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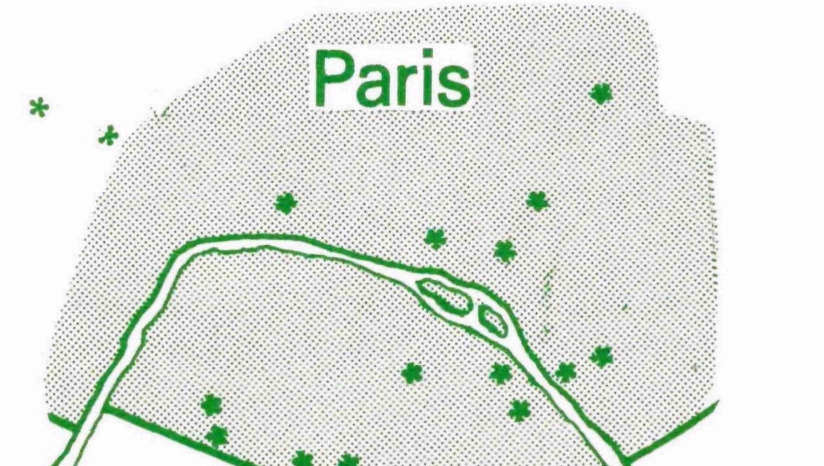

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MEASUREMENT OF ASBESTOS AIR POLLUTION INSIDE BUILDING SPRAYED WITH ASBESTOS

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ABSTRACT

This report is a translation of a document prepared in 1977 for the French Ministry of Health and the French Ministry for the Quality of Life-Environment on the measurement and assessment of airborne asbestos levels in buildings throughout Paris. The methods of air sampling and transmission electron microscopic analysis, as well as a discussion of the results, are presented. Also included are extensive tables and figures summarizing the data collected. The study was completed in 1977 by the Laboratoire d'Etude des Particules Inhalées (Préfecture de Paris) and the Institut de Recherches Universitaires Sur l'Environnement (Université Paris-Val de Marne). Mr. Patrick Sebestien (Préfecture de Paris) provided this revised update of the study in July 1980.

PREFACE

The Office of Pesticides and Toxic Substances (OPTS) encourages international cooperation and collaboration on the measurement and control of toxic chemicals. In this spirit, OPTS's Survey and Analysis Division (SAD) has been collaborating with the Préfecture de Paris, Laboratoire d'Etude des Particules Inhalées, and the Université Paris-Val de Marne on the measurement and assessment of airborne asbestos levels in schools and public buildings.

The mutual interest of both the French and American groups in dealing with the asbestos indoor pollution problem has resulted in an open and continuing exchange of information and data from their respective efforts. This document represents one result of this cooperative interaction. Dr. Bignon and Mr. Sebastien have made their report to the French Ministries available to SAD and have obtained permission for the publication of its English translation as an EPA report.

The translation has been cited as a major reference in the OTS technical support document for the Asbestos-In-Schools Identification and Notification Rule. This report and other publications by Bignon and Sebastien constitute a significant portion of the transmission electron microscopy data available on asbestos indoor air pollution.

CONTENTS

TABLES

FIGURES

1. INTRODUCTION AND OBJECTIVES

Asbestos has been classified as a pollutant of the first category by the World Health Organization and by the Commission of the European Community. Measurements of atmospheric pollution by asbestos in the environment and epidemiological observations have shown that the health risks from ambient exposure to asbestos can be found outside the work place. The problems related to hazards to public health posed by the use of asbestos have been discussed in a document of the European Community[1].

The building industry utilizes asbestos on a large scale: asbestos-cement, insulating materials (thermal, electrical, or acoustic), additives for floor coverings or wall coverings, filters for ventilation, and sprayed insulation. The procedure of insulating by spraying mineral fibers was introduced in the U.S. in 1932[2].

There are many sprayed materials which differ in their compositions and the manner in which they have been applied. The fibers used are generally a mixture of synthetic fibers (glass wool, mineral wool) and asbestos fibers. The proportion of asbestos in these mixtures ranges from 0 to 100%.

The sprayed asbestos insulation is utilized for fire protection, thermal and sound insulation, decoration, and condensation control. The cost of spraying is less than the cost of insulating by conventional means. The sprayed insulation ensures a uniform protective coating without joints, it can be applied quickly and easily, and it weighs less.

Unfortunately, the spraying with asbestos brings up a series of problems in both the areas of industrial hygiene and environmental pollution. For example:

A. Its use exposes the workers who apply the insulation to high concentrations of asbestos fibers[3].

B. During this work, the atmospheric pollution in the vicinity of sites of work is abnormally high[4].

C. The workers actually spraying the insulation are not the only workers exposed. A whole series of other workers such as electricians, plumbers, and painters can inhale the dust they produce while working on the insulation material[3].

D. The problems related to the pollution with asbestos do not end with the completion of the construction. Indoor pollution also occurs due to degradation of the insulation material exposing the users of the building[2,5].

E. There are several technical means to prevent this indoor pollution but neither the efficiency nor the long-term effectiveness of these methods has been thoroughly tested.

F. The destruction of the insulation due to demolition or modifications of the buildings causes considerable pollution[6].

Facing the multiple problems set up by spraying insulating materials containing asbestos, some countries, such as the United States, have forbidden the spraying of insulation materials containing more than one percent of asbestos[7]. Similar regulations have been recently established in France.* However, the present

*Décret n 78-394 du 20 mars 1978 relatif à l'emploi des fibres d'amiante pour le flocage des bâtiments. Journal Officiel De La Republique Francaise. 23 Mars 1978, p. 1279.

or future problems associated with existing insulation still remain. It is estimated that, to date, about 4,500,000 m^2 have been insulated with sprayed asbestos materials in France[8/].

The "Laboratoire d'Etude des Particules Inhalées" has developed a program for the measurement of the levels of air pollution in the areas insulated by sprayed asbestos materials. This program has been partially financed by the Ministery of the Quality of Life and by the Ministery of Health. The following objectives have been established:

1. To conduct an "investigative survey" to compare the levels of indoor airborne asbestos pollution found in these buildings with the levels of airborne asbestos pollution which have been measured in other circumstances.

2. To make a list of different factors contributing to indoor airborne asbestos pollution.

3. To specify mechanisms involved in the generation of indoor asbestos pollution associated with sprayed asbestos materials.

4. To evaluate the effectiveness of several technical procedures aimed at reducing the release of asbestos from the sprayed surfaces.

5. To assess the exposure of the general public to indoor airborne asbestos pollution resulting from the use of sprayed materials.

6. To propose measurement criteria which could serve as a basis for regulation.

2. METHODS

2.1. Sampling

There are two phenomena which could lead to the pollution of indoor ambient air:

- The activity of an interior source of emission.

- The influence of the exterior atmospheric pollution. Measurements have shown that for some pollutants, the internal levels may be higher than the external levels[9/].

Ambient airborne asbestos pollution by asbestos is relatively well known[10/]: there exists, notably in large urban centers, a general pollution level to which local higher concentrations, often related to sources of industrial emissions, are added.

In order to compare indoor and outdoor airborne asbestos pollution, the following sampling and analysis program has been carried out (Table I):

- Measurements were made in the vicinity of ten buildings sprayed with asbestos to verify that these sites were not located in areas of elevated ambient asbestos concentrations.

- Measured levels of ambient airborne asbestos pollution in Paris have been reviewed to permit an estimation of the background asbestos levels in the metropolitan areas where the buildings studied were located.

- Control buildings (buildings not containing sprayed asbestos insulation) were sampled to compare the asbestos levels inside the control buildings with the outside ambient air.

All the activities of the "Laboratoire d' Etude des Particules Inhalées" at the designated sites were made after written inquiries were submitted to the "Direction des Affaires Sanitaires et Sociales de Paris". In addition, within the framework of the contract with the Ministry of Health, some of the air sampling was conducted by the "Centre Scientifique et Technique du Bâtiment". These points are mentioned to emphasize that the buildings were not chosen by statistically representative random sampling. The results have been analyzed retrospectively.

2.2. Descriptive Study of Sprayed Buildings

Despite the fact that the field of construction materials does not represent an area of expertise for this Laboratory, certain technical information was collected in order to enable us eventually to correlate the measured levels of indoor airborne asbestos with the architectural data. Following a literature survey 2,6,8/, it appeared that the following parameters were of interest:

a. Composition of the sprayed materials:

Given the diversity of materials used, the most accurate information would be supplied by the builder. Unfortunately, in the majority of the cases studied, this information was not available. In all instances, samples of materials taken from the sites have been analyzed with a polarizing light microscope to determine the presence of asbestos. This method allowed us to distinguish without any confusion between the asbestos fibers (amphibole or chrysotile) and the glass fibers which are usually mixed in these materials. However, the above protocol did not allow us to determine the percentage of the asbestos fibers in these materials. There are other methods which are more quantitative, but slower, such as x-ray diffraction and differential thermal analysis; however, the use of these methods is hindered by the complex matrix of the sprayed insulation materials. (The materials usually contain 5 to 30% asbestos besides mineral wool, clay binders, and synthetic resins.)

Not all the materials sampled contained asbestos. Such sites have therefore been treated as control sites. The use of the microscopic method has allowed us to document the heterogeneous distribution of the asbestos fibers in the sprayed insulation materials. It was necessary to analyze several samples from the same insulation material in order to document the presence of asbestos.

b. The method of spraying the insulating material:

The following two techniques have been used:

- Dry spraying, where the fibers and the binder are carded, then drawn in by suction, and wetted only at the exit through the nozzle of the sprayer. This technique is known to produce a friable sprayed material or a "soft sprayed material."

