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DRAFT

FINAL REPORT

on

INDUSTRY PROFILE AND BACKGROUND INFORMATION ON ASBESTOS-CONTAINING SPRAYED-ON DECORATIVE CEILING AND ACOUSTICAL OR THERMAL INSULATION PRODUCTS

to

DEPUTY ASSOCIATE EXECUTIVE DIRECTORATE
FOR ECONOMIC ANALYSIS
U.S. CONSUMER PRODUCT SAFETY COMMISSION - Dale Ray

December 31, 1978

by

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Requested by Dale Ray, HICP

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EXECUTIVE SUMMARY

Spray-applied asbestos-containing insulation material has been recognized as a possible source of release of asbestos fiber into surrounding air. Asbestos-containing sprayed insulation was extensively used in the United States from 1954 through 1973. These materials were commonly applied in buildings such as schools, office complexes, apartments and nightclubs.

The method of application as well as the various compositions of the insulation materials are discussed. The current methods for detection, sample taking and analysis of the samples are given.

Three possible corrective measures: (1) removal, (2) protective barrier, and (3) encapsulation with a sealant are explained including both the advantages and disadvantages of each measure. Information is also given as to the required properties needed for an encapsulating sealant to be effective.

This report also includes estimated cost breakdowns for sample collecting, analysis of samples, removal and encapsulation. Two scenarios are given as examples of possible costs that can be expected for either removal or encapsulation with a sealant.

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BACKGROUND

The Consumer Product Safety Commission recognizes that asbestos in its fibrous form poses a significant environmental health hazard. Asbestos and asbestos containing products also are of concern to CPSC because the use of these products, under certain circumstances, may result in the release of respirable fibers which could pose a long-term risk of cancer to users. Some of the products are currently regulated and others are targets for possible future regulation (e.g., labeling or banning). The Commission has directed the staff to investigate several products containing asbestos to determine the extent of current and potential health hazards.

Objective and Scope

The objective of this task is to provide CPSC with background data on the use of the friable, asbestos-containing, spray-applied material used for decorative ceiling, acoustical, and thermal insulation.

Although the United States Environmental Protection Agency (EPA) in 1973 banned spray application of insulation and fireproofing materials containing more than one percent asbestos by weight, there exist huge quantities of asbestos-containing acoustical and fireproofing material applied during the years from 1954 to 1973. Also, decorative use of asbestos-containing materials was not included in the ban. To cover this exclusion, the EPA on June 19, 1978, promulgated an amendment to the national emission standards that extended spraying restrictions to all materials with more than one percent asbestos by weight. Only materials with bituminous or resinous binders which are non-friable after drying were excepted.

HISTORY OF SPRAY-APPLIED ASBESTOS-CONTAINING MATERIALS

Asbestos-containing sprayed insulation material was first used in Great Britain in 1932 where it was used for condensation control and acoustical purposes. The asbestos-containing material was introduced in the United States for acoustical and decorative purposes in nightclubs, restaurants, and hotels. Because of the fire resistant nature of the asbestos-containing material, it soon found use as a fireproofing material. In 1950, Underwriters Laboratory gave approval for the use of fibrous spray-applied asbestos material as a fireproofing medium. After World War II, extensive use was made of this material for the fireproofing of structural steel and other components of high rise office buildings. It was also used as fireproofing and acoustical material in many schools. In fact, noise control was a major reason for spraying asbestos materials in auditoriums, libraries, hallways, classrooms, and other areas of school buildings. There are two basic types of sprayed material applications--wet and dry.

Magnitude of the Problem - Location - Prevalence of Usage

In recent years, data have been accumulated showing that erosion damage and disintegration of the asbestos containing material have led to significant concentration of asbestos fibers in the air. There have been many reports published as to the locations of buildings, schools, and dormitories containing fibrous asbestos materials. For example, at Yale University asbestos containing material was used in a building of approximately 118,000 square feet of floor space. It housed the school library, the School of Art, and the School of Architecture. Completed in 1963, this reinforced concrete structure has been used by over 2000 persons each academic year. The ceiling material in the building was a spray-applied mixture of asbestos and fibrous glass which caused occupant exposure to asbestos fibers under all conditions of activity. In fact, the measured exposure of asbestos fibers concentration in some situations exceeded the Occupational Safety and Health Administration's allowable limits for industrial exposure.

Another major location reported was Bond Hall at Montclair State College in New Jersey. Bond Hall is a sixteen story, twenty-seven wing dormatory from which 35,000 square feet of asbestos material was removed. In New Jersey, it has been reported that 265 schools in 142 school districts had nearly three million square feet of what they considered to be asbestos in their buildings. The extent to which these data are correct needs to be determined. They do suggest the possibility of a wide-spread problem in New Jersey schools, and those of other states as well.

A recent article in the New York Times[1] reported that the New York City Board of Education has begun inspection of 240 schools for asbestos-containing materials. In an old technical bulletin advertising Pryospray®, a spray-applied material which was a blend of chrysotile asbestos fibers, refined white mineral fibers, and inorganic binders, several buildings were listed as containing this material; One Oliver Plaza in Pittsburgh, Pennsylvania; the National Geographic Society Membership Operation Building in Gaithersburg, Maryland; the Midwest Federal Building in Minneapolis, Minnesota; the Pratt and Whitney Plant in East Hartford, Connecticut; and the New England Mercantile National Bank in Boston, Massachusetts. The November 22, 1978, issue of the Miami Herald reported that six Dade County schools have been identified as having surfaces coated with asbestos-containing materials.

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* Baldwin-Ehret-Hill Catalog 68, Special Coatings Fire-Resistant, Circa 1960.

