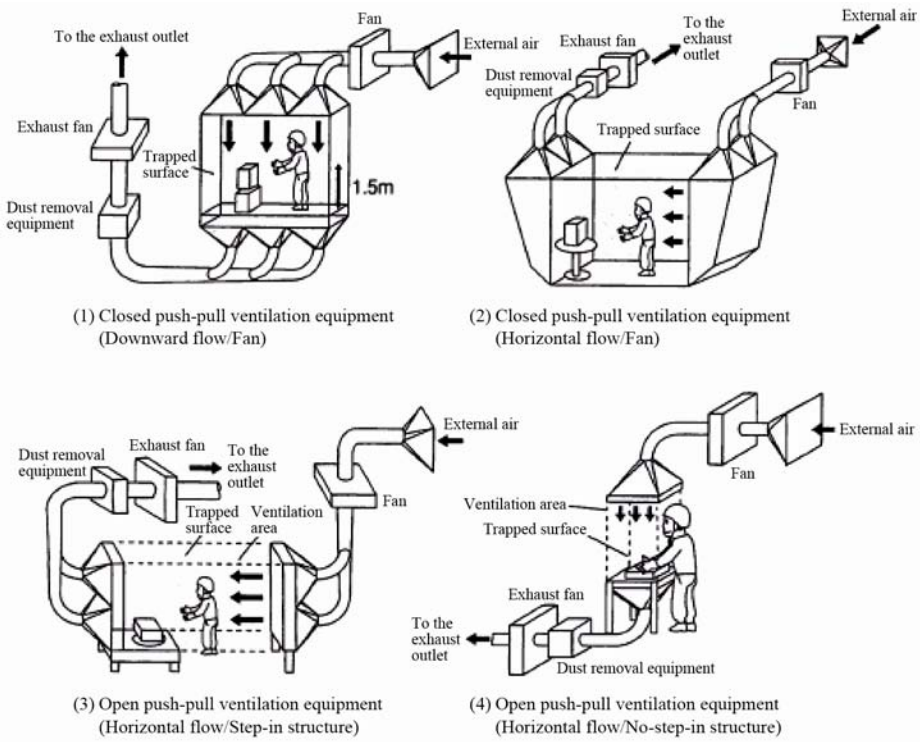


Figure 5-6 Example of the push-pull ventilation equipment

Source: Japan Industrial Safety and Health Association (2009), Text for Foremen for Asbestos-Related Work

Push-pull ventilation equipment should be installed paying particular attention to the following matters (see Figure 5-7):

1. Install the current plate to ensure that air from the blowoff hood is blown out at the same velocity from any part of the hood opening.
2. Ensure that there is no swirling, turbulence or stagnation in the flow of air between the blower hood and the suction hood.
3. Ensure that all the air blown out is sucked into the suction hood.
4. As the ventilation equipment causes the convolutional turbulence of air, it is not suitable in cases where workers operate inside.

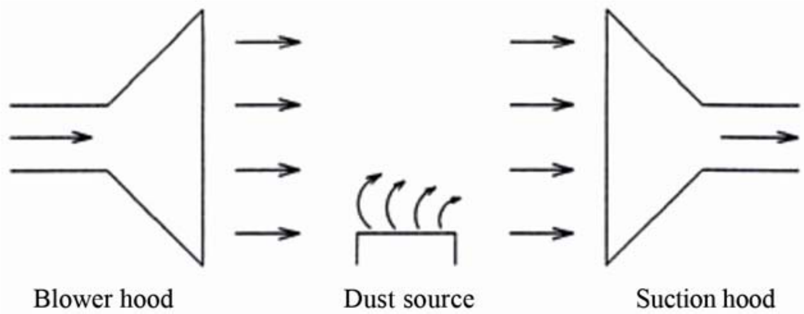


Figure 5-7 Push-pull ventilation equipment

Source: Japan Industrial Safety and Health Association, Standard Design and Maintenance Management of Local Ventilation/Air Cleaning Equipment

5.3 Checkups of Local Ventilation Equipment and Other Facilities

In the removal of contaminated substances discharged from the source of generation, if they are released into the external air without installing air cleaning equipment (dust removal equipment) in the local ventilation equipment, it could cause air pollution in the vicinity and wider areas and bring health hazards to many residents. Therefore, the maintenance of equipment for pollutant removal in the local ventilation equipment within manufacturing plants would constitute important countermeasures against air pollution.

In Japan, the Industrial Safety and Health Act calls for annual voluntary inspections of the local ventilation equipment, push-pull ventilation equipment and dust removal equipment, etc. Items to be checked include hoods (type, control velocity and exhaust air volume, etc.), designed value, specifications of fans installed, etc. and dust removal equipment. These inspections are required by law. On tops of these measures, it is necessary to carry out voluntary checkups at a frequency of once a week or so to confirm that the local ventilation equipment and other equipment are working effectively. Voluntary checkups should cover hoods, ducts and the dust removal equipment. It is desirable to make these checkups on a routine basis with the aid of arbitrary checkup record forms. If these equipment and devices fail to work effectively, it could not only contaminate workplaces but also cause air pollution.

The fuming method with the use of smoke testers is the easiest and most convenient way to check the suction of hoods. The hot-wire anemometer is used to examine the control velocity. How checkups should be conducted is outlined below:

5.3.1 Checkup items for hoods, etc.

1. Are there any obstructions near the hood?
2. Is the exhaust air volume from fans sufficient?

3. Is the distance between the source of dust and the hood opening too long?
4. Is the external air having any influence?
5. Is the divergence speed of hazardous substances too fast to disperse them out of the control area of the hood? Is the hood opening positioned adequately toward the direction of dispersal?
6. Is dust accumulating within the ducts, exhaust fans or the dust removal equipment?
7. Is air flowing in or out due to leakages of ducts?
8. Is the damper adjusted adequately?
9. Are the air volume and total pressure of exhaust fans sufficient?

5.3.2 Checkup items for ducts

1. Are there any breakage failures (wear, holes due to corrosion, damage) in the ducts?
2. Are there any loose connections (flange faces, soldered portions)?
3. Is dust accumulating within the ducts (muffled sounds in response to tapping on the ducts indicate a possible accumulation of dust)?
4. Measure the wind velocity within the ducts as necessary.

5.3.3 Checkup items for the dust removal equipment (bag filters)

1. Is there any breakage in the filtering media?
2. Are the fixing portions of the filtering media loose or disengaged?
3. Is air leaking from the dust chamber and/or the slots?
4. Is dust filling up the dust chamber?
5. Are the filtering media clogged?

5.4 Work Management Approaches

The Ordinance on Prevention of Health Impairment due to Asbestos calls for the use of personal protective equipment, use of protective clothes/work clothes, installation of local exhaust ventilation equipment, wetting of work, special educational courses for workers to be engaged in demolition work, management of break rooms, cleanup of workplaces, a ban on smoking, establishment of depositories for asbestos waste, measurement of the working environment (except for demolition and renovation work), and medical examinations, etc. These measures are outlined below.

5.4.1 Respiratory protective equipment

The use of respiratory protective equipment is one of the effective ways to protect workers from exposure to the hazardous working environment, but it is necessary to select adequate protective equipment. General criteria for the selection of protective equipment are shown below:

1. The equipment should have effective protective performance against the hazardous substances workers have to deal with.
2. The equipment should be easy to operate and use.
3. The equipment should not hamper workability.
4. Select the protective equipment certified by the national government.

For respiratory protective equipment against asbestos, the respiratory protective equipment against dust is effective. The equipment can be broadly divided into the filtering respirator and the atmosphere-supplying (supplied-air) respirator. The filtering respirator can remove dust in the air, but it cannot be used in the working environment with an oxygen concentration of less than 18% as it does not have the function of supplying oxygen.

Concerning asbestos-handling work, the Ordinance on Prevention of Health Impairment due to Asbestos requires the installation of effective protective equipment, the provision of protective equipment in the same or greater number than the number of workers engaged in the work at the same time, and efforts to keep such protective equipment clean and store them in isolation. However, as the manufacture, importation, transfer, provision and use of products containing asbestos of over 0.1% by weight have been banned in Japan, asbestos-containing building materials and industrial products are no longer being manufactured in the country. Thus, asbestos-handling work now is limited to specialized operations, such as removal of asbestos-containing spray-on materials used in the past, removal of asbestos-containing refractory covering materials, heat insulation materials and lagging materials, removal of asbestos-containing slates and other molded products, dismantling of ships, and harmless treatment of asbestos-containing products.

In Japan, the exposure to asbestos is classified into Levels 1-3 in accordance with the extent of dispersal. Specifically, Level-1 exposure involves work amid a significantly high extent of asbestos dust dispersal, such as the handling of spray-on asbestos, Level-2 exposure involves work amid a high extent of asbestos dust dispersal, such as the handling of refractory covering materials, heat insulation materials and lagging materials, and Level-3 exposure involves work amid a low extent of asbestos dust dispersal, such as the handling of molded products like slates and acoustic boards.

Employers have been advised to select respiratory protective equipment under certain criteria by taking into account the types of asbestos-containing products and the extent of asbestos dust dispersal. The relationships between asbestos-handling work and employable respirators are shown in Figures 5-2 and 5-3. Since removal of asbestos-containing spray-on materials and enclosure work such as the containment of asbestos-containing spray-on products and the fitting of hanging bolts are work amid a significantly high extent of asbestos dust dispersal, the Ordinance on Prevention of Health Impairment due to Asbestos requires workers to use respirators equipped with electric fans or respirators with equivalent performance (respirators in Category 1), as well as isolation measures to prevent the dispersal of asbestos dust into the surrounding environment. For work to handle refractory covering materials, heat insulation materials and lagging materials amid a high extent of asbestos dust dispersal, the guidance has been given for the use of respirators in Category 2 or Category 3. However, for the removal of refractory covering materials, heat insulation materials and lagging materials involving cutting, boring and grinding operations (limited to operations with a significantly high extent of asbestos dust dispersal), the Ordinance on Prevention of Health Impairment due to Asbestos requires such removal work to be done in isolation. Thus, it is deemed desirable to use respirators in Category 1 for such work, as with the case of work to remove asbestos-containing spray-on materials. For work to remove molded products such as slates and acoustic boards, positioned as work amid a low extent of asbestos dust dispersal, it has been advised to use respirators in Category 3 or higher. Japan requires the use of respirators with a trapping efficiency of 95% or higher certified in the national assay. The use of disposable masks and other makeshift masks is not permitted.