- Paste spraying, where the fibers are mixed with a wetted binder. These sprayed materials generally have a plaster base. Such types of insulation are usually much harder and heavier and, as a consequence, these characteristics must be considered for in planning the structure of a building.

c. The cohesion of the sprayed material:

Some authors[2/] claim that the visual examination of the surface of the insulation (in particular, the soft spray type) allows one to assess the cohesion of the sprayed material. This is possible in those cases where delamination of portions of the sprayed insulation is visible. However, visual inspection is of little use when faced with situations involving microscopic degradation of the insulation material.

In fact, the cohesion of the sprayed material is a parameter which we find difficult to evaluate; it depends both on the nature of the material and on its support as well as on the method of application.

d. The insulation material's potential to contaminate and degrade as a function of its location:

The surface area covered by a sprayed material within a building is an important parameter. Maximum surface area is attained when both the walls and ceilings are sprayed; in other buildings only the ceilings or the metal beams (horizontal or vertical) are sprayed. Independent from any degradation of the sprayed material, the possibilities of contamination of the ambient air can be different, depending upon the plan of the building and the location of the sprayed insulation. Accordingly, we have encountered four distinct configurations:

- Exposed sprayed material without protection, directly in contact with ambient air.

- Protected sprayed material (double ceiling, encasing of vertical parts). In this case, the lack of air-tightness could lead to contamination of the ambient air.

- Sprayed material within the ventilation circuit. In buildings equipped with an air conditioning system, the air returns can occur between the sprayed surface and the suspended ceiling. Accordingly, if the air is being recycled in the building, the contamination of the air in the building is therefore possible.

- Sprayed material in neighboring areas. In this case the sprayed material is not located in rooms generally used by the occupants of the buildings but is found in adjacent technical service space. Circulation of the air between the two areas can lead to contamination of the occupied space.

The potential possibilities for the degradation of sprayed materials can be related to the different types of structural configurations mentioned above. Thus, exposed sprayed materials could be degraded by mechanical impact. In the same way, sprayed materials in air returns are subject to degradation due to the forced circulation of air.

e. Activities in the building:

Certain work environments (such as machine shops) can produce structural vibrations and mechanical shocks of the insulation which can lead to its degradation. In addition, the activity of personnel in a given area contributes to reentrainment of the asbestos debris.

f. Air renewal in the buildings:

This is a general parameter which influences all types of pollution resulting from a source located within the building. One can wonder, nevertheless, if the air movements associated with the air renewal do not play a role in the degradation of the sprayed material.

g. Building maintenance:

The degradation of the sprayed asbestos material is increased if, during building maintenance (replacement or modification of the ventilation ducts, electrical wiring, plumbing, etc.), the sprayed material is subjected to mechanical shocks. The cleaning services provided in a building is another factor to be considered; the accumulation of dust in places difficult to reach represents a potential risk for contamination.

h. Protective measures:

In some of the buildings studied, work has been done in order to prevent the emission of fibers from the insulation. The effectiveness of such measures has been studied by analyzing the levels of pollution before and after these operations.

The descriptive data collected to date are qualitative and quite approximate. A preliminary survey using a standardized questionnaire to be completed by the occupants of the building was attempted but promptly abandoned:

- The questionnaire requested detailed information on the construction and repair of the building which was not available to the participants completing the form.

- The participants considered the questionnaire to be too technical and too precise in the information requested.

- The validity of the information gathered was placed in doubt because it was addressed to the users of buildings rather than to the builders. Moreover, the "Laboratoire d'Etude des Particules Inhalées" did not have the needed know-how to judge the validity of the construction materials data gathered.

- The response time of survey participants was generally too long to be of value.

- It was found that the diversity of the situations encountered made it difficult to match the on-site observations with entries on the standardized questionnaire.

2.3. Air Sampling

Several sampling sites were established in each building. The number of these sites was a function of the homogeneity of the sprayed materials as well as the use and structural characteristics for each site. In the study conducted for the Ministry of Health, four indoor and two outdoor sampling sites were established in each building. The samples were taken so as to insure that they would provide an estimate of exposure to the occupants of those buildings, i.e:

- The air sampling devices were installed in the activity areas at about 1.5 meters above the ground.

- They functioned simultaneously during normal work periods.

- Airborne particles were collected on membrane filters, nominal porosity 0.45 μm, positioned vertically. The flow rate was 5 liters/minute.

- In order to simulate a workweek's average exposure on each filter, the sampling times were integrated over the work periods of five consecutive days.

2.4. Analysis

The method of analysis was developed according to the recommendations of the C.C.E[12] (Commission of the European Community) and consisted of the following:

- Destruction of the filter and of the organic particles by ashing at low temperatures.
- Recovery of the ashes in a liquid phase.
- Dispersion of the particles by ultra-sonification.
- Separation of the phases by microfiltration.
- Preparation of grids by direct transfer for the transmission electron microscope (TEM).
- Observation of an area of the prepared grid by means of the TEM with a direct magnification of 30,000 times.
- Identification of the asbestos fibers by means of morphologic examination, selected area electron diffraction, and energy dispersive spectrometry.
- Measurement of the dimensions (length and diameter) of the fiber.
- Integration of the morphometric data and the expression of the pollution mass by mass concentration of asbestos per cubic meter of sampled air.

The detection limit using this method is estimated to be 10^{-10}g asbestos per m^3 of air. The statistical validity of the results was automatically controlled as the preparation was being observed. The morphometric data were continuously recorded on a calculator which performed the gravimetric integration and indicated the 95% confidence interval. The area of a given sample preparation observed was a function of the homogeneity of the fiber distribution on the preparation. Sample examination was stopped when the precision of the measurement was less than 50%. In some cases, precision below 30% could be obtained.

The analysis of one sample requires about six person hours.

3. RESULTS

The results corresponding to different parts of the sampling program are presented in Tables II, III, and IV.

3.1. Background Levels of Ambient Airborne Asbestos Pollution

The results from Table III show that there is background pollution with chrysotile asbestos in the air of Paris. The concentrations are quite consistent and are distributed within a narrow range where 10 ng/m^3 represents the upper limit.

The measurements of ambient airborne asbestos pollution in the vicinity of ten sprayed asbestos buildings as well as the measurements inside the seven control buildings did not reveal any differences from the background levels observed throughout Paris. Given these results, the following conclusions have been made:

- The background ambient airborne asbestos pollution is due only to chrysotile asbestos.

- The background pollution levels throughout Paris are relatively uniform.

- The sprayed asbestos buildings studied were not located in areas with pollution levels higher than ambient background levels.

- Differences between the background airborne asbestos levels and the indoor ambient levels of the control buildings have not been detected.

- The background asbestos levels are statistically distributed. Factors influencing distribution include: sampling site, period of sampling, meteorological conditions, techniques of sampling, and analytical errors.

Keeping these observations in mind, all the measurements relating to background pollution (background measurements in Paris, measurements outside the sprayed buildings, and measurements inside the control buildings) have been pooled and analyzed. The statistical distribution of the 161 measurements is presented in Figure 1 (see below).

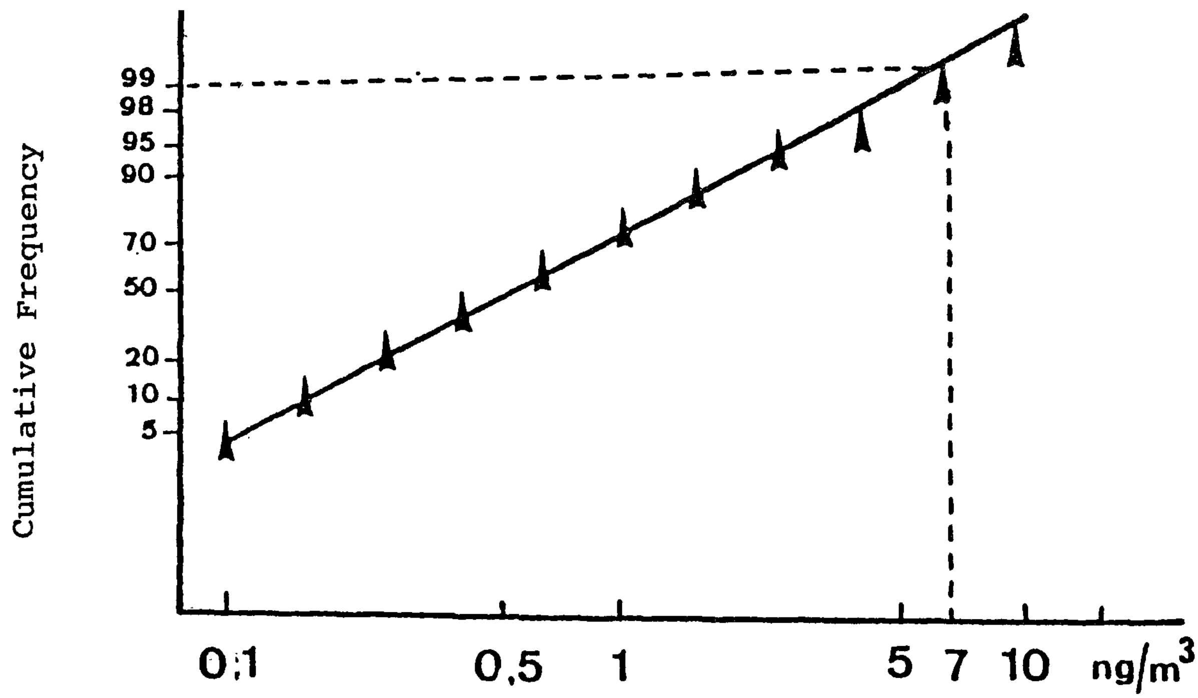


Figure I - Statistical distribution of values for the background level of pollution with asbestos in Paris.