A report[2] by Dr. William J. Nicholson, Environmental Sciences Laboratory, Mt. Sinai School of Medicine, described a study of the use of sprayed asbestos surfaces in school buildings. Dr. Nicholson stated that about 11 percent of the schools surveyed by the State of New Jersey had asbestos material in them. Dr. Nicholson visited 48 of these schools. Two-thirds of them had some visible damage to the materials while five had significant damage. Such damage can cause release of asbestos fibers. Dr. Nicholson mentioned that the conditions of the sprayed surfaces vary widely. In some cases, they are intact and consequently release little or no asbestos fiber. In other instances in which the surfaces are damaged and friable, there is a high possibility of significant fiber release. He stated that in general, cementitious asbestos materials are more likely to be intact and less likely to release the asbestos than loosely compacted fibrous materials.

The total magnitude of the problem in the United States has not been determined. However, limited surveys conducted to date indicate the problem may be substantial. Estimates have been made that about 50 percent of the office buildings constructed during the period 1958 through 1970 were fireproofed with asbestos materials. Sawyer[3] reported that "although exact figures are not available, if it is assumed that spray application was a common practice from 1958 to 1973, and that fireproofing was the major use of this material, a conservative order of magnitude estimate of the total amount of asbestos sprayed over this period would be 500,000 tons". In <u>Asbestos: An Information Resource</u>[4], it was stated that, "in the early 1970's there were approximately 36,000 insulation installers employed largely in insulating industrial equipment, commercial buildings and ships". Another report[5] stated, "it is seen that disposal through repairs, replacement, and demolition will involve approximately 20,000 tons per year of discarded asbestos insulation. This is currently the major release of asbestos insulation products (sic, asbestos fiber) to the environment. It will fade out as the presently installed materials are replaced with asbestos-free insulation. However, the disposition will be near the above rate for about 15-20 years."

Environmental Defense Fund Petition

On March 14, 1978 the Environmental Defense Fund (EDF) sent a letter to the Assistant Administrator of the EPA, Steve Jellinek, urging them to use the Toxic Substances Control Act authority under Section 6 to regulate asbestos emissions from buildings. The EDF attorney, Robert Rauch, described such indoor emissions as "one of the most severe public health problems which EPA has ever confronted".(6) Section 6(A) of that Act states that "if the Administrator finds that there is a reasonable basis to conclude that the manufacture, processing, distribution in commerce, use, or disposal of a chemical substance or mixture, or that any combination of such activities, presents or will present an unreasonable risk of injury to health or the environment, the Administrator shall by rule apply....requirements to such substance or mixtures to the extent necessary to protect adequately against such risks using the least burdensome requirement". Although the EPA has proposed regulations under the Clean Air Act that would prohibit the spraying of buildings, structures, structural members, pipes, and conduits with materials containing more than one percent asbestos by weight, the proposed regulations do not control emissions from existing buildings that have been sprayed with asbestos containing materials. The EDF contends "that continued use of asbestos in these applications, as well as the disposal of structural components containing asbestos, falls within that prohibition contained in Paragraph 6(A)".

Specifically, the EDF recommends that the agency require the owners of buildings containing asbestos materials to seal such materials permanently from public exposure or replace these materials altogether. This requirement would only apply in those situations where conditions are such that public exposure is likely or already occurring.

In order to determine which sources should be subject to these requirements, the EDF recommends "that (EPA) under the authority of the Toxic Substances Control Act or the Clean Air Act gather the necessary information to determine which sources may pose a public health hazard".

The EDF suggested "that (EPA) seek two types of information from suspected sources":

(1) A physical sample of any ceiling or other structural material which may contain asbestos.

(2) The completion of a brief but descriptive field questionnaire.

The physical sample would be sent to either an EPA or an industrial laboratory for analysis. If it should be found to contain asbestos and if the location and the conditions of the material represent a potential threat to public health the EDF recommends that the EPA require appropriate corrective action. The questionnaire would solicit information as to the accessibility of the suspected material to physical abuse or other physical contact, as well as information regarding the thickness of the substance and its current physical appearance. All of this information is essential for determining whether the ceiling or other structural components present hazards as well as the appropriate regulatory responses. The EDF also states that one of the unresolved questions is the extent to which the asbestos industry itself should be compelled to pay for any required investigations, determinations of the extent of the problems, or any subsequent corrective measures.

In summary, the EDF is recommending:

(1) A ruling by the EPA under either Section 114 of the Clean Air Act or Paragraph 11C of the Toxic Substance Control Act requiring the submission of information from suspected sources which will be helpful in determining whether those sources should in fact be regulated.

(2) A proposed rule under Paragraph 6 of the Toxic Substance Control Act requiring either the sealing of the suspected source or removal of the material altogether if sealing is not suitable.

(3) That the EPA consider proposing a rule under Section 6(A) which would require the manufacturers or distributors of asbestos coating material to bear some or all of the expense of investigation into the extent of the hazard as well as subsequent corrective measures.

METHODS OF APPLICATION, DETECTION AND ANALYSIS

This section describes the two methods that were employed for applying the asbestos-containing insulation and/or soundproofing materials during the period from 1950 through 1973. It also includes suggested methods for detection and analysis of the asbestos-containing materials.

Description of Material and Methods of Application

The formulation for asbestos-containing material depends to some degree on the method of application. There have been two main methods of application: the wet method and the dry method.

In the wet method, asbestos (generally 5 percent to 30 percent by weight of the total formulation), mineral wool, and/or fiberglass was mixed with portland cement and gypsum as cementitious binders in a slurry. This material, as applied, tends to be more dense and therefore less susceptible to friability than dry-applied materials. With the slurry-cementitious product maximum application thickness was usually three-quarters to one inch, with most applications being within a one-quarter to one-half inch range.

The dry method was a dry blend of asbestos fibers (anywhere from 5 percent to 80 percent of the total weight), mineral wool, some portland cement, water soluble resins, starches, and possibly other additives. These materials were blended in a hopper on site and then forced through a hose to the application surface. As the dry blended asbestos-containing material left the nozzle, it passed through a ring of water jets which converged several inches from the end of the nozzle. This wetted the dry blended material and activated the water-soluble binders, producing a wet fibrous matrix which readily attached itself to the application surface. It was usually applied from one to two and one-half inches thick. The asbestos fibers used in both wet and dry applications were generally chrysotile.