Table 5-2 Relationships between asbestos-removing work and employable respirators

Type of work	Category of employable respirators			
	Category 1	Category 2	Category 3	Category 4
Removal of asbestos-containing spray-on materials	○			
Enclosure work such as the containment of asbestos-containing spray-on products and the fitting of hanging bolts	○			
Enclosure work for asbestos-containing spray-on materials	○	○		
Removal of refractory covering materials, heat insulation materials and lagging materials involving cutting, boring and grinding operations (limited to operations with a significantly high extent of asbestos dust dispersal)	○	○		
Work to contain and enclose refractory covering materials, heat insulation materials and lagging materials other than the above	○	○	○	
Removal of molded products such as slates and acoustic boards	○	○	○	
Cleanup and other work	○	○	○	○

Table 5-3 Categories of respirators

Category	Type of respirator
Category 1	・Respirator equipped with an electric fan ・Pressure-demand airline respirator ・Air-supplied respirator ・Self-contained breathing apparatus (air-breathing apparatus, etc.)
Category 2	・Full-face replacement-type dust respirator (trapping efficiency of 99.9% or higher)
Category 3	・Half-face replacement-type dust respirator (trapping efficiency of 99.9% or higher)
Category 4	・Replacement-type dust respirator (trapping efficiency of 95.0% or higher)

In the use of a respirator, it is important that the face of the respirator is firmly attached to the face of a wearing worker. Since it has a lot to do with the size of the wearer’s face, nose, cheeks and forehead, it is necessary to select a respirator that matches the facial surface of the wearing worker. As ways to measure the contact with the facial surface, there are fitting tests by negative-pressure and positive-pressure methods. It is necessary to measure the contact with these methods.

In Japan, employers are required to provide special educational courses on how to use personal protective equipment to workers who engage in work to demolish/renovate, contain or enclose asbestos-containing buildings, industrial products and ships, etc.

5.4.2 Protective clothes/work clothes

Protective clothes are used for work amid a significantly high extent of asbestos dust dispersal. As for the performance of protective clothes used for the work to handle asbestos dust, it is desirable to wear the sealed protective clothing for use against fine particles. Cellular materials that allow air to pass through easily but are nonporous for asbestos dust are used in the sealed protective clothing for use against fine particles for workers who operate under high temperatures during summer. The sealed protective clothing has good contact with respiratory protective equipment, particularly full-face respirators, and as such is quite effective in preventing exposure to asbestos. There also is the disposable type of sealed protective clothing that can be discarded after each use.

Work clothes are used in asbestos-handling work that does not require protective clothes. Adequate work clothes are those that have a reduced number of pockets and it should be easy to brush off dust from those clothes. Each time the work is finished, it is necessary to remove asbestos dust from contaminated work clothes with the use of a vacuum cleaner equipped with a HEPA filter. Workers are prohibited from moving to other work sites or going home with contaminated clothes on out of concern for exposure to asbestos at home.

Employers are also required to have workers use other protective equipment, such as eye protectors, gloves and shoe covers as necessary. As with any protective equipment, it is absolutely necessary to confirm before use that protective equipment has no breakage or damage.

5.4.3 Other work management

5.4.3.1 Wetting

Wetting is a time-tested and effective method to suppress the dispersal of asbestos dust. The wetting approach includes the watering method that uses a shower, spray or sprinkler, the atomizer method that uses fine water droplets sprayed into the air to capture airborne dust for sedimentation and the moisturization method to suppress the dispersal of dust by pre-moisturizing raw materials that are the sources of dust.

5.4.3.2 Cleanup

At indoor workplaces where dust-related work is done, the secondary emanation of accumulated dust could have an adverse impact on the working environment. Particularly because asbestos dust induces extremely serious health impairment, it is quite important to contain the secondary emanation. In order to suppress the secondary emanation of asbestos dust, it is important to clean up workplaces by wetting and other methods that minimize the dispersal of dust. The workplace cleanup should be done at least once a day, in principle. Accumulated dust that cannot be removed in routine cleanup must be periodically swept out once a month.

Dust may be wiped off by mopping, but it is necessary to clean it out with the use of vacuum cleaners equipped with a HEPA filter. The cleaned dust must be double-bagged and stored in the primary depository of asbestos waste.

5.4.3.3. Management of break facilities

Employers have to establish break facilities away from asbestos dust-related work areas when they have their workers engaged in dust-related work constantly. As precautions for the use of break facilities, employers should furnish implements for removal of dust attached to work caps, work clothes and work shoes and have workers acquire the habit of removing asbestos dust by using these implements without fail before taking a break.

Appendix VI Measures to Prevent Asbestos Dispersal into the General Environment

6.1 Measures to Prevent Asbestos Dispersal from Facilities/Processes

The dispersal of asbestos into the general environment include the dispersal from discharge outlets of dust-removing devices installed at manufacturing plants of asbestos-containing products, dispersal from cutting and other operations at sites handling asbestos-containing building materials, dispersal from the demolition of buildings that used asbestos-containing building materials, and dispersal from the disposal of asbestos waste. Measures to prevent each type of asbestos dispersal are described below:

6.1.1 Measures to prevent dispersal from asbestos-containing product manufacturing plants

As mentioned in Appendix V, asbestos dust generated at buildings manufacturing asbestos-containing products is discharged through local ventilation equipment, dust collected is filtered by dust removal equipment and clean air is released into the atmosphere. Since the filtration capacity of dust-removing equipment influences the concentration of the number of asbestos fibers released into the atmosphere, it is vitally important to constantly maintain and manage the equipment with full heed given to cloth used and the filtration velocity (1m/min as a target). It is desirable to load a high efficiency particulate air (HEPA) filter behind the dust-removing equipment.

6.1.2 Measures to prevent dispersal from sites handling asbestos-containing building materials

At sites handling asbestos-containing building materials, effective dispersal prevention measures would include reduced cutting of asbestos-containing building materials or, when cutting is still necessary, the use of cutters and other manually-operated tools instead of such things as circular saws. Where possible, water-based humidification helps the prevention of dispersal. It is desirable to seal off the powder, including asbestos, generated by cutting operations in a strong plastic bag.

6.1.3 Measures to prevent dispersal from demolition of buildings that used asbestos-containing building materials

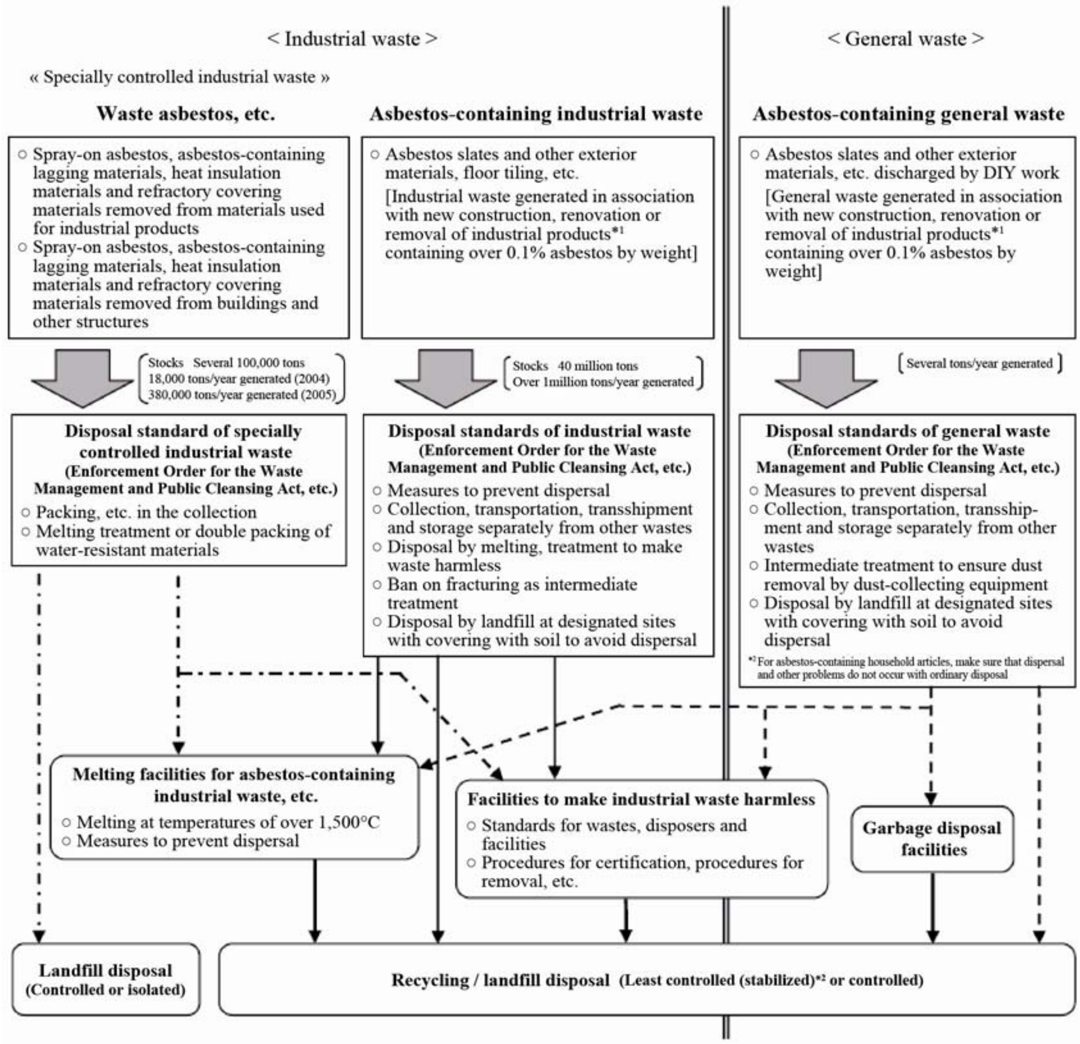
At sites of the demolition of buildings, it is desirable to break down asbestos-containing building materials manually. During demolition operations, take steps to prevent the dispersal of asbestos dust, including the sprinkling of water.