Examining this figure, the following comments can be made:

- The measurements of the background chrysotile levels are log-normally distributed over the interval 0.1 - 10 ng/m^3.

- The arithmetic mean is 0.96 ng/m^3.

- The geometric mean is 0.47 ng/m^3.

- 99% of the values are below 7 ng/m^3.

- The value of 7 ng/m^3 has been chosen as a statistical limiting value (SLV) for the background levels in Paris. Any measurement greater than 7 ng/m^3 may be considered to represent a pollution level greater than the background.

It was important to have adequate analytical data on the background levels in Paris in order to properly assess indoor asbestos levels associated with sprayed materials.

3.2. Levels of Indoor Airborne Abestos Pollution in Sprayed Buildings

Measurements inside sprayed buildings are presented in Table V. Only those results corresponding to the samples taken during periods of normal activity within the buildings are reported. In this Table, concentrations of chrysotile and amphibole have been added together. The presence of amphibole fibers in an air sample which differs from the background level of chrysotile is evidence for a specific source of pollution.

Figure 2 (see p. 15) is a schematic representation of the results presented in Table V. The buildings have been ranked in the order of increasing geometric mean.

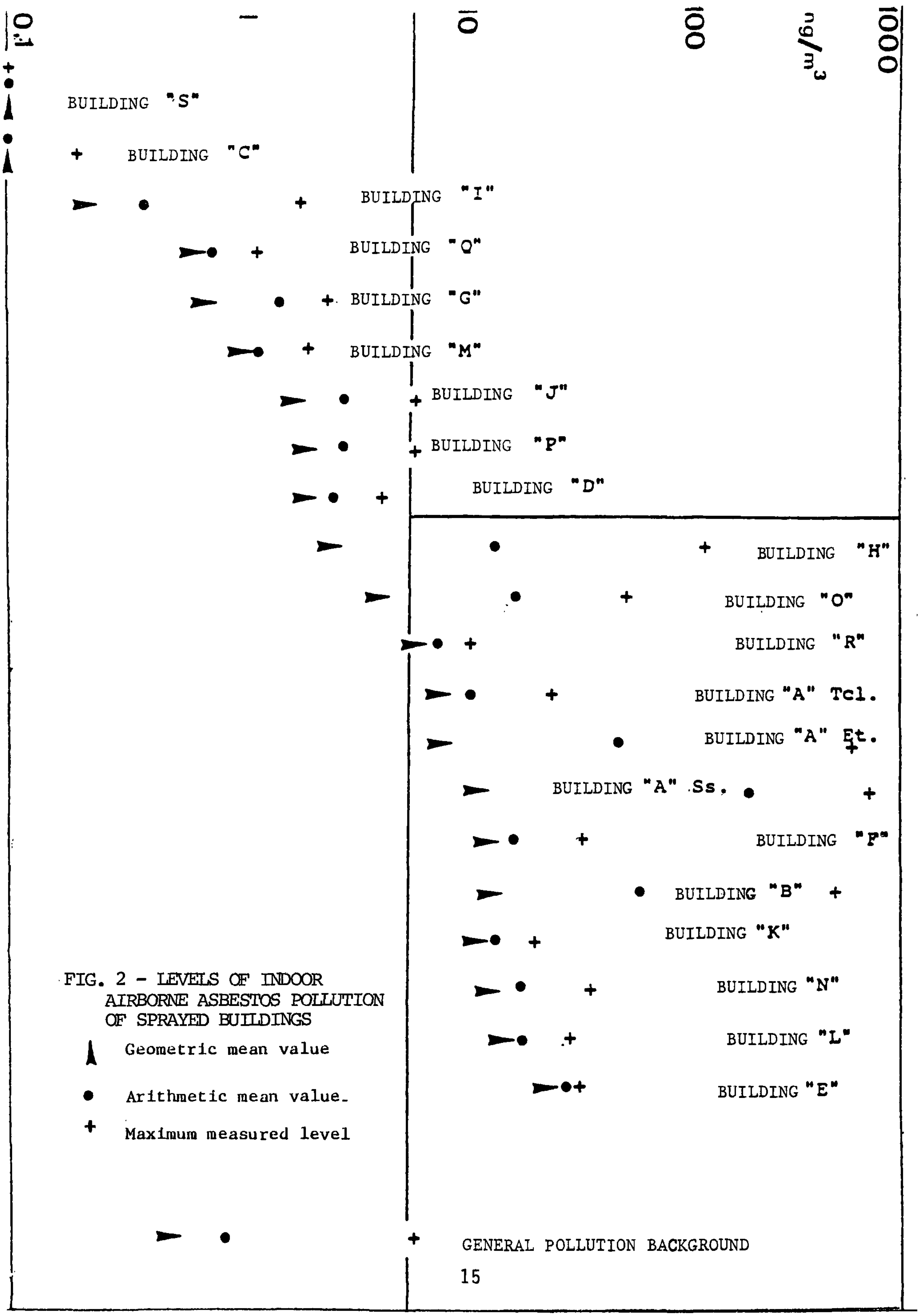


FIG. 2 - LEVELS OF INDOOR AIRBORNE ASBESTOS POLLUTION OF SPRAYED BUILDINGS

It is seen that the 21 buildings studied divide into two groups:

- For 9 buildings, the maximum values were not higher than the SLV (statistical limiting value) of 7 ng/m^3. It should also be noted that the geometric and arithmetic mean values were not significantly different from the mean background values.

- For each of the other 12 buildings studied, at least one value higher than 7 ng/m^3 has been recorded. Also, the geometric and arithmetic mean values were significantly higher than the mean background values.

These observations allow an initial distinction between polluted and nonpolluted buildings. It appears that the geometric mean value is a good indication of the overall pollution of a building given the homogeneity of the two groups identified above (see Figure 2). It should be noted that there is an unequivocal correspondence between the buildings where the maximum value measured exceeds the SLV of 7 ng/m^3 and the buildings where the two mean values (arithmetic and geometric) are significantly different from the mean background levels. This statistical differentiation between polluted and nonpolluted buildings was observed even in cases where only three measurements were made.

3.3 Descriptive Study of Sprayed Buildings

The relevant data gathered by the descriptive survey are reported in Table VI. It has been established that the several technical factors which are responsible for the pollution of a building always act simultaneously. In order to identify the more important factors contributing to the level of asbestos pollution, a statistical analysis should be conducted using multiple variables, more consistent data on construction materials and methods, and a larger number of samples. Nevertheless, the results tabulated in Table VI do provide insight into assessing indoor airborne asbestos pollution.

Spraying procedure

In this study, it has been found that dry spraying has been used more frequently (15 cases) than wet spraying (6 cases). Both types of sprayed materials were found in polluted and non-polluted buildings. These observations do not agree with those made by NICHOLSON[2] who reported that the "hard sprays", resulting from wet spraying, were nonpolluting. However, it should be noted that the "soft sprays" are more common in polluted buildings.

Cohesion of the insulation

It was difficult to evaluate rigorously the cohesion of the insulation materials. However, it might be considered that the observations of visual degradation (visible flaking, deposits of dust) of the sprayed materials would indicate elevated asbestos levels. Indeed, Table VI reveals, with one exception, that each time damage was observed the measurements indicated asbestos levels greater than 7 ng/m^3. It should, however, be noted that no such degradation was observed in five out of twelve buildings with elevated asbestos levels (greater than 7 ng/m^3).

Location of the insulation

Table VI shows that exposed insulation appears to be the most polluting type, no doubt because of their direct exposure to the air space and the relative ease with which they may be disturbed.

We have classified as "protected sprayed material" all those cases where any barrier was placed between the sprayed surface and the ambient air. This classification leads to results that are difficult to interpret since the degree of isolation for such surfaces was different from case to case.

Sprayed materials within the ventilation systems did not appear to contribute to elevated asbestos levels. It should be noted that in several cases the air was not recycled. Since the air spaces containing asbestos were under negative pressure, the potential of contaminating the environment within these buildings was reduced. It is also possible that the air filtration systems of these buildings play an equally protective role in minimizing asbestos levels.

Utilization of the area

The activities taking place in the area are a very important factor and this has been systematically observed during this study. It has been shown that the measurements were always lower in the less utilized areas, regardless of the type of building. This point will be discussed later in connection with the study on the mechanisms of indoor pollution generated by the sprayed material.

As a first conclusion of this descriptive study, it can be said that the polluted buildings are generally those where there is significant activity and where the insulation is exposed, was sprayed dry, and shows evident signs of deterioration. A second, more interesting conclusion concerns the possibility of predicting the pollution levels in a building based on the observation of some architectural characteristics. Such an assessment would avoid the necessity of an extended monitoring program using transmission electron microscopy of air samples. However, results of this study show that such an approach with the current state of knowledge would risk underestimating the number of polluted buildings.