Fiber Contamination in Buildings

Asbestos fiber contamination in buildings containing asbestos insulation fall into three general categories: (1) fall-out, (2) impact and (3) redispersement or reentrainment. It is useful to evaluate separately for each mode of contamination the various risks and methods for hazard elimination.

Fall-out is an inherent characteristic of asbestos insulation material. One would expect greater fall-out from the dry-blended, asbestos-containing, sprayed-insulation than from the wet-blended, slurry-applied, cementitious-type product. The wet-blended slurry-applied coatings or insulation are usually more dense and less friable than the dry-blended material. Consequently, when in good condition very minimal fall-out should occur with wet blended products. Fiber fall-out from the friable asbestos insulation (if it has not been sealed) can be continuous for long periods of time and at fairly low levels of contamination. This fall-out may occur without any actual physical contact with the fiber bearing material. It depends somewhat on the condition of the insulation and the type of adhesive used. Fall-out rates also can be influenced by structural vibration, air movement from heating and ventilating equipment, variations in humidity, and vibration and turbulance of the air due to human activity.

One of the common practices in the construction industry has been to use the area above the false ceiling as a return air tunnel or plenum. If the plenum contains friable sprayed-on asbestos the flow of air through this area could cause significant fiber release, its quantity dependent on the condition and age of the insulation material.

Physical contact with friable, sprayed-asbestos surfaces may cause significant fiber release due to the low impact resistance of the material. Even minor contact from a ball or broom handle can free fibers from their matrices. Where the material is very accessable--as in hallways, low classroom or apartment building ceilings--it is likely that physical contact will occur and that fiber concentrations be significant.

Custodial work such as replacing lightbulbs, changing fixtures, or any work near or around sprayed-on asbestos coatings may result in accidental physical contact and subsequent release of asbestos fibers at levels near or above the current EPA guidelines. Both impact and reentrainment contamination are directly affected by such contact situations. It has been reported that in some cases fiber concentration can exceed 100 fibers per cubic centimeter.

The third category of fiber contamination--redispersement or reentrainment--can be difficult to control. Because of their aerodynamic properties, fibers remain airborne for long periods of time. It has been reported that a single fiber five micrometers in length and one micrometer in width can remain suspended up to 80 hours in still air.

Dry sweeping, dry dusting, and other similar types of custodial activity can result in high reentrainment levels. Once it is suspected that a friable ceiling material contains asbestos, it is highly recommended that wet or damp cleaning techniques be adopted immediately in the area in question.

Methods of Detection

Because of the complexities and the fragmented nature of the construction industry and the many scattered installations of asbestos-containing materials, it would be virtually impossible to locate systematically all buildings with asbestos containing insulation. It should be noted that not all buildings constructed in the critical time period (1950-1970) will have asbestos containing coatings. Furthermore, not all fibrous appearing insulation materials contain asbestos fibers, since current practices today involve the application of insulating or fireproofing materials containing no asbestos. These insulating materials are applied using the same techniques and basically the same formulations but with the asbestos removed and mineral wool substituted. Consequently, it is difficult to detect by observation which type of material has been used in a building.

It becomes obvious that each situation and each building must be evaluated on its own merit. Certain questions must be answered. "Does the insulation or soundproofing material contain asbestos?" If it does, "What is the potential for exposure to the occupants of the building?" and, "What, if any, remedial actions will be most suitable for alleviating the problem?"

Since it is difficult to tell by observation if the insulation material contains asbestos, several detection methods have been identified for determining asbestos content. If possible, the architectural specifications should be reviewed for any information concerning product use. If the specifications cannot be located or the information is questionable, a bulk sample for analysis should be taken.

Bulk Sampling

The only positive method of determining if a suspected insulation material contains asbestos is by sample analysis. Although taking a bulk sample for analysis is not a difficult procedure, it should be done with some care and caution.

An EPA Guidance Document[3] recommends the following procedure for obtaining a bulk sample.

"Use a small sealable glass or plastic capped container holding the container as far as possible from the face. Obtain a full thickness core sample of the sprayed material by penetrating the surface with the container using a twisting motion. Any surface coating such as paint on a cement material must be penetrated. The container is then capped, wiped and sealed with tape. Labeling should include building identification, address, sample source location and date. Disturbance of the material other than at the sampling point should be kept to a minimum."

It is important that the sample taker wash his hands and wipe the bottle with a damp cloth after sampling to eliminate any threat of fiber spread. If only one sample is taken, it is recommended that the sample taker hold his breath while disturbing the insulation material. If several samples or a series of samples are taken from different locations in the building, it is recommended that an approved respirator be used. Samples can be submitted to approved laboratories for analysis (see partial listing of laboratories on p. 28 ff). EPA plans to provide technical assistance to schools on sampling techniques.

Airborne Asbestos Sampling

Bulk sampling is a reliable method for identification and quantification of asbestos in the suspected insulation or soundproofing material. However, air sampling is the only method for determining the concentration of asbestos fibers in the air.

To sample the air a pump is used to draw a constant volume of air through a membrane filter. Usual sampling rates for low volume sampling are 2.0 liters per minute (1/min) and 10.0 1/min for high volume sampling. Low volume sampling is usually associated with personnel monitoring and high volume for general sampling. Sampling times can vary. However, they generally range from 30 to 60 minutes. The sampling time is regulated basically by the anticipated fiber load.

Following the sampling period, the membrane filter should be placed in a glass or plastic container for storage. The membrane filter should be carefully identified as to building, location in the building, sampling flow rate and time of sampling. Care must be taken when transporting the samples to avoid loss of fibers from filter surfaces.

Methods of Analysis

There are two distinct types of analysis performed upon samples obtained through the procedures outlined above. Bulk analysis is used to determine if the insulation material sample contains asbestos fibers. The other type of analysis provides a measurement of the amount of hazardous asbestos fibers in the air samples taken.