6.1.4 Measures to prevent dispersal from disposal of asbestos waste

In handling the bagged asbestos-containing waste, a few things to keep in mind include paying close attention to possible tears in a bag. In handling bare asbestos-containing waste, humidification measures should help prevent the dispersal of asbestos dust. If possible, it is desirable to add specialized agents (such as surface-activating agents) to prevent the dispersal.

Appendix VII Methods to Dispose of Asbestos Waste

A flow chart of the disposal of asbestos waste in Japan below shows methods of disposing of waste asbestos, etc. and asbestos-containing waste.



*1: "Industrial products" in relation to asbestos-containing industrial waste and asbestos-containing general waste include "buildings and other structures."
*2: Waste that falls into the category of industrial waste prescribed by Ministry of the Environment Notice No. 105, 2006 (industrial waste designated by the Minister of the Environment as industrial sate of stabilized type listed in Article 6, Paragraph 1, Item 3-a of the Enforcement Order for the Waste Management and Public Cleansing Act) can be disposed at least controlled landfill sites.

Figure 7-1 Flow of disposal of waste asbestos, etc. or asbestos-containing waste

Source: Manual for Disposal of Asbestos-Containing Waste, Etc. (Second Version),
Ministry of the Environment, 2011

7.1 Regulatory Disposal Standards of Asbestos-Containing Waste, etc.

Asbestos-containing waste, etc. are regulated by the Waste Management and Cleansing Act. As reference for an overview of the disposal of waste asbestos, etc. and asbestos-containing waste, Manual for Disposal of Asbestos-Containing Waste, Etc., Ministry of the Environment, 2007, and Manual for Disposal of Asbestos-Containing Waste, Etc. (Second Version), Ministry of the Environment, 2011, are shown below.

7.1.1 Waste asbestos, etc.

7.1.1.1 Storage at sites of discharge – Prevention of dispersal

・In landfill disposal, solidify waste asbestos, etc., stabilize them with agents or take similar measures in advance before taking necessary measures, such as double-packing using water-resistant materials, pending transportation.

・In intermediate treatment, humidify wet asbestos, etc. with water or dust-prevention agents, etc. in advance before packing them using water-resistant materials, pending transportation.

・For water-resistant materials, use plastic bags of adequate strength or some other things that have secure containers and do not break easily. For plastic bags, it is desirable that they are at least 0.15mm thick.

7.1.1.2 Collection and transportation

・Collection and transportation should be undertaken in a manner that does not disperse waste asbestos, etc.

・Waste asbestos, etc. should be collected and transported separately from other wastes, etc. to avoid any mixing.

・Loading of plastic bags, etc. should be carried out manually, in principle. When loading is done by heavy equipment, use flexible container bags and pallets so that heavy equipment does not directly touch plastic bags, etc.

・In order to minimize the risk of re-dispersal, do not store waste asbestos, etc. in the process of collection and transportation except storage for their transshipments.

7.1.1.3 Intermediate treatment

・Except for landfill disposal of waste asbestos, etc. as specially controlled industrial waste, intermediate treatment of waste asbestos, etc. should be undertaken by melting at melting facilities that meet both structural criteria and management criteria or harmless treatment conducted by those certified for harmless treatment technology.

・Waste asbestos, etc., after intermediate treatment, may be collected/transported, recycled and disposed of as ordinary industrial waste (slag).

7.1.1.4 Final disposal

・Sea-dumping disposal of waste asbestos, etc. is not permitted.

・In order to avoid dispersal into the air, solidify waste asbestos, etc., stabilize them with agents or take similar measures in advance before taking necessary measures, such as double-packing using water-resistant materials, for landfill disposal.

・Landfill disposal of waste asbestos, etc. should be made at specified areas of controlled final disposal sites in a manner that keeps them from dispersing. Take measures to prevent them from dispersing or leaking out of landfill sites, such as covering the surface with earth and sand.

・Final disposal site managers should permanently keep records on landfill amounts and landfill locations of waste asbestos, etc.

7.1.2 Asbestos-containing waste

7.1.2.1 Storage at sites of discharge – Prevention of dispersal

・Asbestos-containing general waste discharged from households should be put into double bags to prevent dispersal, pending transportation.

・Businesses that discharge asbestos-containing industrial waste should take the following measures, pending transportation:

1. Stack it up in an orderly manner so that it does not deform or fracture under load.
2. Take dispersal-prevention measures, such as covering it with sheets or putting it in bags.

7.1.2.2 Collection and transportation

・Asbestos-containing waste should be collected and transported in a manner that does not fracture it and also separately from other wastes to avoid any mixing.

・Load or unload asbestos-containing waste in its original shape in an orderly manner so that it does not deform or fracture in order to prevent dispersal due to contracts during collection/transportation or under load.

・Take dispersal-prevention measures, such as covering it with sheets or putting it in flexible container bags.

・Do not put asbestos-containing waste into packer vehicles or press packer vehicles to avoid fracturing it.

・When making transshipments of asbestos-containing waste (including storage for transshipments), take necessary measures to avoid its mixing with other wastes, such as setting up partitions at transshipment locations.

7.1.2.3 Intermediate treatment

① Asbestos-containing general waste

・Intermediate treatment of asbestos-containing general waste should be undertaken by melting at melting facilities that meet both structural criteria and management criteria, by treatment to render it harmless conducted by those certified for harmless treatment technology, or by crushing and incineration in mixture with other general wastes.

② Asbestos-containing industrial waste

・Intermediate treatment of asbestos-containing industrial waste should be undertaken by melting at melting facilities that meet both structural criteria and management criteria or by treatment to render it harmless conducted by those certified for harmless treatment technology.

・Asbestos-containing industrial waste, after melting treatment/harmless treatment, may be collected/transported, recycled and disposed of as other industrial waste.

7.1.2.4 Final disposal

・Final disposal of asbestos-containing waste should be made by landfill disposal. Sea-dumping disposal is not permitted.

・Landfill disposal of asbestos-containing waste should be made at specified areas of final disposal sites in a manner that keeps it from dispersing. Take measures to prevent it from dispersing or leaking out of landfill sites, such as covering the surface with earth and sand.

・Final disposal site managers should permanently keep records on landfill amounts and landfill locations of asbestos-containing waste.

7.1.3 Melting treatment

In melting treatment in the intermediate treatment above, adequate care must be taken to ensure that the temperature in a furnace is sufficiently high to melt asbestos and that asbestos is not dispersed into the atmosphere in the process of melting treatment.

Melting facilities must meet technical standards requiring that they can melt asbestos-containing waste, etc. at temperatures of over 1,500℃, that they have equipment that adjust an amount of air and other equipment to maintain temperatures within a melting furnace at adequate levels, and that they have exhaust-gas treatment equipment that can prevent gases discharged from facilities' chimneys from causing problems in the preservation of the living environment. There are eight certified melting treatment facilities across Japan.

Reference: Material for the Study Committee on Standards for Landfill Disposal of Waste Asbestos, Etc., Ministry of the Environment, June 8, 2010

7.2 Special System for Certification of Harmless Treatment Technologies

7.2.1 Background to the establishment of the system

At present, ways to dispose of waste containing asbestos are largely limited to landfills at final disposal sites. With emissions of waste containing asbestos expected to increase going ahead, accumulations of large quantities of wastes containing asbestos and frequent improper disposal of them are feared to exert serious adverse effects on human health or the living environment. Under these circumstances, as it is essential to secure a new conduit for disposal of asbestos-containing waste in the form of harmless treatment, Japan has established the harmless treatment certification system, under which those certified by the Minister of the Environment do not need to obtain authorization to engage in waste disposal businesses and establish disposal facilities.

While there are several methods of harmless treatment, they are essentially new technologies based on the combination of different conditions, including types of facilities, furnace temperatures and the mixture fractions of inputs. More specifically, the certification system covers the disposal of asbestos with sophisticated technologies for which the safety needs to be confirmed by each facility and disposal method, including chemical treatment and a method to melt asbestos at temperatures lower than the asbestos melting point of 1,500℃.

As of May 2010, two applications have been certified, with another under examination.

References: Material for the Study Committee on Standards for Landfill Disposal of Waste Asbestos, Etc., Ministry of the Environment, June 8, 2010; The Harmless Treatment Certification System – A Guide for Applications for the Certification System for Harmless Treatment of Asbestos-Containing Waste (First Version), Ministry of the Environment.

7.2.2 Standards for harmless treatment

The standards for harmless treatment of waste asbestos, etc. and asbestos-containing waste are as follows:

1. Asbestos is not detected from waste after harmless treatment in the analysis under the dispersion staining method using a phase-contrast microscope and the X-ray diffraction analysis method using an X-ray diffraction analysis device; and
2. When it is difficult to determine the presence or absence of asbestos, verify it by adopting an analysis method that uses a transmission electron microscope.

References: Manual for Disposal of Asbestos-Containing Waste, Etc. (Second Version), Ministry of the Environment, 2011

Appendix VIII Methods to Measure Asbestos Concentrations in Japan

8.1 Methods to Measure Asbestos Concentrations in Japan

Methods to measure asbestos concentrations in Japan include the working environment measurement conducted under laws and regulations in order to grasp working environment management conditions at asbestos-handling workplaces and the measurement of individual exposure concentration and the airborne environment conducted at the discretion of employers for management of asbestos-handling workers. There also are asbestos concentration measurements in association with the demolition and renovation of buildings and other structures in which asbestos-containing building materials are used.

The working environment measurement to measure asbestos concentrations in the working environment, prescribed under the Industrial Safety and Health Act, is conducted in accordance with the working environment measurement standards and the measurement results are assessed on the basis of the working environment evaluation standards. The administrative level ($0.15f/cm^3$) set by the Ministry of Health, Labour and Welfare serves as the criteria for judgment in the evaluation.

The individual exposure concentration measurement at the discretion of employers is conducted with methods such as the analysis manual #7400 of the National Institute for Occupational Safety and Health (NIOSH) of the United States, and the measurement results are assessed on the basis of threshold limit values (TLVs) of the American Conference of Governmental Industrial Hygienists (ACGIH) and acceptable concentrations set by the Japan Society for Occupational Health (JSOH).