3.4 Measurements after Corrective Actions

Measurements of airborne asbestos levels in buildings after work on the insulation materials has been completed are few in number. Those available are presented in Table VII.

The two examples on the removal (tearing-out) of the insulation reported here indicated levels were always high. With mixed materials (containing both amphibole and chrysotile fibers) airborne amphibole fibers not detected prior to the removal action were generally detected after the removal of the insulation.

From our limited experience, the removal of the asbestos insulation causes not only significant exposure of workers doing this job, but also the persistence of an elevated airborne asbestos level in the building, which is difficult to get rid of despite numerous clean-up operations. However, certain techniques can be used to limit contamination during the removal operation (wetting of the material, use of face masks by the workers, and isolation of the work areas to limit the diffusion of the asbestos particles).

A detailed technical description of methods used to minimize the pollution during asbestos insulation removal was published by SAWYER[6]. In France, similar techniques are employed for limiting the exposure of the workers and the diffusion of the asbestos dust into the neighborhood. However, the removal of the insulation poses practical problems in certain types of buildings. In effect, one of the advantages of sprayed insulation lies in the fact that the least accessible surfaces can be protected. In the same way, the same surfaces are difficult to reach when it comes to stripping and removal.

The removal of the insulation has the advantage that the source of pollution is removed, but maximum precautions must be taken to insure that removal operations do not lead either to exposure of the workers or to a persistant exposure of the occupants of the building after the completion of the work. SAWYER[6] has shown that the pollution levels by large fibers (measured with a light microscope) fall within 24 hours. However, the settled large fibers can be fragmented and resuspended by renewed activities in the building. This is why thorough clean-ups must be undertaken. The proper disposal of the removed material must also be considered.

Table VII shows excellent results have been achieved by protecting the insulation with a layer of plaster on metal. The deterioration of the insulation can be limited when this protective layer is installed to the extent that the plaster is not in contact with the asbestos.

Protection by direct deposition of an organic coating on the insulation has proven to be less effective. This process may present the disadvantage of making the lower part of the insulation heavier thus increasing the possibility of its pulling away from the substrate.

Simple cleaning of the buildings can temporarily reduce the pollution levels.

The data available are too few to recommend one type of corrective active over another. The data simply give an indication of the pollution associated with two types of operations: removal and enclosure. The "Centre Scientifique et Technique des Bâtiment" has proposed different control measures to be used in correcting asbestos insulation problems.

4. DISCUSSIONS

4.1. Mechanisms for the Generation of Indoor Airborne Asbestos Pollution

Mechanisms for generating indoor airborne asbestos pollution in sprayed buildings have been studied[6]. Three mechanisms can be identified (Figure 3, see page 22):

- -M1: Loss of fibers by a slow but continuous degradation of the insulation surface.

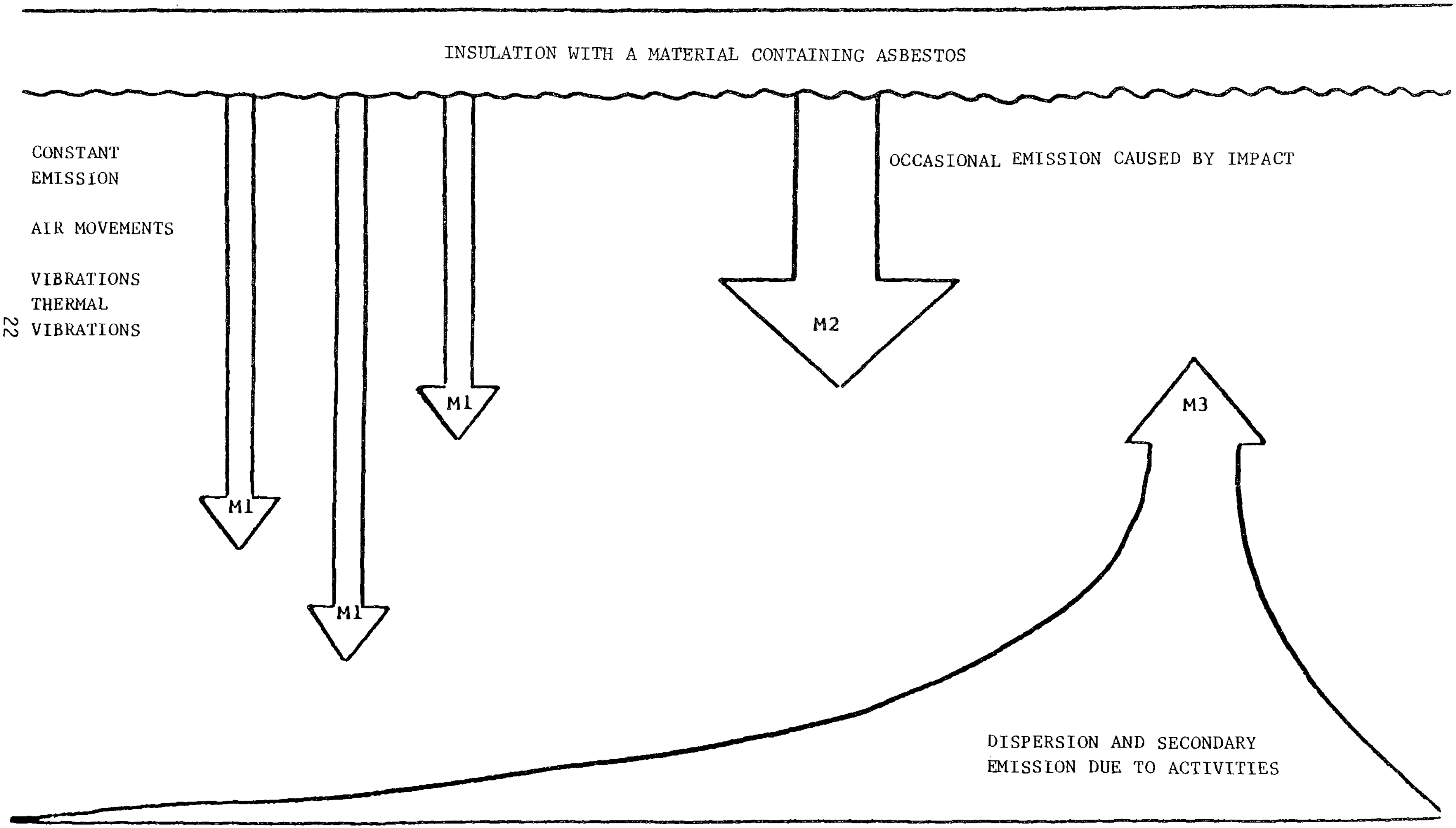
- -M2: Infrequent but intense emission, when the surface is subjected to mechanical impact (ventilation, vibration, tearing, etc.).

- -M3: Secondary emission following reentrainment of ceiling debris which has accumulated on the floor or other surfaces after ceiling degradation.

The pollution levels measured are a function of the above mechanisms, but also depend on the conditions operational during the use of the building (confined air spaces, air renewal, etc.). Since the sampling protocol was designed to evaluate asbestos exposure to building occupants, the samples were taken during periods of normal building use in the majority of cases. Under these conditions, a rigorous analytical study of each factor's contribution is virtually impossible to carry out since these several factors are acting simultaneously.

However, in certain cases, measurements at the same site could be made under different conditions (see Table VIII). From the comparisons between the levels measured and the technical data collected on site, the following observations can be formulated:

Fig. 3 THE MECHANISM FOR IDENTIFYING INDOOR POLLUTION GENERATED BY SPRAYED ASBESTOS



- Samples taken only under M1 conditions always gave lower levels compared to those taken at the same site where conditions M1 and M3 were operating. This suggests that M1 involves the localized degradation of large particles which are not collected under normal air sampling. Activity in the building seems to insure fragmentation and reentrainment of the fibers with the resultant elevated airborne fiber levels.

- The occasional fiber release by mechanical impacts (M2) does not always coincide with the sampling period and the contribution of M2 is therefore difficult to evaluate. However, M2 leads to the accumulation of large particles which can subsequently be fragmented and reentrained by M3 which would significantly increase the pollution levels. Samples have been taken after asbestos insulation was removed without taking any precautionary measures (extreme example of M2). Table II (Building H and Building T) shows a significant increase in pollution which persisted for a long time even after repeated cleaning of the building.

  In certain buildings, M2 might contribute to the pollution if the insulation is easily accessible (insulation on the walls or on exposed vertical pillars as well as on the lower surfaces of staircases). This mechanism is also important during maintenance operations or installment of light fixtures if workers disturb the surface of the insulation.

- In all the cases studied, the importance of M3 has been clearly evident. M3 seems to be the sufficient condition to establish measurable pollution; the necessary conditions being provided by M1 and M2.

These observations have allowed us to make assumptions on the mechanism by which pollution is established inside a sprayed building: sedimentation of a majority of "large" particles emitted from the sprayed insulation by mechanisms M1 and/or M2, followed by fragmentation and reentrainment by mechanism M3. Under these conditions, three levels of action can be envisioned to counteract indoor asbestos pollution:

Detachment of particles

This phenomenon is dependent on cohesion of the material and its exposure to the environment. Attempts to avoid surface degradation of the insulation have been made by coating it with a layer of paint, latex, or synthetic resin. The American data indicate a reduction in pollution on the order of 70% with a latex covering [6/]. However, we do not have data concerning the durability of such double coatings over time and in the case of organic coatings the fire resistance characteristics are compromised. Moreover, the increased weight of the surface layers may aggrevate the degradation of the insulation. In any case, such flexible coatings do not protect asbestos insulation against mechanical impact.