Bulk Sample Analysis

Bulk sampling analysis is relatively straightforward and reliable. There are three methods in common use for determining the presence and quantity of asbestos fibers. The major concern is that the analysis be performed in a competent manner. Following a report to one U. S. school system confirming that submitted material contained asbestos, an extensive and expensive removal operation was undertaken. Later, it was discovered that the removed material was asbestos-free and instead contained glass fibers. Conversely, failure to identify asbestos in the material may continue to endanger building occupants.

The three methods of analysis recommended are (1) petrographic microscopy, (2) X-ray diffraction to supplement petrographic microscopy, and (3) electron microscopy (only if doubt still exists following analysis by petrographic microscopy and X-ray diffraction). It is widely acknowledged that petrographic analysis should be performed by a laboratory of recognized competence in optical crystallography.

Petrographic Microscopy. Petrographic analysis techniques are well established and the equipment is relatively low in cost. The petrographic microscope is a transmitted polarized light instrument used to identify and characterize crystalline substances based on their optical and crystallographic properties. A possible drawback to this method is that a high level of competence is required of the microscopist.

X-ray Diffraction. The X-ray diffraction method of analysis requires expensive equipment, reference and mineral standards, and a very high level of technical competence by the operator. In routine examinations of bulk samples, X-ray diffraction may fail to detect small concentrations of asbestos fibers. Also, the presence of other crystalline materials may interfere with accurate identification. Even with these defects the X-ray diffraction analysis method provides a high degree of reliable information. This method is generally used only as a confirmation tool for questionable petrographic microscopy analysis.

Electron Microscopy. The use of the electron microscopy technique to identify asbestos fibers is very specific and accurate. However, it is an inefficient and costly method for analyzing bulk samples. Its greatest value is as a tool to resolve ambiguities from petrographic microscopy and X-ray diffraction methods.

Air Sample Analysis

Air sampling analysis may be performed by either of two techniques: (1) phase contrast microscopy and (2) electron microscopy.

The membrane filter containing the asbestos fibers may be a sample source for several analyses since only a small segment is removed for each examination. Consequently, the same filter may be examined by various methods and/or laboratories to establish uniformity of asbestos analyses and interlaboratory agreement.

Phase Contrast Microscopy. Phase contrast microscopy is an optical method which has been specified by the Occupational Safety and Health Administration in their regulations for determination of airborne asbestos in occupational settings. The filter is segmented, mounted, treated chemically to make the filter membrane transparent and examined using a special microscope and counting procedures with phase contrast illumination at 400 to 500 magnifications. The particles are observed for size and shape. Each particle having a length to width ratio greater than three to one and a length of five micrometers or greater is counted as an asbestos fiber. The results are presented as the number of fibers per cubic centimeters of air.

Phase contrast microscopy is an optical technique for viewing small particles rather than a method for determining the specific properties of a substance. This technique is based on the shape of the particle rather than the specific properties of a substance. It is possible that fibers satisfying a three to one length to width ratio may not be asbestos fibers. Also, the resolution limit of optical microscopy and the specified five micrometer cut-off point for fiber lengths precludes possible identification of a potentially larger population of short fiber lengths which may be present and which may be of biological significance.

Electron Microscopy. Fiber counting by electron microscopy permits a detailed examination/identification of asbestos fibers of all sizes. Both scanning electron microscopes and transmission electron microscopes are used. The magnification required to identify asbestos at its smallest dimension is well within the range of these instruments. The actual counting is usually done using a magnification of 20,000 to 50,000 X. The electron microscope is presently the definitive method for fiber counting and exposure estimation.

Following a sample preparation, a large number of fields are examined for fibers. Each fiber is observed and is counted, its length and width dimensions measured. The accuracy of the calculated fiber mass is primarily dependent upon the representativeness of the fiber population actually measured. One important problem is that each laboratory may prepare the samples differently and use a different instrument which can result in poor laboratory to laboratory correlation. There is at this time no standard procedure or technique. A provisional optimum procedure is now being developed by the EPA which would enhance inter-laboratory agreement.

Other concerns associated with electron microscopy are that sample preparation techniques are lengthy, the equipment costly, and that highly trained and qualified technical people are required for its operation.

METHODS OF CONTAINMENT

The primary consideration during containment operations must be to eliminate or minimize exposure to asbestos fibers. To estimate the exposure to or possible risk from any of these materials involves a variety of factors. The type of asbestos-containing insulation materials used, application procedures, and location of the sprayed materials can vary widely. Therefore, method of containment or removal of hazard cannot be standardized for all situations.

Several facts should be considered in making a determination of possible corrective action. The wide variety of applications and the possibility that not all friable insulation material will contain asbestos necessitates that the first step be a determination of whether the material contains asbestos.

Once the asbestos content has been identified, several additional factors must be considered:

(1) The age and condition of the material. Aging of the friable material can reduce the cohesive strength and the effectiveness of the binders and can result in higher fiber loss.

(2) How accessible the material is to damage from physical contact.

(3) The function of the space containing the insulation material. It may be used for a classroom, storage room, furnace room, or kitchen. Use is important because the activity in a room can, to some extent, determine the amount of fibers released. Heavy useage and activity can mean higher fiber levels in the surrounding air.

(4) The activity or work habits of custodians. They may disturb or impact the ceiling when replacing lights or repairing fixtures.

(5) Possible water damage to the insulation material especially if it is located in a high humidity area such as a natatorium. Although at one time this type of material was used for condensation control, high moisture and high humidity conditions tend to increase deterioration rates.

Temporary Correction Measures

There are a few, positive temporary correction methods that can reduce asbestos fiber contamination during the period between identification of the problem and control of the problem. These temporary methods can include changing of custodial work procedures, reducing maintenance activities and delaying repairs in questionable areas. Rescheduling of custodial work also can substantially reduce occupant exposure.