In either measurement method, a cellulose ester white membrane filter is used to collect asbestos dust with the filtration method and the filter is treated with the acetone/tricetin filter mounting method. Using a phase-contrast microscope, the number of asbestos fibers that have fibrous particles with a length of 5μm or more, a width of less than 3μm and an aspect ratio of 3 or larger are counted to calculate the asbestos concentration against a quantity of air collected.

8.2 Methods to Measure Asbestos Concentrations in Ambient Air in Japan

The methods to measure asbestos concentrations in ambient air are described in the Asbestos Monitoring Manual (Version 4.0) (Ministry of the Environment, 2010). The contents of the manual are outlined below.

8.3 Overview

8.3.1 Measurement of Asbestos

The Asbestos Monitoring Manual has been prepared as a technical guideline for the measurement of the concentration of asbestos fibers in ambient air. Asbestos fibers are six types of fibrous minerals: the serpentine family of chrysotile (white asbestos) and the amphibole family of amosite (brown asbestos), crocidolite (blue asbestos), tremolite, actinolite and anthophyllite. Each type of asbestos can be identified by its physical properties, such as fibrous form and refractive index, chemical composition and crystal structure.

Given that sites of the demolition of building and other structures are the main sources of asbestos fibers in Japan, this manual presents the two different basic methods to measure the concentration of asbestos fibers for measurement locations other than demolition sites (hereinafter referred to as the "general environment") and for demolition sites.

8.3.1.1 General environment

Asbestos concentrations in the general environment have been decreasing in recent years, generally standing at the levels less than 0.5f/L in terms of the total number of fibers. However, as sites of the demolition of buildings in which not only chrysotile but also such other asbestos as amosite and crocidolite are most likely to have been used become the main sources of asbestos fibers going forward, in order to cover all types of asbestos, including chrysotile, in the general environment as well, the total number of asbestos fibers should be measured first with phase-contrast microscopy and, with samples that show somewhat higher values (over 1f/L as a rough indication), identify and count asbestos fibers by an analytical scanning electron microscope, etc., in place of the conventional method to count the number of asbestos fibers with biological microscopy and then find the difference with the number counted with phase-contrast microscopy. In some cases, it is recommended that an electron microscope is used from the beginning to count the number of asbestos fibers with similar sizes to be counted with phase-contrast microscopy.

8.3.1.2 Demolition sites

In addition to the measurement methods in the general environment, for demolition sites where expeditious measurements are required, phase-contrast/polarizing microscopy, field-portable analytical scanning electron microscopy and fluorescent microscopy have been introduced as methods for the on-site identification and counting of asbestos fibers. Further, though not a measurement method that can identify asbestos, the measurement by an automatic fibrous particle measuring instrument is also shown as a method to roughly grasp the total number of asbestos fibers.

8.3.2 Measurement plan

8.3.2.1 Measurement procedures

The concentration measurement in the general environment should be conducted with the method shown in Figure 8-3 (XIII-9), while the concentration measurement at demolition sites should be conducted with the method shown in Figure 8-4 (XIII-12). The method shown in Figure 8-5 (XIII-13) should be adopted in cases the status of air pollution by asbestos needed to be measured immediately, given that the work to remove asbestos at demolition sites is usually completed in several hours.

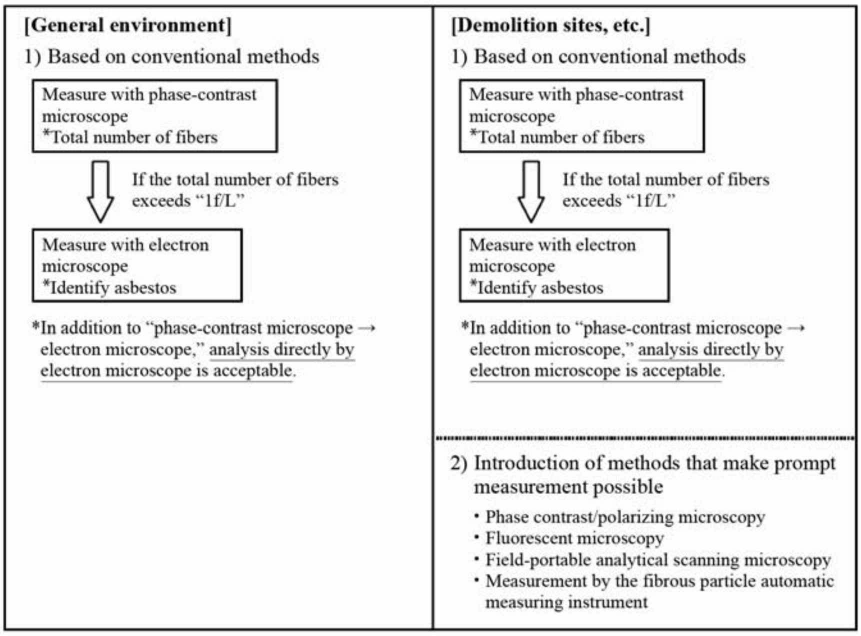
Details of measurement methods in the general environment and those for demolition sites are described in sections 8.4 and 8.5, respectively.

8.3.2.2 Preliminary survey

In measuring the concentration of asbestos fibers in ambient air, collect the following information on the environment surrounding measurement locations as much as possible and make use of it in developing a measurement plan.

① Information on the measurement of samples

1. Utilization of areas surrounding measurement points and sources of asbestos in the vicinity;
2. For work sites for the demolition, renovation and repair of buildings and industrial products (hereinafter referred to as "demolition sites of buildings and other structures"), the number of years after the construction of buildings, types of asbestos fibers contained in building materials, and the presence of gypsum boards, etc.;
3. Types of asbestos discarded in areas around waste disposal sites;
4. Demolition and renovation of buildings (including residential houses) in areas around measurement points in residential areas; and
5. Past asbestos measurement results at measurement points.



8.3.2.3 Development of a measurement plan

Determine the measurement locations, the sample collection schedule and the sampling methods on the basis of the information gathered in advance (see 8.3.2.2). Measurement locations are broadly selected on the basis of the categorization of measurement points and data on the predominant wind direction. The sample collection schedule is set to include hours when high levels of airborne asbestos fibers can be expected in cases where they fluctuate widely like the volume of traffic or in cases of measurement around facilities that restrict working hours.

8.4 Methods to measure asbestos in the general environment

8.4.1 Sampling methods

8.4.1.1 Selection of measurement locations and measurement points

① Measurement points

Measurement points are described in Table 8-1.

Table 8-1 Categorization of measurement points

Categorization	Facilities and areas
General environment	① The vicinity of former asbestos product manufacturing plants ② Serpentine deposits ③ Areas with former plants handling asbestos ④ The vicinity of waste disposal facilities ⑤ Areas along expressways ⑥ Areas along highways
General environment (Background areas)	⑦ Inland mountainous areas ⑧ Remote islands ⑨ Residential areas ⑩ Commercial and industrial areas ⑪ Agricultural areas

② Selection of measurement points

Measurement points are selected by considering the following matters:

A. General environment

1. The vicinity of former asbestos product manufacturing plants

   Two sites on the leeward side of the predominant wind direction near the border of the premises of a former manufacturing plant that had a facility to generate specified dust, with the distance between these two sites being 100-200m, in principle. The filter holder is positioned toward the former manufacturing plant.

2. Serpentine deposits

Two sites in the residential area closest to the serpentine deposits are selected. The distance between these two sites should be in the range of 100-300m. The filter holder should be positioned toward the serpentine deposits.

3. Areas with former plants handling asbestos

Two sites are selected at least 50m away from the edge of the road in the area where small-scale asbestos product manufacturing places existed. There should be no direct influence of any particular fixed source of asbestos emissions in the field of measurement.

4. The vicinity of waste disposal facilities

Two sites on the leeward side of the predominant wind direction near the border of the premises of the waste disposal facility, with the distance between these sites being 100-200m, in principle. The filter holder should be positioned toward the waste disposal facility. Samples are collected by taking into account the facility's operating days.

5. Areas along expressways 6. Areas along highways

Two sites on the leeside of the predominant wind direction about 20m away in a vertical direction from the edge of the road. In cases where it is impractical to locate the measurement point in a vertical direction from the road or the leeside of the road, the measurement points can be adjusted appropriately. The filter holder should be positioned toward the road.

B. General environment (Background areas)

7. Inland mountainous areas 8. Remote islands

Two sites that are representative of the quality of the ambient air of the area without any obstacles nearby are selected. The distance between these two sites is in the range of 10m to several 100m. There should be no major obstacles in the field of sampling. The filter holder should be positioned toward the windward side of the predominant wind direction.

9. Residential areas 10. Commercial and industrial areas 11. Agricultural areas

Two sites that are representative of the quality of the ambient air of the area and at least 50m away from the edge of the main road are selected. The distance between these two sites should be in the range of 100-200m. There should be no direct influence of any particular fixed source of asbestos emissions in the field of measurement (points 50m, or if possible, at least 100m away from the plant). The filter holder should be positioned toward the closest major road.

8.4.1.2 Sampling equipment and instruments

① Filters

A cellulose ester round white membrane filter with a diameter of 47mm and average pore diameter of 0.8μm is used for asbestos air sampling. The use of a membrane filter printed with a grid should be avoided, as it may obscure the field of view during the fiber count.

Of the A-SEM methods, when the concentration measurement is conducted with the polycarbonate filter technique, a polycarbonate filter with a diameter of 47mm and average pore diameter of 0.8μm is used. The filter should be coated with gold or carbon in order to reduce electrostatic charge.

② Filter holders

A filter with an effective filter paper diameter of 35mm is loaded on an open-faced filter holder with a round filter paper diameter of 47mm. The filter holder should be equipped with a cowl in order to prevent the attachment of water droplets and stabilize the air flow of the sample collection side. The appropriate cowl length is 0.5-2.5 times the effective filter paper diameter (see Figure 8-1).