A radical solution is to remove the asbestos insulation. This procedure generates significant levels of asbestos and several precautions must be taken: worker protection, isolation of the work areas, wetting of the material prior to its removal, removal of the debris in sealed containers, and cleaning of the work area. Such a complex operation was carried out in the U.S. at Yale University where 10,000 m^2 of asbestos insulation were removed. Despite the precautions taken, the removal of the insulation always generates significant asbestos levels, which experience has shown are difficult to minimize.

Sedimentation

The installation of an airtight surface between the asbestos insulation and the ambient air represents an effective method of control. In this case, the insulation is protected from mechanical impact and the dust which is naturally released is trapped behind the airtight surfaces. Nevertheless, its installation involves some mechanical impact on the asbestos insulation and it is necessary to clean the work area at the completion of the installation.

The critics of this method point out that it does not definitely solve the problem, in that the asbestos insulation must be dealt with when the building is demolished.

Reentrainment

Without disturbing the insulation, reentrainment of the fibers can be minimized by repeated damp moppings and good ventilation of the areas involved. While this method can be effective in offices with slightly elevated asbestos levels, its use is limited for other types of buildings (such as parking garages or work shops).

Moreover, this method is not satisfactory since, in order to be effective, it implies complete settling without reentrainment of the dust, followed by its complete removal. It is known, however, that both sedimentation and reentrainment often occur simultaneously during building use.

4.2. Significance of Measurement Results

The relation between dose and effect (such as asbestosis and pulmonary cancer) has been studied primarily in the work place[13/]. The dose is estimated as the product of the average concentration of optical fibers per cm^3 of air times the number of years of exposure. These data are then compared with epidemiological observations.

Analogous studies of low level exposures measured by TEM are not currently available. This is essentially due to the relatively recent use of this analytical method.

Approximate conversions between the two types of measurements (light microscope and TEM) have been advanced by some authors[14,15]. They lead to the following equivalency: two optical fibers of chrysotile per cm^3 are approximately equal to 100,000 ng/m^3 based on TEM analysis.

The highest asbestos levels recorded in buildings would therefore be approximately 100 times lower than the standard occupational exposure for asbestos, i.e. two optical fibers/cm^3. The Federal Republic of Germany standard for chrysotile fine dust is 0.15 mg/m^3 or 150,000 ng/m^3, which compares favorably with the above equivalency between 2 optical fibers per cm^3 and 100,000 ng/m^3.

It should be remembered that pathological effects attributed to the inhalation of asbestos have been described in several instances of nonoccupational exposure to asbestos. Measurements using TEM in conditions of environmental pollution are presented in Table IX. It is seen that several measurements of asbestos in sprayed buildings are in the range of the values measured in the vicinity of asbestos plants where cases of mesothelioma have been reported[1].

4.3. Measurements of Airborne Asbestos Pollution in the Environment with the Transmission Electron Microscope and Regulatory Considerations

The standard two optical fibers/cm^3 has been established in accepting a 1% risk of inducing asbestosis in a group of workers exposed to this level for 50 years. Could such an approach be extended and adapted to asbestos related cancers and to the general population? BRUCKMAN[15] has proposed an environmental standard of 30 ng/m^3 measured with TEM so that the number of mesotheliomas would not exceed 10% of the transportation deaths (automobile, train, and airplane).

The choice of an environmental standard for asbestos should be based on a comparison between environmental monitoring and epidemiological data. Currently, however, the necessary monitoring support for the development of such surveys and air quality controls seems to be insufficient. Only the measurements by TEM have provided to date useful results for the monitoring of low level asbestos pollution in the environment. However, the implementation of this method is time consuming and tedious; it requires a large capital investment in materials and in the training of qualified technicians.

Current studies are underway aimed at developing more automated methods of instrumental analysis which would also perform well at lower concentrations.

5. SUMMARY AND CONCLUSIONS

This study focused on asbestos exposure in buildings insulated by sprayed asbestos materials. Air samples have been taken inside and outside in the vicinity of asbestos insulated buildings, inside of control buildings which had not been insulated with asbestos, and, finally, of the ambient air of Paris. The analytical results were obtained by TEM analysis of air sample filters which were taken for at least five days at an air sampling rate of 5 liters per minute. The sampling was done continuously or discontinuously, depending on the type of exposure (example: continuous for ambient outdoor pollution measurements; discontinuous for measurements inside buildings).

After a detailed study of the background of ambient asbestos levels in the metropolitan areas of Paris, it was possible to characterize as abnormally high any concentration higher than 7 ng/m^3.

Twelve out of the 21 insulated buildings which were surveyed have shown at least one measurement higher than 7 ng/m^3. The highest recorded value was 750 ng/m^3. Although the asbestos levels in the same building may vary from one room to another, it was observed that once a single value greater than 7 ng/m^3 was found, the geometric and arithmetic means for all the measurements of that building were significantly higher than the mean values recorded for the background ambient levels.

The study correlating the structural characteristics of the building and the airborne asbestos levels was inadequately documented and therefore precluded the drawing of significant conclusions. Based on the structural information available, it seemed difficult to predict the asbestos pollution levels of a given building without measuring them.

The mechanisms of generating asbestos indoor pollution in sprayed buildings appeared to be as follows: release and settling of large particles of the insulation, followed by their fragmentation and the reentrainment of the finer particles due to activity in the building. The activities in a building constitute a sufficient condition for elevated asbestos levels.

The technique of covering the insulation by an airtight surface has been shown to be quite effective. This technique does not definitively solve the asbestos problem when it comes to the demolition or remodeling of a building. If the asbestos insulation is removed, extreme precautions must be taken to limit worker exposure and environmental contamination.

It is technically possible to determine whether a building is polluted or not after an air monitoring program employing TEM.

The dose-effect relationships relating to asbestos exposure are currently too uncertain to accurately determine the health effects associated with this type of low levels asbestos exposure. We can merely note that the asbestos levels in certain buildings are as high as those measured in the neighborhood of asbestos plants where cases of mesotheliomas have been reported.

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TABLE I. SAMPLING

Study	Sites	Buildings	Outdoor Measurements	Indoor Measurements
Indoor pollution of sprayed buildings		22		132
Pollution in the vicinity of sprayed buildings		10	19	
Measurement of the pollution background of Paris	11		126	
Indoor pollution in the control buildings		7		16

TABLE II: DESCRIPTION OF SPRAYED BUILDINGS STUDIED AND THEIR RECORDED POLLUTION LEVELS

A card has been made for each building, containing the following data:

- Denomination and address of the building.
- General description of the building, especially concerning the insulation by spraying with asbestos.
- Places (sites) from which the samples have been taken.
- Date of sampling.
- Particular observations on different parts of the building.
- Pollution levels, in nanograms, separately for amphibole and chrysotile. The precision is assumed in order to enable the classification.
- The samplings done within the framework of the contract with the Ministry of Health are preceeded in the first column from the left with the initials <u>MS</u>.

BUILDING A - BASEMENT

In the basement there were parking lots, shops, labs. The ceilings were uniformly covered with a "soft" asbestos (type Asbestospray). With one exception, there was no forced ventilation. The windows are situated on the upper part of the rooms; in some places whole pieces of insulation were hanging loose from the ceiling. After the first samplings, certain protection measures have been taken such as spraying the metal with plaster. In certain instances, control samples have been taken after the repairs or in any other conditions of utilization of the given rooms.

Place	Date of sampling	Particular observations	Conc. in asbestos (ng/m^3) A	C
Indoor samplings taken during the normal use of the building:				
T23 Phys. Sol. 2	9/74	Shop - machine tool		751
T23 Phys. Sol. 1	9/74	Shop - machine tool		518
Hallway 13-23	3/76	Hallway		19
T34, p. custodian	10/74	Parking and access routes		2
Hallway 13-23	3/76	Hallway		0.6
44-54, p. 11	10/74	Laboratory, X-Ray instruments, little traffic		0.4
Indoor samplings taken during holidays:				
T23 Phys. Sol. 2	9/74	Shop - machine tools		15
T23 Phys. Sol. 1	9/74	Shop - machine tools		1
T23 Phys. Sol. 1	9/74	Shop - machine tools		0.7
Indoor samplings taken after repairs of the flocking and cleanup. Normal use of the room:				
54-64, p. 01	11/76	Room for preparation of minerals		58
54-64, p. 01	4/77	Room for preparation of minerals		12
IBM 1	6/76	Shop		1
T23 Phys. Sol. 2	6/76	Shop - Machine tools		1
44-54, p. 19	4/76	Shop		0.8
IBM 2	11/76	Animal quarters		0.4
T23 Phys. Sol. 1	6/76	Shop - machine tools		0.1

BUILDING A - CENTRAL TOWER

Metallic construction with supporting beams covered with asbestos insulation. In the rooms, the beams and the ceiling are hidden behind a double ceiling consisting of soundproof panels. There is an air conditioning system without recycling. The fresh air intake is located on the 10th floor on one side of the building. The air is introduced into the rooms under the windows and the extraction of the air is made through the double ceiling. It is possible that the fresh air comes in contact with the asbestos covering the sprayed beams located in the dead space between the ceilings. The air is exhausted through the side of the building opposed to the intake. Most of the rooms are offices and the indoor air samples were taken during the normal working hours.