Control Methods

There are three possible methods for controlling asbestos fiber release from spray-applied friable asbestos-containing insulation materials. The first method is complete removal. The second method is to place a barrier (such as a drop ceiling) between the asbestos-containing material and the usable area of the room. The third method of containment is by applying a sealant (encapsulant) to contain and prevent release of asbestos fibers.

Removal

Complete removal is the most positive method of controlling asbestos fiber contamination. Some of the concerns about removal are (1) that the recommended removal techniques be developed and followed by all contractors and (2) where the removed asbestos-containing material has been used for fireproofing that a replacement non-asbestos material be applied to maintain the required fire protection.

Removal Techniques. There are two methods of removal, dry and wet. In all cases, dry removal has resulted in massive asbestos fiber release and therefore is not recommended except in very special cases where wetting the material with water would be hazardous. When dry removal of the material is necessary, extreme precautions for worker protection and containment should be observed.

Wet removal involves wetting the asbestos-containing material with water. The water is amended with a surfactant to enhance penetration into the asbestos-containing material and to reduce the amount of water required.

Both removal methods require that the area be isolated by the use of disposable plastic sheeting or tarpaulins to prevent fiber contamination to other areas of the building. For the same reason the EPA guidance document suggests that all ventilating and heating systems should be shut down and all vents into the area sealed.

The workers are protected by wearing approved respirators and disposable protective clothing, by taking showers each time they leave the work area, including lunch breaks, and by not smoking or eating within the containment area.

Protective Barrier

Installation of a protective barrier, such as a drop ceiling, has been suggested as a possible method of containment in situations where removal is not practical or necessary. However, a drop ceiling is relatively less effective than other methods of fiber containment. One disadvantage in this method is that loose asbestos fibers can collect on the reverse side of the barrier and any entry into this area may result in significant fiber release. Also, unless the drop ceiling is tightly sealed, fibers can filter down through spaces between the tiles.

Placing a barrier such as plaster board directly against the friable asbestos-containing material may provide some protection if all joints are taped and sealed. However, installation of hangers or lathe to support the plaster board can result in fiber release. Also, unless the barrier system is constructed within large flat areas containing no pipes, duct work or electrical fixtures, it is doubtful that a complete seal can be achieved. Moreover, any entry into this area can result in substantial fiber release.

Encapsulation with a Sealant

Sealant encapsulation of asbestos-containing materials has both advantages and disadvantages. One disadvantage is that when a sealant is used, the asbestos-containing material is retained in the building. Therefore, in areas where constant repairs or reworking would be required, a sealant would be less effective than removal. Also, sealants should not be used where there is the possibility of heavy or constant impact or where there is high accessibility to the encapsulant or sealant, such as in low classroom ceilings or hallways.

The primary advantage of using a sealant is that application difficulties are minimized. Uneven surfaces or even those areas cluttered with conduit, duct work, and other equipment are frequently located in overhead maintenance areas. Removal of asbestos-containing insulation from cluttered areas is time consuming and difficult.

Before a sealant can be used the condition of the material to be sealed must be determined. If the insulation material has poor bond strength, poor cohesive strength, or has been damaged by water, the use of a sealant would be questionable. To be effective the sealant should (1) eliminate fiber release by adhering to or penetrating into the fibrous insulation material, (2) have good impact strength so that when struck accidently by an object it does not crack or break loose, (3) have sufficient flexibility to resist structural settling and atmospheric changes, (4) not significantly reduce the fire protection provided by asbestos, (5) have a low level of smoke and toxic fume generation, and (6) have good aging properties.

Categories of Sealants. Sealants fall into two basic categories: penetrating sealants and bridging sealants. Penetrating sealants generally are water-thinned, unpigmented, and fairly low in solids. These sealants function by penetrating into the asbestos-containing insulation material. Ideally, they should penetrate to the underlying substrate and improve both the adhesion and the cohesive strength of the asbestos-containing insulation. Obviously, penetrating sealants must contain the asbestos fibers within the insulation material.

Bridging sealants usually are pigmented and contain a higher level of solids than penetrating sealants. Bridging sealants can have some penetration into the asbestos-containing material, usually about one-half inch, but mainly the sealant forms a complete film over the entire surface of the insulation material. A bridging sealant also has a more decorative finish than a penetrating sealant.

Sealant Application Method. The recommended method for applying a sealant to the friable asbestos-containing material is through the use of an airless spray unit. This unit provides a low spray pressure that gives good atomization of the sealant. Even with these precautions significant asbestos fiber release can occur. Therefore, airless spray application of a sealant requires similar worker protection and containment to that recommended for removal of asbestos material. In some areas where heavy usage occurs a combination of the sealant and a dropceiling may be very effective in containing the release of asbestos fibers.

Battelle Columbus Laboratories presently is conducting a study of the effectiveness of various sealants under a contract for the EPA, Power Technology and Conservation Branch, Industrial Environmental Research Laboratory located in Cincinnati, Ohio. This study should be available in mid-1979 from EPA.

COST ESTIMATES

Very little data have been reported detailing time and costs associated with corrective measures for either the removal of or the encapsulation with a sealant of spray-applied asbestos-containing materials. However, the following discussion provides a broad estimate of costs associated with each corrective measure.

Bulk Sampling

The costs associated with taking bulk samples should be minimal. As discussed earlier, taking a bulk sample is relatively easy although the suggested precautions should be followed. The sampling can be performed by custodial personnel and approximately 10 to 12 bulk samples can be taken from a building in an hour. From these data, it is estimated that the cost of bulk sampling should range from $1.00 to $1.50 per sample.

Air Sampling

Only by taking an air sample can the amount of hazardous asbestos fibers in ambient air be determined. As described earlier, this method involves collection of the fibers on a filter using a pump to direct a known quantity of air through the filter. Although this procedure is not difficult it should be performed by trained personnel so that the exposed filters are handled properly, insuring that no fiber loss occurs through careless handling. Sampling times can range from one hour to four hours. Several sampling units may be operated in various locations within a building at the same time. Initial capital outlay for pump and filter holder range between $500 and $750.