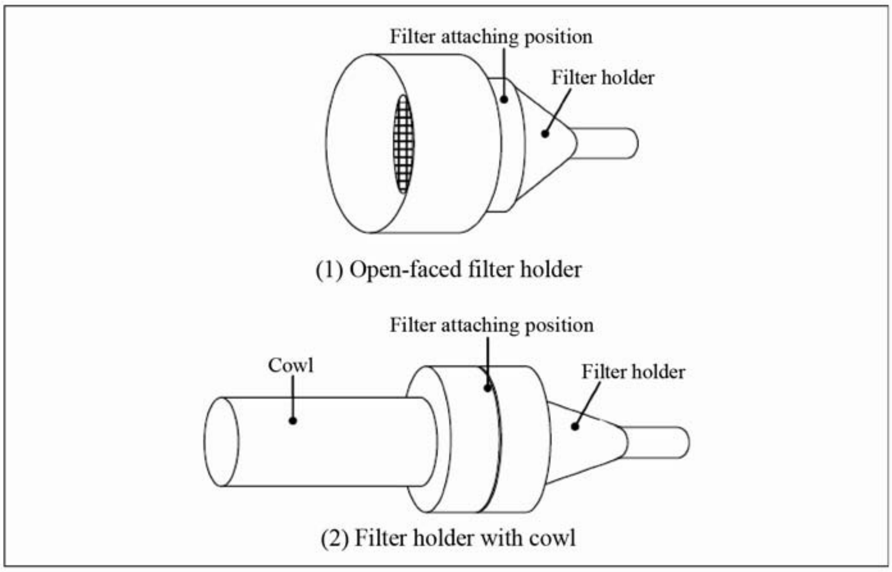


Figure 8-1 Filter holder

③ Suction pumps and flowmeters

The suction pump should be electrically powered and capable of producing a constant suction air flow (free from pulsation) prescribed in 8.4.1.3② over the prescribed sample collection hours. The flowmeter should be calibrated with a variable area flowmeter or a standard flowmeter. It is also permissible to use an automatic measuring instrument that combines a mass flow controller and a suction pump, but it is desirable to use a mass flow controller.

④ Connecting tubing

Connecting tubing (rubber hose) provides the link between the filter holder, the flowmeter and the suction pump. The capacity of the tubing should be sufficient to withstand the suction pressure over the sample collection hours. Testing the joints for leakage prior to each use is essential.

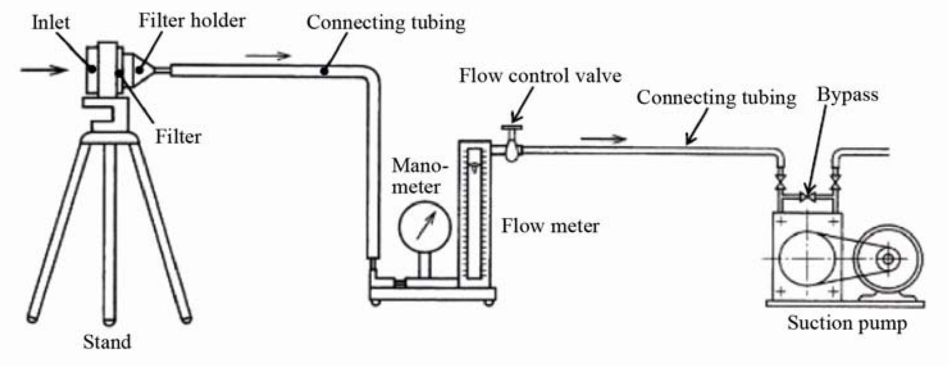
⑤ Filter storage container and storage box

A dedicated container is used for storing and transporting filters after the collection of samples. After the air sampling, the sample filter, dust side up, is carefully placed inside the container. A wooden storage box is recommended for storing the container in order to reduce the electrostatic charge during the storage and transportation.

It is also convenient to use a filter holder equipped with a tight-seal cap, in which the sample is collected and subsequently sealed with the cap for transportation. At the laboratory, the filter is removed from its holder for analysis.

⑥ Structure of air sampling devices

Figure 8-2 illustrates an example of an air sampling device structure.



Source: JIS K 3850-1:2006 Methods for Measuring Particulate Matters Part I: Optical Microscopy and Scanning Electron Microscopy (Japanese Standards Association) (in Japanese)

Figure 8-2 Example of an air sampling device structure

8.4.1.3 Conditions for sampling

① Frequency of sample collection

In the general environment, the collection of three sample series constitutes a measurement. In general, it is desirable to collect samples over a period of 3 consecutive weekdays between 10:00am and 4:00pm. When the measurement is conducted in an area around a waste disposal facility, the facility’s operating days should be taken into account.

② Flowrate, sampling duration and air volume

In principle, use a paper filter with a diameter of 47mm and a filter holder as described in 8.4.1.2 ① and ② above to collect air at a rate of 10L/min for 4 continuous hours (2400L).

Of the A-SEM methods, the measurement is conducted with the polycarbonate filter technique, the collection hours may be increased appropriately to enhance the measurement accuracy.

③ Sampling height

The sample is collected at a height of 1.5-2.0m above the ground level, in principle. The sampling height may be adjusted appropriately to avoid any obstacles that might influence the air flow around the measurement point.

④ Determination of measurement points

The measurement points should be determined by taking into consideration the broad location selected on the basis of information on the predominant wind direction in developing a measurement plan and a possible impact of nearby obstacles on the wind direction. When the collection of samples is conducted by using a membrane filter and a polycarbonate filter in parallel, the two filter holders should be positioned at the same height and oriented in the same direction in a way where the two samplers do not influence each other.

⑤ Weather conditions

Taking samples during and after rain and strong winds should be avoided. When sampling points are selected based on the information on the predominant wind direction, it is desirable to take samples when the wind blows in that direction. In the event of rain after the commencement of air sampling, a rain cap or a hood should be used to protect the filter, power source and suction pump. Under unusual conditions, such as heavy rain and strong winds, when appropriate sampling is not possible, the sampling may be conducted on any three (not necessarily consecutive) days with favorable weather conditions.

8.4.1.4 Instructions for sampling

The flowmeter must be calibrated prior to sampling in order to evaluate the volume of air collected. If the volume of air collected is too high, the overlapping of fibrous particles on the filter makes it difficult to count asbestos fibers with a microscope. It has been found that a total dust loading exceeding $0.3mg/cm^2$ impairs the ability to count fibers. In order to avoid the influence of this phenomenon, the sampling time should be adjusted in order to maintain the fiber loading below $0.3mg/cm^2$.

In this regard, loading particles with a particle diameter of 10μm or larger can yield a total suspended particulate concentration of 0.5mg/m^3 at the highest. Provided that the suspended particulate concentration in the atmosphere is 0.5mg/m^3, a sampling duration of 9.6 hours with a rate of 10L/min would be required in order to achieve a particulate density of 0.3mg/cm^2.

Thus, a sampling duration of 9 hours or less at a rate of 10L/min is thought to produce acceptable filter loadings without the effect of the particle overlapping. However, in situations where there is the influence of carbon particles in diesel exhaust, it may be impossible to count the number of asbestos fibers even with a shorter sampling duration.

When the sampling duration is set at 4 hours, the effect of overlapping of particles is quite unlikely, as described above. When the amount of dust collected is likely to be large, it is desirable to divide the sampling duration appropriately and change filters for the collection of samples for a total of 4 hours (collection of 2,400L). In this case, it is desirable that the sampling duration is split evenly (e.g., 2 hours x 2 times, 1 1/3 hours x 3 times, or 1 hour x 4 times). The filter should be replaced when the dust layer loaded on the filter becomes visible. The number of filters used in a measurement should be limited to four, as the use of five or more filters in a single sampling could cause errors associated with the replacement of filters. Filters should be replaced at the above-mentioned frequency by estimating the amount of airborne dust with a digital dust meter.

Care should also be taken to ensure that there is no leakage from the sampling device. If air leakage has been detected during air sampling, the samples should be discarded.

After the sampling, the sample filter is carefully placed in the container. Precautions should be taken for containers made of plastic, where there is a possible risk of fiber loss due to electrostatic charge with fiber particles being stuck to the surface of the container. Moisture from exhaled breath is one way to help remove electrostatic charge.

8.4.2 Calculation of the fiber concentration

The collected samples should be preprocessed promptly to count the number of asbestos fibers. After counting, the fiber concentration is calculated on the basis of information on the number of fibers, the filter area, the area of the field of view and the amount of air collected. As the three sample collections constitute a measurement, the average of the fiber concentration of each collection is considered to be the fiber collection in the area of the measurement concerned. The geometric average is adopted as fiber concentrations fluctuate due to weather conditions and exhibit a lognormal distribution.

8.4.3 Measurement methods

8.4.3.1 Measurement procedures

The measurement procedure for samples taken in the general environment is shown in the flow ① in Figure 8-3. For electron microscopy, either the A-SEM method or the A-TEM method is acceptable.

Count the total number of asbestos fibers with a phase-contrast microscope. When the total number of fibers exceeds 1f/L, electron microscopy should be used to confirm the result, in principle. The measurement procedure has been structured to allow the use of an electron microscope alone from the beginning in some cases for the counting of the number of fibers to be done with a phase-contrast microscope. When the total number of fibers counted with a phase-contrast microscope exceeds 1f/L, low-temperature ashing may be allowed to exclude organic fibers.

8.4.3.2 Phase-contract microscopy

The phase-contrast microscope to be used should have an eye lens with a magnification ratio of 10 times or more, a field lens with a numerical aperture of 0.65 or more and a magnification ratio of 40 times, equipped with an eyepiece graticule (great circle: 300μm). The phase-contrast microscope is used to confirm and count fiber particles per view of a transparent sample. Use acetone and triacetin to make the sample transparent.

When gypsum and other asbestos fibers may be mixed in the sample, the results of measurement with phase-contrast microscopy need to be confirmed. The preliminary survey, confirmation of measurement site conditions at the time of sampling and comparison with past data are important to verify the possibility of the mixing of gypsum and other asbestos fibers. Full care must be taken as thin fibers can be overlooked easily.