Place	Date of sampling	Particular observations	Conc. in asbestos (ng/m^3) A	C
Indoor sampling:				
3rd floor, p. 318	9/74	Office		28
3rd floor, p. 318	10/74	Office		7
11th floor, p. 114	10/74	Office		3
Outdoor sampling:				
11th floor, p. 114	10/74			2

BUILDING A - ROOMS ON UPPER FLOORS

The new rooms are grouped in webs arranged geometrically around suspended bars. These webs are separated from each other by cylindrical towers which are the routes for access. Each bar has five levels. The interior arrangement is relatively uniform:

- The rooms are separated by brick walls.
- No air conditioning in general (the windows can be opened).
- The vertical beams are sprayed and are hidden (but accessible) by metal panels.
- The horizontal sprayed beams are hidden by a perforated metal double ceiling.
- The heating consists of hot air circulating through metal ducts located between the ceilings (real and false).
- The rooms consist of laboratories, lecture halls, and offices.
- The degradation of the insulation and of the double ceilings varies from room to room.
- Certain laboratories have been cleaned up before the samplings.
- The sprayed material consisted of both chrysotile and amphibole asbestos fibers, heterogeneously distributed within the insulation.

Place	Date of sampling	Particular observations	Conc. in asbestos (ng/m^3) A	C
Indoor sampling during regular working hours:				
34-44 Library 1 A	9/74	Library. Pollution of the tables was visible		630
43-44 4th floor, p. 05	4/76	Laboratory	461	0.5
34-44 Library 1 A	?/74	Library. Visible pollution on the tables		420
44-45 5th floor, p. 05	12/74	Laboratory		225
43-42 5th floor	7/76	Hallway. Degraded spray		106
MS 43-42 5th floor, p. 01	7/76	Shop	47	0.4
34-44 2nd floor p. 03	1/76	Library	1	44
44-45 3rd floor p. 08	12/74	Laboratory		37
23-24 3rd floor p. 16	12/75	Laboratory. Degraded spray	0.2	31
24-34 1st floor p. 07	1/76	Reproduction room		28
MS 43-42 5th floor p. 03	7/76	Laundry	12	3
44-45 5th floor p. 03	12/74	Laboratory		14
34-44 4th floor p. 24	9/74	Office		13

44-45 2nd floor p. 20	12/74	Office		9
44-45 2nd floor p. 07	12/74	Hallway		7
MS 43-44 4th floor p. 05	7/76	Hallway. Degraded spray		6
T53 1st floor Rot.	9/74	Rotunda. Degraded spray		6
44-45 1st floor	12/74	Hallway		6
T44 5th floor JPC 2	7/76	Laboratory	5	0.4
MS 43-42 5th floor p. 04	7/76	Laboratory	4	1
44-45 1st floor	11/74	Hallway		5
44-45 5th floor p. 07	12/74	Laboratory		4
MS 43-44 4th floor p. 04	7/76	Laboratory		4
T44 5th floor JPC 1	7/76	Laboratory		4
44-45 2nd floor p. 13	12/74	Laboratory		4
44-45 2nd floor p. 15	12/74	Corner room		4
23-24 3rd floor p. 20	12/75	Laboratory		4
T44 5th floor JPC 1	7/76	Laboratory		3
T44 5th floor JPC 1	7/76	Laboratory		2
23-24 3rd floor	12/75	Hallway. Degraded spray		2
T44 5th floor JPC 1	7/76	Laboratory		2
MS 43-44 4th floor	7/76	Hallway		2
44-45 2nd floor p. 15	12/74	Corner room		1
34-44 5th floor p. 07	9/74	Library		1
23-24 3rd floor p. 16	11/76	Laboratory	0.2	1
23-24 3rd floor p. 03	12/75	Laboratory		1
MS 43-44 4th floor p. 05	7/76	Photo lab		1
13-23 2nd floor p. 05	3/76	Laboratory		0.8
34-44 2nd floor p. 10	1/76	Typing room		0.3

Indoor sampling; rooms not used:

T44 5th floor JPC 4	9/76	Lecture room		3
34-44 3rd floor p. 03	9/74	Lecture room		2
34-44 3rd floor p. 13	9/74	Lecture room		1
T44 5th floor JPC 3	8/76	Lecture room		0.1

Indoor sampling, after cleanup:

24-34 1st floor p. 10	1/76	Laboratory	2	1
23-24 3rd floor p. 16	1/76	Laboratory. Previous measures: 0.2 A, 31 C		3

23-24 3rd floor p. 03	1/76	Laboratory: Previous measures: 1.2 C		0.1
23-24 3rd floor p. 09	1/76	Laboratory		0.1
Outdoor sampling:				
MS 43-42 5th floor p. 11	7/76	Sampling done through the window of the given room	0.6	1
MS 43-42 4th floor p. 14	7/76	Sampling done through the window of the given room		0.9
MS 43-44 4th floor p. 16	7/76	Sampling done through the window of the given room		0.4
MS 43-42 5th floor p. 12	7/76	Sampling done through the window of the given room		0.1

BUILDING B

Large metallic hangar, recently built; the beams have been sprayed with asbestos. The analysis of the material showed the presence of both mineral varieties of asbestos, i.e., amphibole and chrysotile. At the time of sampling the shop had not been put in service.

Place	Date of sampling	Particular observations	Conc. in asbestos (ng/m^3) A	C
Indoor sampling:				
1st floor	6/75	Shop	492	0.3
Hangar	6/75	Shop	65	0.3
Ground floor	6/75	Shop	30	0.5
Ground floor	6/75	Shop	23	0.2
Ground floor	7/75	Shop	5	1
Ground floor	7/75	Shop	3	3
Ground floor	7/75	Shop	3	2
Closet 1	7/75	Shop	1	0.6
Closet 2	7/75	Shop	1	0.2

BUILDING C

Recently built building. The metallic structure has been treated by insulating with asbestos of the type "Asbestospray." The metallic structures are hidden by an airtight double ceiling. There was no air conditioning.

Place	Date of sampling	Particular observations	Conc. in asbestos (ng/m^3) A	Conc. in asbestos (ng/m^3) C
Indoor sampling:				
Building 1, 4th floor, 029	1/76	Offices		0.2
Building 1, 4th floor, 16	1/76	Offices		0.2
Building 1, 9th floor, 001	1/76	Offices		0.1

BUILDING D

Recently built building. The metallic frame of this building has been sprayed with asbestos and covered by a double ceiling providing acoustic insulation. The building is provided with an air conditioning system without recycling. The air is being exhausted through the double ceiling where it comes in contact with the asbestos covering.
The stairs have been sprayed underneath with asbestos covered with plaster. In this case, there is no protection and the insulation is exposed.

Place	Date of sampling	Particular observations	Conc. of Asbestos (ng/m^3) A	C
Indoor sampling:				
Stairs	1/76	Staircase; nonprotected spray		5
Stairs	1/76	Staircase; nonprotected spray		5
112	1/76	Library		2
211	1/76	Office		0.6

BUILDING E

The ceiling of the dining hall is covered by a "soft" insulation with asbestos. The users complained about a white powder covering the tables.

Place	Date of sampling	Particular observations	Conc. of asbestos (ng/m^3) A	C
Indoor sampling:				
GIF 1	4/76	Dining hall		29

BUILDING F

Many of the large halls have been sprayed with asbestos. The lining is uniform and unprotected. The material has been blown as a paste "WANNER".
The users of the rooms mentioned "a very fine white powder which settled everywhere."

Place	Date of sampling	Particular observations	Conc. of asbestos (ng/m^3) A	C
Indoor sampling:				
Dance room	1/76	Uniform lining, acoustic	11	29
Organ room	1/76	Uniform lining, acoustic	9	16
Office	1/76	Untreated. Close to insulated hallway		6
Franck room	1/76	Uniform lining, acoustic	1	3

BUILDING G

16-story high tower built in 1972 with about 1,100 people working there. The metallic frame and the tower surfaces of the armored concrete floors have been sprayed with asbestos. The material has been blown as a paste.
The building has an air conditioning system which recycles and filters the air. The ceilings are provided with acoustic insulation of mineral wool.

Place	Date of sampling	Particular observations	Conc. of asbestos (ng/m^3) A	C
Indoor sampling:				
12th floor	2/76	Offices		3
12th floor	2/76	Offices		2
6th floor	2/76	Offices		0.1

BUILDING H

Several laboratories and machine shops have been sprayed with asbestos. This insulation is a "soft insulation" uniform and unprotected, blown on the walls and ceilings. The building is not provided with an air conditioning system. The users of the building were concerned about the poor quality and the imperfections of the insulation. In one case, the insulation has been torn apart.