In a private communication with a contractor, it was learned that he charged between $200 to $250 a day to take air samples. This rate is dependent upon the location, accessibility and the number of samples required.

Bulk Sample Analysis

Analysis costs for bulk samples have been listed in an EPA report entitled Sprayed Asbestos-Containing Materials in Buildings[3]. These costs are as follows:

(1) Petrographic microscopy

$25 to $100 per sample, with the cost per sample varying with the total number of samples submitted (higher costs for fewer samples).

(2) X-ray diffraction

$75 to $150 per sample.

(3) Electron microscopy

$300 to $500 per sample.

Air Sample Analysis

The cost for asbestos fiber analysis in air samples also was estimated in the same report[3]. Phase contrast optical microscopy (the NIOSH method) costs between $35 and $50 per sample. Electron microscopy was estimated to cost between $300 to $500 per sample.

Removal Costs

No actual costs for removal of sprayed-applied asbestos-containing insulation are available in the published literature. It has been reported[8] that "two New Haven Schools spent about $10,000 for small removal operations, while a larger job in Lee High School, in which the natatorium and gym required attention, cost about $20,000". No indication was given as to the amount of square footage removed.

Another report[2] stated that "Removal work went efficiently with 1000 square feet of asbestos being removed in less than 90 minutes by two workmen following room enclosure".

Personal contact with a contractor who has performed a considerable amount of removal work and sealant application resulted in the following cost estimates for removal. For ideal areas, that is, large flat surfaces with little duct work or other structural members, the cost was estimated to be $1.75 per square foot. In more congested areas containing duct work and steel structural members, the cost per square foot increases to as much as $4.20. These costs include the expense of containment, workers' protective clothing and breathing equipment as well as the cleanup and correct disposal of waste.

Barrier Installation

One local contractor quoted a price of $1.25 to $3.50 per square foot for installation of a barrier-type ceiling. The price is dependent upon job complexity, that is, the amount of duct work or the type of substance encountered (cement, dry wall, or metal grid). As the number of complicating factors increases, so does the cost.

Sealant Application

Application costs for sealants range from $1.80 to $2.50 per square foot according to the contractor noted above. Another source has estimated sealant costs to be as high as to $3.00 per square foot. Again, these costs provide for complete containment, worker protection, and clean-up.

Other Costs

In areas where removed materials served as a fireproofing material, reinstallation costs for spray-application of nonasbestos containing materials for fire protection range from $1.50 to $2.50 per square foot.

COST SCENARIOS

The following two scenarios are given as examples of possible costs that can be expected. Each scenario describes a probable situation and the costs involved in correcting that individual situation. The school is a fairly simple example whereas the office complex is a much more involved situation. In the office complex, cost estimates are included for both encapsulation with a sealant and removal.

A School Building

In this school completed in 1964, an insulation material can be seen on the gym ceiling and in the surrounding halls. The insulation material is about one and one-half inches thick and is in poor condition. In some areas, mainly in the hallways, it has been heavily damaged by the students.

The building specifications do not identify what type of insulation material was used. The gym is 280 feet long and 120 feet wide for a total area of 33,600 square feet. The hallways were eight feet wide and a combined length of 408 feet for a total area of 3,264 square feet.

To determine the type of insulation material used, eight bulk samples were taken. After analysis by petrographic microscopy it was found that the insulation contained a 30 percent asbestos fiber content by weight. Due to the high accessibility and poor condition of the insulation, air sampling for actual fiber count was deemed not to be necessary. The decision was made to completely remove the insulation material. Because there was no duct work or exposed support beams, the removal task was considered to be an ideal situation. After removal of the insulation all areas were painted. Table 1 lists cost estimates for this removal and painting operation.

TABLE 1. COST ESTIMATES FOR REMOVAL OF ASBESTOS-CONTAINING MATERIALS IN A SCHOOL

Item	Number	Cost, dollars	
		Unit	Total
Taking bulk samples	8 ea	1 ea	8
Analysis of bulk samples	8 ea	50.00 ea	400.00
Removal of asbestos containing insulation[a]	36,864 sq ft	1.75/ sq ft	64,512.00
Painting	36,864 sq ft	0.11/ sq ft	4,055.00
Total			68,975.00
Cost Per Square Foot			1.87

vs sealant at $2.25 (p.26)

(a) Removal procedure includes isolation, worker protection, clean-up, and disposal of asbestos waste.

An Office Complex

A small office complex, four stories high, was insulated according to the building specifications with an asbestos-containing material. The building is a poured concrete structure. All overhead areas are enclosed with a suspended acoustical tile ceiling. This ceiling conceals the electrical conduit, communications conduit, water lines for a sprinkler system used for fire protection, and duct work for air conditioning. Also, the area above the drop ceiling is used as a return air plenum.

The entire area above the suspended ceiling was coated with a spray-applied insulation material. The total floor area of the building is 72,000 square feet, which gives 18,000 square feet per floor. However, the total area covered would be in excess of this square footage, because the insulation was applied on the walls down to the 18 inch drop of the suspended ceiling as well as covering all duct work. An estimated factor for actual area covered would be 1.2 times the actual floor area.

Bulk samples were taken from each floor to confirm that the insulation did contain asbestos. Several air samples were taken. Analysis e.m.? of the air samples indicated that as long as the suspended ceiling was not disturbed, the fiber count was low. When the ceiling was distrubed the fiber count increased dramatically.

Because of the difficulty in completely removing the material caused by the congestion above the suspended ceiling, it was decided to use a sealant to encapsulate the asbestos surface. Cost estimates for this procedure are listed in Table 2.

Removal costs for the same office complex can be estimated by substituting an estimated cost for difficult removal work in the congested area ($4.20 per square foot), for the sealant application cost. In this scenario, the price per square foot is increased by 50 percent or more. The total cost would be $465,108.00 and the cost per square foot of floor area would be $6.46.