8.4.3.3 Analytical scanning electron microscopy (A-SEM method)

The scanning electron microscope (SEM) to be used should have an energy dispersive X-ray analysis (EDX) device and meet an acceleration voltage of around 15kV, and should also be capable of observing and identifying fibers (a length of 5μm or more, a width of 0.2μm or more to less than 3μm, and an aspect ratio of 3 or larger) for the counting. The counting should be conducted with a magnification ratio that can reliably confirm fibers with a width of 0.2μm. It is desirable to use a field-emission SEM in consideration of the long-term stability of the instrument.

As the accuracy of the scale against the observation screen magnification ratio in the counting directly influences the measurement results of the fiber concentration and fiber dimensions, the magnification ratio should be calibrated as necessary by using the standard sample for magnification ratio calibration, such as the standard sample for an electron microscope (standard microscale) that shows the standard dimensions. In many cases, a lot of manufacturers express the magnification ratio of SEM as the ratio between the sample and the printout plane of paper. For example, even when a SEM device displays a magnification ratio of 2,000 times, the actual magnification ratio on the monitor screen may be 10,000 times.

The preprocessing method for collected samples is chosen from the following three types:

A. Membrane filter/low-temperature ashing technique

B. Membrane filter/carbon paste impregnation technique

C. Polycarbonate filter technique

Methods A and B have the advantage of being able to use the same sample as phase-contrast microscopy. Method C requires the collection of samples in parallel with the use of the membrane filter, but the preprocessing is simple and the electron microscopic appearance is easily viewable. While method A excludes organic fibers through low-temperature ashing and observable fibers are limited to inorganic fibers, methods B and C can observe organic fibers as they do not undertake low-temperature ashing. In choosing the preprocessing method, it is necessary to consider, aside from the above characteristics, the purpose of measurement and types of facilities and equipment in possession.

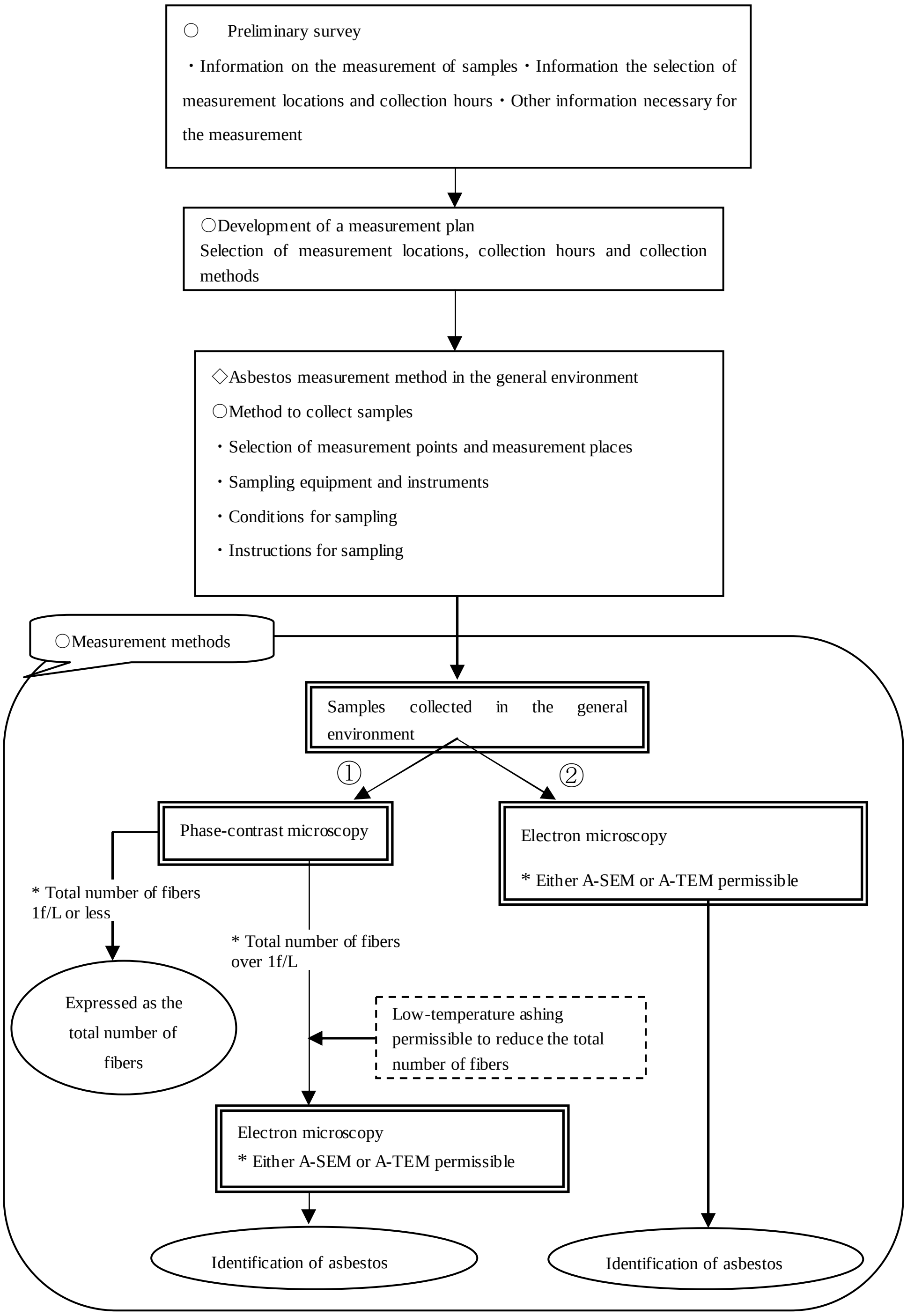


Figure 8-3 Flow of measurement in the general environment

8.4.3.4 Analytical transmission electron microcopy (A-TEM method)

Under the method to measure asbestos in the air using A-TEM, the membrane filter through which a certain quantity of air has passed is converted into a TEM sample and asbestos present in the TEM sample is counted by TEM. There are two techniques to produce the TEM sample: the technique to convert the membrane filter into a TEM sample while asbestos-containing dust is still collected on the filter (TEM-1 technique) and the technique to transfer dust collected on the membrane filter to another filter (nuclepore filter) and then convert a part of the nuclepore filter into a TEM sample (TEM-2 technique).

As the TEM-1 technique produces a TEM sample that maintains the conditions of the sample collected on the membrane filter, it is easier to form a 1:1 homology with the membrane filter. The TEM-2 technique is characterized by its capability to efficiently conduct a measurement using a sample that concentrates low-concentration asbestos in the ordinary air as it can concentrate (or dilute in some cases) the collected sample by the ratio of the area of the initial membrane filter to the filtration area of the next nuclepore filter.

8.5 Measurement Methods at Demolition Sites

8.5.1 Sampling methods

8.5.1.1 Selection of measurement locations and measurement points

① Measurement points

Measurement points are described in Table 8-2.

Table 8-2 Categorization of measurement points

Categorization	Facilities and areas
Demolition sites, etc.	① Sites of demolition of buildings and other structures in which specified building materials are used ② Sites of demolition of buildings and other structures that handle asbestos-containing molded products, etc.

② Selection of measurement points

Measurement points are selected by considering the following matters:

Demolition sites, etc.

1. Demolition sites, etc. of buildings and other structures in which specified building materials are used
2. Demolition sites, etc. of buildings and other structures handling asbestos-containing molded products, etc.

Select four points closest to the facility where demolition work is carried out (the source of asbestos dust) where there is traffic of a lot of people (they do not have to be on the border of the facility's premises) (two points on the windward and leeward sides of the predominant wind direction and two points perpendicular to the predominant wind direction, across the source of asbestos dust). In principle, select these measurement points at an equal distance from the source of dust as much as possible with few obstacles that might block the air flow from the source of dust. By taking into account the shape of the premises and the location of the source of dust on the premises, it is desirable to select measurement points suitable to grasp the load on the general environment from the demolition site. The filter holder should be positioned toward the source of dust.

If the area of removal covers limited parts of buildings and other structures, such as work to remove spray-on asbestos within elevators, and an unspecified number of people are operating outside the covering, it is not desirable to make the measurement outside the facility. In these cases, select measurement points by assuming that places where an unspecified number of people are coming and going are the border of the premises.

Also select at least one measurement point each outside the entrance to a room (hereinafter referred to as the "anterior chamber") created to prevent asbestos from directly dispersing outside when workers enter and leave and near the exhaust outlet of dust-collecting/exhaust equipment (hereinafter referred to as the "exhaust outlet"). The filter holder should be positioned toward the source of dust.

8.5.1.2 Sampling equipment and instruments

* Follow "8.4.1.2 Sampling equipment and instruments." As for the flowmeter, it is desirable to use a mass flow controller that is capable of measuring an integrating flow.

8.5.1.3 Conditions for sampling

① Frequency of sample collection

The collection of samples is conducted just once (one day) when the demolition work is carried out.

② Flow rate, sampling duration and air volume

In principle, use a paper filter with a diameter of 47mm and a filter holder as described in 8.4.1.2 ① and ② above to collect air at a rate of 10L/min for 4 continuous hours (2400L). Even when the demolition work is finished within the sampling duration, samples should be collected for 4 continuous hours.

③ Sampling height

The sample is collected at a height of 1.5-2.0m above the ground level, in principle. The sampling height may be adjusted appropriately to avoid any obstacles that might influence the air flow around the measurement point. If the exhaust outlet is positioned low, the sampling height should be set at an adequate height accordingly. If the exhaust outlet is positioned at a window on the second or higher floor, the measurement point should be set at the closest border of the premises.

④ Determination of measurement points

The measurement points should be determined by taking into consideration the broad location selected on the basis of information on the predominant wind direction in developing a measurement plan and a possible impact of nearby obstacles on the wind direction. When the collection of samples is conducted by using a membrane filter and a polycarbonate filter in parallel, the two filter holders should be positioned at the same height and oriented in the same direction in a way where the two samplers do not influence each other.

8.5.1.4 Instructions for sampling

When the measurement point is set outdoors, it is desirable to use a cowl in preparation for rain. The filter holder and the cowl should be cleaned before they are used. As the excessive deposition of particles on the filter makes microscopic observation difficult, pay particular attention to the amount of particular deposition at the measurement point set at the entrance door of the security zone where the concentration of dust is likely to be high.