Place	Date of sampling	Particular observations	Conc. of asbestos (ng/m^3) A	C
Indoor sampling:				
MS PHN 100 M3	5/76	Large shop, machine tools	112	22
MS PHN 100 M2	5/76	Large shop, machine tools	17	5
MS PHN 100 M4	5/76	Large shop, machine tools		14
AL 206	4/76	Shop for the linear accelerator	7	5
AL Igloo	4/76	Cupola		11
APHS 095	12/75	Shop		6
APHS 090	12/75	Shop		5
APHS 093	12/75	Shop		2
MS PHN 100 M1	5/76	Large shop, machine tools		0.9
LPH Hall	2/76	Hall		0.4
APHS Hallway	12/75	Hallway		0.2
LPH Transformer	2/76	Technical room. Quite weak		0.1
Gym.	12/76	Gym room		0.1
Indoor sampling after removal of the lining and cleanup of the rooms:				
APHS 090	5/76	Previous measurements: 5 C 12/75	130	0.3
APHS Hallway	11/76	Previous measurements: 0.2 C 12/75		8
APHS 090	11/76	Previous measurements: 130 A, 0.3 C 5/76	0.2	0.1
Outdoor sampling:				
MS PHN 100 M5				5
MS PHN 100 M6				0.2

BUILDING I

Four-floor building, erected in 1975 with about 500 working people on the premises. The lower part of the platforms has been sprayed with asbestos using a procedure of spraying of a paste (Dermacoustic). The building is climatized. The insulation is not protected by a double ceiling and the air is recycled about 50%. The induced air is filtered through high efficiency filters.

Place	Date of sampling	Particular observations	Conc. of asbestos (ng/m^3)	
			A	C
Indoor sampling:				
Office 3	2/76	Offices	2	0.5
Office 1	2/76	Offices		0.2
Office 2	2/76	Offices		0.1
Office 3	2/76	Offices		0.1
SA1 4	2/77	Offices		0.1
DP1 3	2/77	Offices		0.1
DU 232	2/77	Offices		0.1
Outdoor sampling:				
CPR	2/77			2

BUILDING J

42-level tower in which about 1,500 people work. The lower faces of the armored concrete platforms are covered with a lining of asbestos which was sprayed dry (copris spray). The building has an air conditioning system. The air ducts are insulated externally with asbestos (Isolasbestos). The evacuation of air is achieved through the ceiling where there is a possibility of contact with the asbestos. The recycling varies from 0 to 60%, depending upon the temperature outside the building. The induced air is filtered.

Place	Date of sampling	Particular observations	Conc. of asbestos (ng/m^3)	
			A	C
Indoor sampling:				
26th floor, 26-15	6/76	Office	2	5
22nd floor	6/76	Hallway		2
30th floor, 30-07	6/76	Office		0.6

BUILDING K

Under the glass casing of the central railroad station of Paris there are several buildings which constitute a complex consisting of the following:

- the usual installations of a large railroad station,
- the subway station,
- the tracks leading to the suburbs,
- different offices,
- a three-level parking area, and
- several access ramps for the cars, travelers and personnel.

These installations are not partitioned because they are all under the same glass enclosure of the train station which has been considered in this study as a large building.
The three-level parking area has been made out of a metallic frame. All the beams and supporting pillars as well as the lower parts of the levels have been covered with a thick lining of sprayed blown asbestos in 1974. This parking area occupies about 1/3 of the total surface covered by the glass roof of the train station and is placed approximately in the center of this area.

Place	Date of sampling	Particular observations	Conc. of asbestos (ng/m^3) A	C
Indoor sampling:				
MS Level 1	6/76	Air from the station	0.2	24
MS Level 3	6/76	Air from the station	6	5
MS Level 2	6/76	Air from the station		10
Outdoor sampling:				
MS Ext. 1	6/76	Vicinity of the river Seine		0.6
MS Ext. 2	6/76	Vicinity of the river Seine		0.1

BUILDING L

An eight-story concrete building. The samples have been taken from the 4th floor consisting of offices and a sorting room. The ceilings and the supporting horizontal beams are covered by a sprayed material containing chrysotile asbestos. This insulation is covered with a layer of paint. The building is provided with a system of air circulation where the fresh air is sucked in and the used air is blown out of the building. The visible parts of the insulation appeared to be very damaged. As a matter of fact, this insulation has been subjected to a variety of shocks such as: ventilation, vibration, and degradation.

Place	Date of sampling	Particular observations	Conc. of asbestos (ng/m^3) A	C
Indoor sampling:				
MS 4th floor	9/76			34
MS 4th floor Et. 2	9/76	Sorting room		18
MS 2nd floor Et.	9/76	Sorting room		17
MS 4th floor Et.	9/76	Sorting room	3	9
Outdoor sampling:				
MS Ext. 1	9/76	Air intake at 4th floor		0.4

BUILDING M

35-floor tower consisting of 400 apartments (approximately 600 persons). The insulation is nonexistent in the apartments but does exist in the parking area from the first underground level next to the tower. There is a possibility of air communication between the underground levels and the upper floors of the building.
The insulation of the parking area was applied in 1975. This is a soft insulation (Asbestospray). The apartments are not provided with air conditioning.

Place	Date of sampling	Particular observations	Conc. of asbestos (ng/m^3) A	Conc. of asbestos (ng/m^3) C
Indoor sampling:				
MS A1	10/76			2
MS A2	10/76			2
MS A4	10/76			0.8
MS A3				0.3
Outdoor sampling:				
MS	10/76			0.8
MS	10/76			0.6

BUILDING N

Tower of 30 floors with 240 apartments. The concrete ceilings and some walls from the basement have been covered in 1972 with a material blown dry (Asbestospray). The apartments have not been sprayed but there is a direct communication between the first underground level and all the upper floors of the tower. There is no air conditioning in either the apartments or the underground levels.

Place	Date of sampling	Particular observations	Conc. of asbestos (ng/m^3) A	C
Indoor sampling:				
MS B1	10/76			42
MS B3	10/76			8
MS B4	10/76			13
Outdoor sampling:				
MS	10/76			9
MS	10/76			6

BUILDING O

Traditional building with the walls and ceilings from certain rooms sprayed with asbestos. This is a uniform acoustic lining, unprotected, and, judging by its appearance, degraded.

Place	Date of sampling	Particular observations	Conc. of asbestos (ng/m^3) A	C
Indoor sampling:				
S 00 5	5/76	Laboratory		62
S 00 5	5/76	Laboratory	2	11
S 00 54	5/76	Technical room - weak activity		1
S 00 54	5/76	Technical room - weak activity		0.4

BUILDING P

A 10-story building lodging 100 rooms for students. In 1968, the metallic structures have been covered with an insulation of asbestos blown as a paste (Asbestospray THX). The insulation is protected by a false ceiling with solid (full) acoustic panels. The metallic pillars which have been sprayed were protected by casings made out of metallic sheets.
No air conditioning.

Place	Date of sampling	Particular observations	Conc. of asbestos (ng/m^3) A	C
Indoor sampling:				
MS C3	10/76		0.2	7
MS C2	10/76		3	0.5
MS C1	10/76		0.8	0.8
MS C4	10/76		0.2	0.6
Outdoor sampling:				
MS	10/76			0.8
MS	10/76			0.3

BUILDING Q

Construction of 3 floors. In 1967, the metallic structure was covered with an asbestos insulation blown as a paste (Asbestospray type THX). The insulation was hidden by a double ceiling made of acoustic panels. In addition, a thermal protection made out of mineral wool-on-paper (as a vapor barrier) has been laid inside the false ceiling onto the panels. The metallic pillars were nonaccessible except for the attic where the insulation could be seen.

Place	Date of sampling	Particular observations	Conc. of asbestos (ng/m^3) A	C
Indoor sampling:				
MS AM 22	11/76			1
MS AM 20	11/76			1
MS AM 19	11/76			0.7
MS AM 21	11/76			0.3
Outdoor sampling:				
MS AM 23 Ext.	11/76			0.9
MS AM 24 Ext.	11/76			0.8

Building "R"

This a recent construction. The ceilings are covered with an asbestos insulation (procedure Progypsol).

The insulation was covered by a double ceiling of acoustic panels.

No air conditioning.

Place	Date	Observations	Concentrations of asbestos(ng/m^3)
Indoor Samplings			
CMP 2	10-76	Office	12
CMP 3	10-76	Office	11
CMP 1	10-76	Office	2

Building "S"

In 1965, an asbestos insulation has been sprayed over the ceilings in certain rooms in order to improve the acoustics.

The users have complained about the defective insulation (peeling and falling).

Place	Time	Observation	Concentrations of asbestos(ng/m^3)
Indoor Samples			
BA 1	1-77	Dining-hall	0.1
BA 2	1-77	Playroom	0.1
BA 3	1-77	Classroom	0.1

Building "T"

This building was a part of a former American military base. For acoustical purposes, the concrete celings in all rooms have been sprayed with asbestos.

This is a "hard" spray which however exhibited numerous spot degradations. In many of the rooms of this building, the insulation has been torn away dry. This operation has been achieved by nonexperienced workers and no protection measures have been taken. In view of the importance of the "macroscopic pollution" observed by the users, measurements have been made after the completion of the removal and the subsequent clean-up.