TABLE 2. COST ESTIMATES FOR SEALANT APPLICATION IN AN OFFICE COMPLEX

Item	Number	Cost, dollars Unit	Total
Bulk sampling	8 ea	1.00 ea	8.00
Bulk analysis	4 ea	50.00 ea	200.00
Air sampling	1 set	200.00 set	200.00
Air sample analysis	6 ea	50.00 ea	300.0C
Sealant application[a]	86,400[b]	2.25/sq ft	194,400.00
Removal and replacement of suspended ceiling (quoted as one job)	72,000 sq ft	1.41/sq ft	101,520.00
Total Cost - Entire Building			296,628.00
Cost Per Square Foot of Floor Space			4.12

(incl clean-up & disposal?)

(a) Sealant application includes cost of sealant, protective clothing for workers, total containment of fiber within the rooms, and clean-up and disposal of the protective clothing and containment materials used.

(b) Square footage multiplied by factor of 1.2.

Removal cheaper than sealant.

COMPANIES ACTIVELY ENGAGED IN ASBESTOS ANALYSIS, ENCAPSULATION OR REMOVAL

The listings of contractors or companies included here are by no means completed. Also no recommendation is implied by includion of their names in this report.

Table 3 listes accredited laboratories, who will analyze samples for asbestos content on a fee basis. The list was received from the American Industrial Hygiene Association (AIHA). Most State laboratories also do asbestos analysis. Table 4 lists those state laboratories accredited by the AIHA whose work is typically done at no charge for public institutions such as schools and hospitals.

Thus far, the use of sealants has been limited. Battelle Columbus Laboratory's study of sealants sponsored by EPA is in its final stages. It has as its objective the identification of suitable sealants and the demonstration of their use in the field. A final report still to be prepared will make available information on sealant materials, application methods, and precautions to be taken in their employment. Further, Battelle is preparing a video tape aid as part of the EPA technical service program which will describe inspection and sampling procedures and show removal, encapsulation and enclosure operations.

Many companies submitted samples of materials for evaluation in the EPA program. Obviously, numerous companies sell or supply materials which might be used as sealants. However, these suppliers are not actively engaged in application of the materials. Application will probably be done by paint contractors and/or companies engaged in insulation application. One major problem is that their personnel needs to be trained in the proper techniques of both sealant application and asbestos removal.

Battelle has been able to identify only two companies that state they are actively engaged in asbestos removal and/or sealing and that they are following the guidelines recommended in the EPA Guidance

TABLE 3. ACCREDITED LABORATORIES FOR ASBESTOS ANALYSIS

Aetna Life and Casualty Company
Engineering Industrial Hygiene Lab.
151 Farmington Avenue
Hartford, Connecticut 06115
John M. Robinson, Director

American Can Company
Safety & Industrial Hygiene Lab
U.S. Highway 22
Union, New Jersey 07083
R. A. Yerg, M.D., Director

American Mutual Insurance Companies
Industrial Hygiene Laboratory
Wakefield, Massachusetts 01880
Leon D. Horowitz, Director

ASARCO, Incorporated
Department of Environmental
Sciences Laboratory
3422 South 700 West
Salt Lake City, Utah 84119
Robert D. Putnam, Ph.D., Co-Director
M. O. Varner, Co-Director

Anaconda Company
Natural Resources Division
Environmental Laboratory
8000 S. Kolb Road
Tucson, Arizona 85726
Rodney J. Anderson, Director

Analytical Research Laboratories, Inc.
160 Taylor Street
Monrovia, California 91016
M. L. Moberg, Director

Clayton Environmental Consultants, Inc.
25711 Southfield Road
Southfield, Michigan 48075
Jaswant Singh, Ph.D., Director

Continental Insurance Company
Environmental Health Laboratory
1810 Commerce Street
Dallas, Texas 75201
David McNamara, Director

TABLE 3.
(Continued)

Employers Insurance of Wausau
Environmental Health Laboratory
2000 Westwood Drive
Wausau, Wisconsin 54401
Tom Stravros, Ph.D., Director

Enbionics
Occupational Health Laboratory
1469 South Holly Street
Denver, Colorado 80222
Lois L. Gerchman, Ph.D., Director

Environmental Health Laboratory
P.O. Box 6195
Macon, Georgia 31208
Alice C. Farrar, Director

Environmental Health Laboratories
Kemron
Borg-Warner Corporation
32740 Northwestern Highway
Farmington Hills, Michigan 48018
Ralph G. Smith, Ph.D., Director

Fireman's Fund Insurance
(Falcon Customer Services, Inc.)
Environmental Laboratory
3333 California Street
San Francisco, California 94119
Jerry Tuma, Ph.D., Director

Freeport Brick Company
P.O. Box 557
Cotton Road
Meadville, Pennsylvania 16335
J. Richard Wohler, Ph.D., Director

Gannett-McCreath Laboratories
Environmental Analytical Laboratory
P.O. Box 1963
Harrisburg, Pennsylvania 17105
H. Bruce Gerber, Director

Hager Laboratories
12000 E. 47th Avenue
Denver, Colorado 80239
Robert N. Hager, Jr. Ph.D., Director

TABLE 3.
(Continued)

Hanford Environmental Health Foundation
Environmental Health Sciences Laboratory
P.O. Box 100
Richland, Washington 99352
Bruce D. Reinert, Director

Industrial Health Foundation, Inc.
Analytical Laboratory
Carnegie-Mellon Institute of Research
Box 33
Pittsburgh, Pennsylvania 15213
Daniel C. Braun, M.D., Director

Interlake, Inc.
Interlake Technical Center
Environmental Control Laboratory
150 West 137th Street
Riverdale, Illinois 60627
Fred G. Krikau, Director

Kem-Tech Laboratories
Kemron
16550 Highland Road
Baton Rouge, Louisiana 70808
Sham L. Sachdev, Ph.D., Director