Confirm the types of asbestos to be removed before the commencement of the measurement. It is also desirable to observe in advance bulk samples of asbestos to be removed with the phase-contrast and polarizing microscope.

8.5.2 Measurement methods at demolition sites

8.5.2.1 Measurement procedures

The measurement procedure for samples taken at demolition sites, etc. is shown in Figure 8-4. The measurement procedure itself is similar to that for samples taken in the general environment. For electron microscopy, either the A-SEM method or the A-TEM method is acceptable.

Count the total number of asbestos fibers with a phase-contrast microscope. When the total number of fibers exceeds 1f/L, electron microscopy should be used to confirm the result, in principle. The measurement procedure has been structured to allow the use of an electron microscope alone from the beginning in some cases for the counting of the number of fibers to be done with a phase-contrast microscope. When the total number of fibers counted with a phase-contrast microscope exceeds 1f/L, the low-temperature ashing may be allowed to exclude organic fibers.

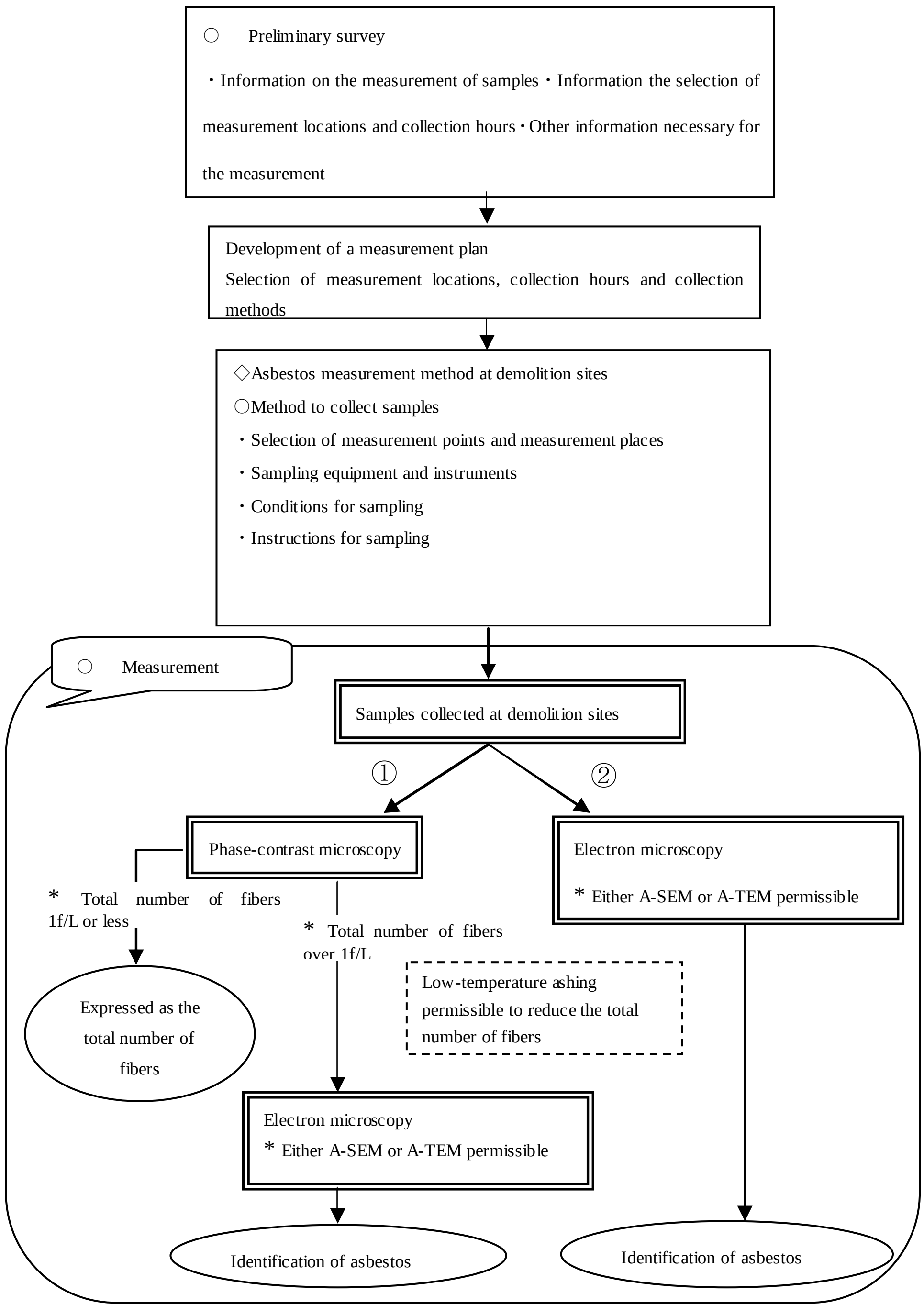


Figure 8-4 Normal flow of measurement at demolition sites

References: Examples of expeditious measurement methods at demolition sites

The measurement method at demolition sites is described in 8.5.1, but the sample collection duration under this method is just 4 hours and it also requires a considerable time before the measurement results are known because specimen materials collected need to be brought back to a laboratory for analysis.

On the other hand, it is desirable that there exists a measurement method to allow expeditious administrative guidance in order to prevent the dispersal of asbestos fibers given that the work at demolition sites, etc. is often completed within several hours or several days at most.

Thus, as examples of expeditious measurement methods at demolition sites, etc., Figure 8-5 shows the four methods of “phase-contrast/polarizing microscopy,” “fluorescence microscopy,” “field-portable electron microscopy” and “measurement with an automatic fibrous particle measuring instrument.” It is desirable to bring in measuring equipment to demolition sites, etc. to conduct on-site measurements in order to examine the leakage of asbestos. However, since there may be many different cases where no places for measurement can be secured at demolition sites, etc. or where a well-equipped research institute or similar facilities exist near demolition sites, the actual measurement should be conducted flexibly by taking the site conditions into consideration.

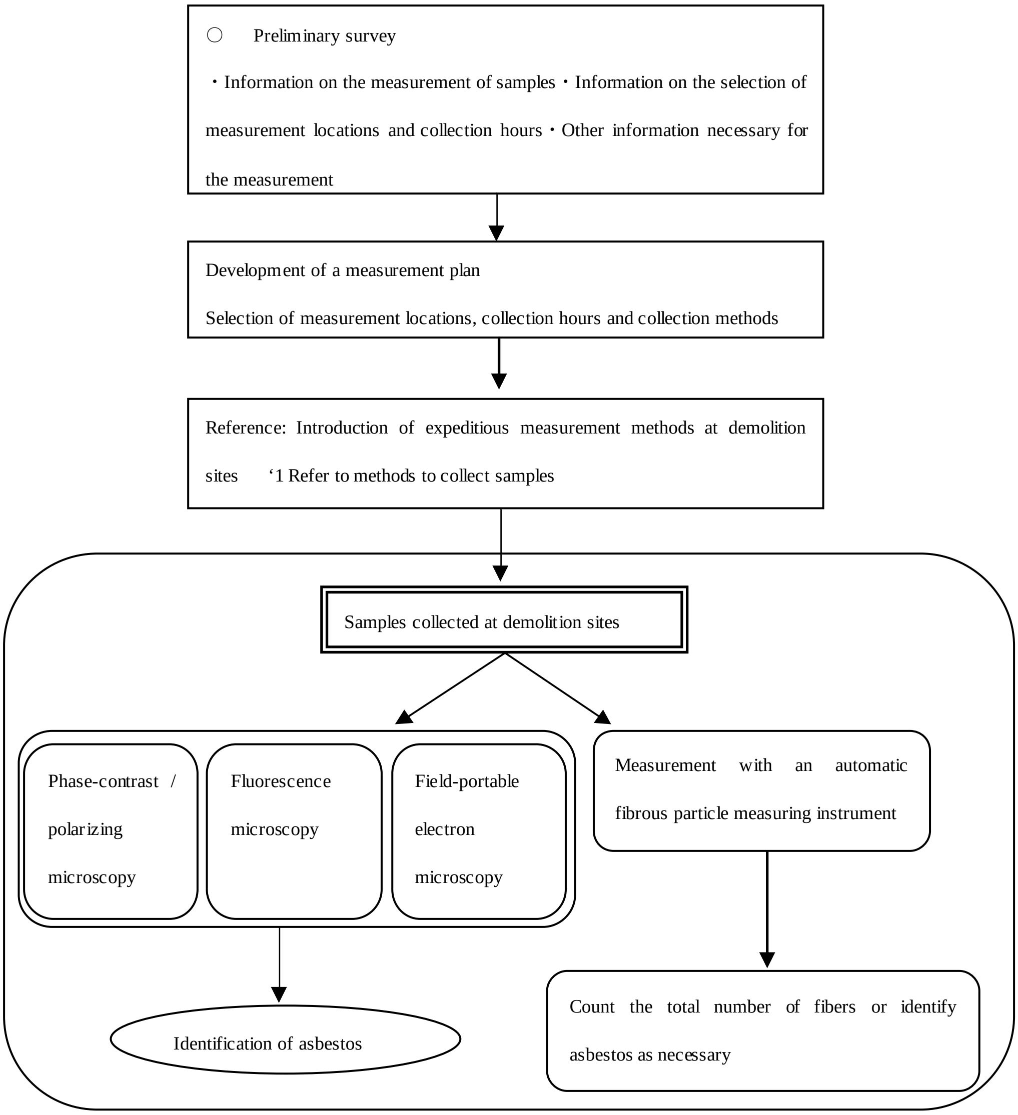


Figure 8-5 Flow of expeditious measurement at demolition sites

Example 1: Phase-contrast / polarizing microscopy

A polarizing microscope has a host of devices to observe optical properties of a material and is one of the powerful tools for the discrimination and identification of minerals in the field of mineralogy. This method measures the asbestos concentration in the air by separating the fibrous particles counted by the phase-contrast microscope into asbestos and non-asbestos through observation with the polarizing microscope. A phase-contrast/polarizing microscope that can conduct the polarization method and the phase-contrast method concurrently only by switching the turret and the field lens is used. The polarizing microscope has its resolution limits and it reportedly can observe only fibers with a diameter of 1μm or larger. However, with the improvement of its field lens and the intensity of light sources, it now can observe optical properties of fibers with a diameter of 1μm or less.