Place	Time	Observations	Concentrations of asbestos (ng/m^3)	
Indoor samplings after completion of work, during the school holidays			A	C
CHAT 1	1-76	Hallway	40	28
S. 11	1-76	Classroom	14	0.6
S. 34	1-76	Classroom		0.6
S. 32	1-76	Classroom		0.4
Indoor samplings after clean-up, under normal conditions of utilization of the building				
S. Perm	3-76	Waiting room	10	90
S. 16	3-76	Classroom		27
CHAT 1	3-76	Hallway		24
S. 4	3-76	Classroom		15

Table III : LEVELS (ng/m3)[a] OF AMBIENT AIRBORNE ASBESTOS POLLUTION IN PARIS

Place of Sampling	Sampling Periods (Numbers of the weeks of the year)																			
	June 1974																			June 1975
	24	25	26	27	28	29	30	31	[b] 32 33 34 35	36 37 38 39	40 41 42 43	44 45 46 47	48 49 50 51	1 2 3 4	5 6 7 8	10 11 12 13	14 15 16 17	18 19 20 21	22 23 24 25
39 bis, rue de Dantzig 75015 R.d.C	2	0.4	2	2	0.5	2	0.3	0.4	0.3	0.1	0.7	0.4	0.3	0.2	.5				
39 bis, rue de Dantzig 75015 Terrasse	0.4	0.3	0.4	0.5	0.5	0.3	0.4	0.2	0.4	0.5	0.2	0.4	0.7	0.1	.2				
Rond-Point des Champs Elysees 75008	0.3	0.9	0.4	1	0.7	1	0.3	0.4	0.5	0.7	0.4	0.4	0.4		.2				
Place Victor Basch 75015	0.2	0.7	0.5	0.2	1	0.9	1	0.5	0.5	0.5	0.4	0.4	0.3	0.2					
Jardin du Luxembourg 75006	2	0.4	0.3	0.3	0.3	0.3	0.1	0.6	0.2	0.2	0.2	0.5	0.5						
37, Bd. Saint-Marcel 75013	0.2	0.4	0.1	1	0.3	0.1	0.5	0.2	0.6	0.6	0.2	0.1	0.2						0.9
Place Mazas 75012	0.4	0.7	6	2	1	0.9	2	5	3	0.2	0.4	0.4	0.4					2	
Autoroute du Sud. P. d'Orleans	0.1	0.3	0.2	0.1	0.2	0.1	0.2	0.1	.3	0.4	0.3	0.4	0.1		.2			C.6	
Renovation XIIIe							3	2	3	1	0.7	2	1						
Quartier de la Defense															.7				
Quartier des Halles																.9	1	1	0.3

[a] Detection level = 0.1 ng/m^3

[b] Values for four 1-week long samples whose filters were combined for a single analysis.

TABLE IV: THE LEVELS OF INDOOR AIRBORNE ASBESTOS POLLUTION IN CONTROL BUILDINGS

Building	Time	Observations	Concentrations of asbestos (ng/m³) A	C
Building .1.	2-76			0.3
	2-76	Insulation without asbestos		0,8
	2-76			3
	2-76			3
Building .2.	9-74	Non-sprayed amphitheatre		2
Building .3.	3-76	Operating room (not sprayed)		0,1
Building .4.	4-76	Insulation without asbestos		2
Building .5.	8-76	Insulation without asbestos		0,1
	8-76			0,2
	8-76			12
	8-76			6
	8-76			0,5
Building .6.	4-75			0,1
	4-75	Non-sprayed offices		0,1
	4-75			0.3
Building .7.	1-75	Non-sprayed offices		0,1

TABLE V

LEVELS OF INDOOR AIRBORNE ASBESTOS POLLUTION IN SPRAYED BUILDINGS

- The levels are expressed in ng/m^3.

- In each column, the number from the left side represent sampling made in the vicinity of the building.

- * Buildings for which the mean values are not significantly higher than the pollution background.

BUILDINGS	NUMBER OF MEASUREMENTS	RANGE OF LEVELS	ARITHMETICAL MEAN VALUE	GEOMETRICAL MEAN VALUE
BUILDING "A" - Rooms in the basement	6	0,4 - 751	21	12
BUILDING "A" - Central tower	1 3	2 3 - 28	12	8
BUILDING "A" - Rooms on the upper floor	4 39	0,1 - 2 0,3 - 630	57	8
BUILDING "B"	9	1 - 492	70	14
BUILDING "C" *	3	0,1 - 0,2	0,1	0,1
BUILDING "D" *	4	0,6 - 5	3	2
BUILDING "E"	1	29	29	29
BUILDING "F"	4	5 - 40	19	13

TABLE V

(Continuation #1)

BUILDINGS	NUMBER OF MEASUREMENTS	RANGE OF THE LEVELS	ARITHMETICAL MEAN VALUE	GEOMETRICAL MEAN VALUE
BUILDING "G" *	3	0,1 - 3	2	0,8
BUILDING "H"	13 2	0,1 - 134 0,2 - 5	16	3
BUILDING "I"	7 1	0,1 - 2 2	0,4	0,2
BUILDING "J"	3	0,6 - 7	3	2
BUILDING "K"	3 2	10 - 24 0,1 - 0,6	15	14
BUILDING "L"	4 1	12 - 34 0,4	20	19
BUILDING "M"	4 2	0,3 - 2 0,6 - 0,8	1	1
BUILDING "N"	3 2	8 - 42 6 - 9	21	16
BUILDING "O"	4	0,4 - 62	20	5
BUILDING "P"	4 2	0,8 - 7 0,3 - 0,8	3	2

TABLE V

(Continuation #2)

BUILDINGS	NUMBER OF MEASUREMENTS	RANGE OF THE LEVELS	ARITHMETICAL MEAN VALUE	GEOMETRICAL MEAN VALUE
BUILDING "Q" *	4 2	0,3 - 1 0,8 - 0,9	0,8	0,7
BUILDING "R"	3	2 - 12	9	7
BUILDING "S"	3	0,1 - 0,1	0,1	0,1

TABLE VI: DESCRIPTIVE DATA ON POLLUTED AND NON-POLLUTED BUILDINGS

TECHNICAL DATA	NON-POLLUTED BUILDINGS	POLLUTED BUILDINGS
Method of Spraying		
Dry spray	6	9
Paste spray	3	3
Behavior of the Insulation		
Macroscopic effects of degradation or visible sedimentation of "white powders"	1	7
No visible sedimentation	8	5
Place of the Insulation		
Exposed insulation	1	8
Protected insulation	3	2
Insulation within the ventilation circuit	4	1
Insulation within the vicinity	1	1
Utilization of the Room		
Labs and shops	-	6
Offices	5	2
Schools	2	2
Apartments	2	1
Parking	-	1

TABLE VII: INDOOR POLLUTION AFTER PROTECTION OR REMOVAL OF SPRAYED MATERIAL

PLACE	NATURE OF WORK	LEVELS OF POLLUTION ng/m^3			
		Before the work		After the work	
		A	C	A	C
BUILDING "T"	Dry removal	-	1	40	28
	Wet cleaning after work	40	28	10	90
BUILDING "H"		-	5	130	0.1
BUILDING "A"	Protection by covering of the exposed metal with a thick layer of plaster followed by clean-up	-	518	-	1
		-	751	-	1
	Protection with a film of polyvinyl	-	3	5	1
	Clean-up of the rooms	-	31	-	3
		-	1	-	0,1

A : Amphiboles ; C : Chrysotile ; - Non-detectable.

TABLE VIII : MODES OF EMISSION AND THE LEVELS OF INDOOR POLLUTION

PLACE AND MODE OF EMISSION		RANGE OF VARIATION (ng/m^3)
BUILDING "A" Underground	M1	0,7 - 15
	M1 + M3	0,4 - 751
BUILDING "A" Room on the upper floors	M1	0,1 - 3
	M1 + M3	0,3 - 630
BUILDING "O"	M1	0,4 - 1
	M1 + M3	13 - 62
BUILDING "H"	M1 + M3	0,2 - 5
	M1 + M2 + M3	0,9 - 130
BUILDING "T"	M1	0,2 - 4
	M2 + 10 days setting	0,4 - 68
	M3 After clean-up	15 - 100

TABLE IX: LEVELS OF AIR POLLUTION WITH ASBESTOS IN DIFFERENT SITUATIONS

TYPE OF SAMPLING AND THE LABORATORIES WHERE THE STUDIES HAVE BEEN MADE	Concentrations ng/m^3
VICINITY OF OPERATIONS EMPLOYING SPRAYING OF ASBESTOS	
. USA, Environmental Sciences Laboratory	10 - 1000
VICINITY OF AN ASBESTOS PLANT	
. U.K., Asbestos Research Council	1 - 100
. USA, Environmental Sciences Laboratory	10 - 5000
. FRANCE, Laboratory of Study of Inhaled Particles	10 - 3000
PRIVATE HOMES OF WORKERS FROM THE ASBESTOS INDUSTRY	
. USA, Environmental Sciences Laboratory	100 - 5000
INTERIOR OF ROOM FIREPROOFED WITH BLOWN ASBESTOS	
. USA, Environmental Sciences Laboratory	1 - 800
. FRANCE, Laboratory for the Study of Inhaled Particles	0,1 - 750

TECHNICAL REPORT DATA

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15. SUPPLEMENTARY NOTES

16. ABSTRACT

This report is a translation of a document prepared in 1977 for the French Ministry of Health and the French Ministry for the Quality of Life-Environment on the measurement and assessment of airborne asbestos levels in buildings throughout Paris. The methods of air sampling and transmission electron microscopic analysis, as well as a discussion of the results, are presented. Also included are extensive tables and figures summarizing the data collected. The study was completed in 1977 by the Laboratoire d'Etude des Particules Inhalées (Préfecture de Paris) and the Institut de Recherches Universitaires Sur l'Environnement (Université Paris-Val de Marne). Mr. Patrick Sebestien (Préfecture de Paris) provided this revised update of the study in July 1980.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
Asbestos Amphibole asbestos Chrysotile Sprayed asbestos insulation Indoor asbestos pollution Asbestos exposure assessment Transmission electron microscopy (TEM)		

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