LFE Corporation
Environmental Analysis Lab. Division
2030 Wright Avenue
Richmond, California 94804
Marcel Nathans, Ph.D., Director

Massachusetts Institute of Technology
Industrial Hygiene Laboratory
77 Massachusetts Avenue
Cambridge, Massachusetts 02139
Richard I. Chamberlin, Director

Monsanto Research
Dayton Laboratory
1515 Nicholas Road
Dayton, Ohio 45407
Dr. William Haynes, Director

National Loss Control Service Corporation
(Lumbermens Mutual Casualty Company)
Environmental Sciences Laboratory
Long Grove, Illinois 60049
Joan A. Wronski, Director

TABLE 3.
(Continued)

Pedco Environmental Specialists
11499 Chester Road
Cincinnati, Ohio 45246
Lawrence A. Elfers, Director

Radiation Detection Company
162 Wolfe Road
P.O. Box 1414
Sunnyvale, California 94088
Joe Lipera, Director

St. Paul Fire & Marine Insurance Company
Environmental Services
Analytical Laboratory
494 Metro Square Building
7th & Roberts Streets
St. Paul, Minnesota 55101
Donald J. Larsen, Director

Sentry Insurance
1800 North Point Drive
Stevens Point, Wisconsin 54481
Robert Voborsky, Director

Sherwin Williams Company
10909 S. Cottage Grove Avenue
Chicago, Illinois 60628
Richard W. Scott, Director

Suntech, Incorporated
Industrial Hygiene Laboratory
P.O. Box 1135
Marcus Hook, Pennsylvania 19061
David M.G. Lawrey, Director

Travelers Insurance Company
Chemical & Environmental Laboratory
1 Tower Square
Hartford, Connecticut 06115
Harry W. Rapp, Jr., Director

University of Cincinnati
Kettering Laboratory, Analytical Section
3223 Eden Avenue
Cincinnati, Ohio 45267
B. E. Saltzman, Ph.D., Director

University of Iowa
State Hygienic Laboratory
Medical Laboratories Building
Iowa City, Iowa 52242
W. J. Hausler, Jr. Ph.D., Director

Utah Biomedical Test Laboratory
520 Wakara Way
Salt Lake City, Utah 84108
James H. Nelson, Ph.D., Director

TABLE 4. STATE LABORATORIES FOR ASBESTOS ANALYSIS

Alberta Labour
Occupational Health and Safety Division
10523 - 100 Avenue
Edmonton, Alberta, Canada T5J0A8
Ian Drummond, Director

Arizona Department of Health Services
State Laboratory
1520 West Adams Street
Phoenix, Arizona 85007
Jon M. Counts, Ph.D., Director

Colorado State Department of Health
4210 E. 11th Avenue
Denver, Colorado 80220
David McGuire, Ph.D., Director

Connecticut State Department of Health
Laboratory Division
10 Clinton Street
Hartford, Connecticut 06106
William W. Ullman, Ph.D., Director

Maryland State Department of Health
and Mental Hygiene
Occupational Health and Air Quality Laboratory
201 West Preston Street
Baltimore, Maryland 21202
Kenneth M. Hallam, Director

North Carolina Department of Human Resources
Environmental Science Branch
Occupational Health Laboratory Unit
P.O. Box 28847
Raleigh, North Carolina 27602
Robert J. Drye, Jr., Ph.D., Director

Ohio State Division of Public Health Laboratory
Industrial Chemistry Section
1571 Perry Street
Columbus, Ohio 43201
C. C. Croft, Sc.D., Director

Pennsylvania Department of
Environmental Resources
Occupational Health Laboratory
3rd and Reilly Streets
Harrisburg, Pennsylvania 17120
Virginia V. Smith, Director

TABLE 4.
(Continued)

South Carolina Department of
Health and Environmental Control
Occupational Health Laboratory
Division of Environmental Health
2600 Bull Street
Columbia, South Carolina 29201
H. Grady Callison, Jr., Director

State of California
Air and Industrial Hygiene Laboratory
2151 Berkeley Way
Berkeley, California 94704
Jerone J. Wesolowski, Ph.D., Director

State of California
Southern California Laboratory
1449 West Temple Street
Los Angeles, California 90026
Remo Navone, Director

State of Oregon
Occupational Health Laboratory
Accident Prevention Division
1400 S.W. 5th Avenue
Portland, Oregon 97201
Olav Merilo, Director

State of Tennessee
Occupational Health Laboratory
Cordell Hull Building
Nashville, Tennessee 37219
Robert Walle, Director

State of Washington
Department of Labor and Industries
Industrial Hygiene Laboratory
P.O. Box 207
Olympia, Washington 98504
Charles E. McTilton, Ph.D., Director

Wyoming Department of Agriculture
Division of Laboratories
P.O. Box 3228
University Station
Laramie, Wyoming 82071
Michael Purko, Director

Document[3]. These companies are:

(1) Acmat Corporation
141 Prestige Park Road
East Hartford, Connecticut 16108

(2) H. E. Murdock & Sons, Inc.
P. O. Box 45
West Haven, Connecticut 06516

The publicity from the EPA program still in progress will probably stimulate companies to enter into the asbestos containment business. As their names become available to the BCL staff they can be supplied to CPSC.

only 2 approved renovation outfits in the USA ?!

REFERENCES

(1) New York Times, Tuesday, November 8, 1978

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(3) Sprayed Asbestos-Containing Materials in Buildings: A Guidance Document, U.S. Environmental Protection Agency, EPA 450/2-78-014, March, 1978.

(4) Asbestos: An Information Resource, U.S. Department of Health Education and Welfare, May 1978.

(5) Chemical Market Input/Output Analysis of Selected Chemical Substances to Assess Sources of Environmental Contamination, Task III - Asbestos, EPA; 560/6-78-005, August 1978.

(6) Environmental Reporter, March 24, 1978.

(7) Toxic Substances Control Act.

(8) American School Board Journal, November 1978.