At demolition sites, etc., an expeditious measurement of asbestos concentrations is required for the prevention of asbestos dispersal into the surrounding environment. This measurement method is capable of on-site analysis and can determine the occurrence of dispersal within around an hour after the commencement of sampling, making it an effective tool in dispersal-prevention measures. It is possible to obtain information on the types of asbestos to be removed by examining whether spray-on materials contain asbestos prior to removal work at demolition sites, etc., and this allows people who conduct an analysis to know the types of asbestos that are likely to be dispersed in advance, helping enhance the analytical precision.

This measurement method requires basic knowledge for observation by the polarizing microscope (observation of birefringence, pleochroism, quenching and extinction angles, and positive and negative extensional properties) as well as training for analysis. It is also necessary to carry out the continuous accuracy management in order to maintain the accuracy of measurement results.

Example 2: Fluorescence microscopy

Fluorescence microscopy has been developed in recent years as a method to detect microscopic asbestos fibers with the use of asbestos binding proteins modified by fluorescent material.

Two asbestos binding proteins are used: specific protein in chrysotile and proteins that bind widely together with the amphibole family of asbestos. When they are modified by fluorescent materials with different fluorescent colors, it is possible to distinguish between chrysotile and the amphibole family of asbestos by color to a certain extent. It is also possible to identify rockwool and other non-asbestos materials. However, it should be fully noted that this method cannot identify some glass fibers, aluminum silicate fibers, silicon carbide or titanium acid microcrystalline whiskers.

As the membrane filter is used to collect samples, this method can use the common filter with phase-contrast microscopy. The filter does not require the ashing process.

Example 3: Method to use a field-portable electron microscope

The field-portable scanning electron microscope (SEM) that can conduct measurements to determine the presence of asbestos within one to two hours at demolition sites, etc. should have an energy dispersive X-ray analysis (EDX) device, meet the acceleration voltage of around 15kV, be of compact size and easy to carry around. It should also be capable of observing and identifying asbestos fibers similar in size to fibers that can be confirmed with the phase-contrast microscope (roughly with a length of 5μm or more, a width of 0.2μm or more to less than 3μm, and an aspect ratio of 3 or larger) in about one to two hours between the installation and the observation of samples.

Example 4: Measurement with an automatic fibrous particle measuring instrument

An automatic fibrous particle measuring instrument, which identifies only fibrous particles from among airborne particles and calculates the fiber concentration of these particles, was developed in the United States in the latter half of the 1970s and was approved by the U.S. Occupational Safety and Health Administration (OSHA) as a measuring method equivalent to the PCM method in 1986. Unlike methods to count the number of fibers by collecting airborne particles on the filter, this instrument makes it possible to know the fiber concentration of airborne fibrous particles at measurement locations, and it can conduct real-time measurement and long continuous monitoring and measurement for preventing the dispersal of asbestos stemming from the work to demolish, renovate or remove buildings and other structures.

(The principle of the automatic fibrous particle measuring instrument)

The sample air is taken in from an opening to obtain air by a suction pump. The air goes through the sensing station, the sampling holder and the flow sensor and then is exhausted outside the chassis. The detector sensor has a high-pressure section that consists of four electrodes, and vibrates when fibrous particles pass through the electrical field where high direct-current and alternating-current voltages are applied. Fibrous fibers emit scattering light due to semiconductor laser radiation irradiated within the sensing station, and scattering light is detected by the light sensor. When fibrous particles vibrate through the sensing station, the intensity of scattering light changes in pulsed patterns. Non-fibrous fibers, on the other hand, show little change in the intensity of scattering light due to the vibration of the electric field when they pass through the sensing station. If fibers of fibrous particles are long and thick, the pulse of scattering light has a higher peak, while the pulse area becomes larger if fibers are longer. The instrument can select and measure fibers that have analytical values consistent with those under the PCM method by setting the aspect ratio (length/width) and length of fibers on the basis of the ratio between the scattering light pulse and the peak area.

The selected fibrous particles are measured on a real-time basis and displayed as the count number. At the same time, the concentration of the total number of fibers is calculated on the basis of the integrated count value and the integrated flow of suctioned air.

The measured concentration is the same concentration of the total number of fibers as the fiber concentration obtained by phase-contrast microscopy and does not necessarily correspond to the asbestos concentration. Thus, if the measuring instrument has a built-in backup filter, it is possible to confirm the concentration by other analytical methods as necessary.

Appendix IX　Asbestos Substitutes

How the conversion to asbestos substitutes proceeded differs depending on the types of asbestos and dust generation in the process of utilization.

(1) Asbestos substitutes for crocidolite

The replacement of crocidolite has been facilitated with relative ease because it was used in products that leveraged crocidolite’s acid-resistant characteristic. Alternative products are cited below:

・Textile products・・・Glass long fiber textile products whose surface is fluorine resin processed

・Water and sewerage pipes・・・Cast-iron pipes

(2) Asbestos substitutes for amosite

The replacement of amosite has been facilitated with relative ease because it has the low bulk density and enhanced strength. Alternative products are cited below:

・Lagging materials・・・Amosite was replaced by glass long fibers and pulp

・Building materials with a density of 1.0 or lower・・・Amosite was replaced by such substitutes as wollastonite and pulp

・Heat insulation materials・・・Amosite was replaced by such substitutes as rockwool, glass wool and glass long fibers

(3) Asbestos substitutes for chrysotile

As mentioned in Appendix IV, chrysotile had been used for various applications due to its characteristics. The replacement of chrysotile was phased in as many problems related to the manufacture, quality and costs had to be cleared. Alternative products are cited below

・Building materials with the density of over 1.0・・・Replaced by a combination of vinyl acetate fiber (vinylon), pulp and wollastonite, etc.

・Textile products・・・Replaced by glass long fibers, carbon fibers, aramid fibers, silica fibers and ceramic fibers either independently or in combination, depending on the intended use

・Friction materials・・・Chrysotile was replaced by aramid fibers, ceramic fibers, rockwool, glass long fibers and steel fibers, etc. in combination

As described above, chrysotile had a variety of applications and its replacement proceeded only gradually. However, as it became necessary to consider responses to prepare for a total ban on asbestos, the Ministry of Health, Labour and Welfare and the Ministry of Economy, Trade and Industry separately called meetings of experts to study the actual conditions surrounding the use of chrysotile and consider measures to prepare for the ban. The following sections cover the types of asbestos-substituting alternative fibers and their potentially harmful effects by referring to the Report of the Technical Committee on Substitute for Asbestos 2006 (Ministry of Health, Labour and Welfare), the Report of the Technical Committee on Substitutes for Exempted Products Related to the Total Ban on Asbestos 2008 (Ministry of Health, Labour and Welfare) and the Report of the Technical Committee on Substitutes for Asbestos 2006 (Ministry of Economy, Trade and Industry).

9.1 Types of Asbestos-Substituting Fibers

The Report of the Technical Committee on Substitutes for Asbestos 2006, compiled in preparation for a total ban on asbestos products, cites synthetic mineral fibers, natural mineral fibers and synthetic fibers, etc. as the main asbestos-substituting fibers. Examples of synthetic mineral fibers include the fibrous form of fused glass or ore, mainly glass wool, rockwool, slag wool and glass long fibers, used as substitutes for asbestos in heat insulation materials, building materials, friction materials and sealants. Natural mineral fibers, or naturally occurring fibrous minerals, such as sepiolite and wollastonite have replaced asbestos in building materials and adhesives, etc. Regarding synthetic fibers and natural organic fibers, aramid fibers, vinylon fibers, pulp and carbon fibers, etc. have been used as replacements for asbestos in building materials, friction materials and sealants.

9.2 Evaluation of Harmful Effects of Asbestos-Substituting Fibers

All types of asbestos have been classified as Group 1 (carcinogenic to humans) by the International Agency for Research on Cancer (IARC). Other synthetic mineral fibers have been classified as either Group 2B (possibly carcinogenic to humans) or Group 3 (not classifiable as to carcinogenicity to humans). In October 2001, glass wool, rockwool and slag wool were reevaluated from Group 2B to Group 3.

Table 9-1 lists the types of asbestos-substituting fibers and their harmful effects on humans.

Table 9-1 Types of asbestos-substituting fibers and their harmful effects

(1) Synthetic mineral fibers (fused and fiberized glass/ore)

Substitutes	Uses	IARC Evaluation
Glass fibers	Building materials, sealants, friction materials, insulation materials	3
Glass wool	Lagging materials, heat insulation materials, sound absorbing materials	3
Rockwool	Spray-on materials, lagging materials, acoustic materials, heat insulation materials	3
Slag wool	Spray-on materials, lagging materials, acoustic materials, heat insulation materials	3
Ceramic fibers	Refractory materials, friction materials	2BB

(2) Natural mineral fibers (naturally occurring mineral fibers)

Substitutes	Uses	IARC Evaluation
Sepiolite	Building materials, coatings, sealants	3
Wollastonite	Building materials, coatings	3

(3) Others (synthetic fibers and natural organic fibers, etc.)

Substitutes	Uses	IARC Evaluation
Aramid fibers	Sealants, friction materials	3
Vinyl fibers	Building materials	3
Pulp (cellulose)	Building materials	No evaluation
Carbon fibers	Building materials, friction materials, sealants, refractory materials	No evaluation

Note: Evaluation of carcinogenic risks by IARC (International Agency for Research on Cancer)

(1) IARC Monograph on the Evaluation of Carcinogenic Risks to Humans Vol. 81 (October 2001)

(2) (3) IARC Monograph on the Evaluation of Carcinogenic Risks to Humans Vols. 1 to 79

IARC Evaluation Category

Group 1: Carcinogenic to humans
Group 2A: Probably carcinogenic to humans
Group 2B: Possibly carcinogenic to humans
Group 3: Not classifiable as to carcinogenicity to humans
Group 4: Probably not carcinogenic to humans

* All forms of asbestos have been classified as Group 1.