CALIFORNIA STATE UNIVERSITY, NORTHRIDGE

A BUILDING SURVEY
FOR ASBESTOS Fallout

A thesis submitted in partial satisfaction of the requirements for the degree of Master of Science in Health Science, Environmental and Occupational Health

by
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CALIFORNIA STATE UNIVERSITY, NORTHRIDGE
ABSTRACT

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A modern sixteen-story office building was surveyed to determine if erosion of spray asbestos fibres from the cementitious surface of the air plenum chambers was contaminating the building air supply system, subjecting the occupants to a potential hazard. The NIOSH approved method of collection and analysis was utilized. This consisted of collecting the fibres on a membrane filter, dissolving the filter on a glass slide, and then counting the fibres utilizing phase microscopy. Fibre concentrations were found to be extremely low and most probably reflect the general ambient level in the urban environment, as two nearby buildings that did not incorporate asbestos-based building materials had comparable levels. These extremely low levels do not appear to be biologically significant.
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I

INTRODUCTION

New Jersey School officials closed down eight schools in suburban Howell township because a pediatrician had declared that a 13-year-old suffered chronic respiratory illness caused by asbestos used on some of the school's ceilings. These facts, reported by the Los Angeles Times, January 5, 1977, are particularly disturbing when one considers that there are tens of thousands of buildings, public and semi-public, all over the United States, that have been sprayed with asbestos-based materials.

Asbestos is a fibrous material found in many geological formations and it is one of the most valuable and versatile materials extracted from the earth's surface. It is utilized in many products, such as the spray coating on the New Jersey school ceilings where it provided fire-proofing and improved acoustics. There are seven varieties of asbestos, all hydrated mineral silicates incombustible in air and separable into filaments. Chrysotile \((3\text{MgO} \cdot 2\text{SiO}_2 \cdot 2\text{H}_2\text{O})\) is the most widely used asbestos type and forms 90% of the world's output. The other types are amosite, crocidolite, tremolite, anthrophyllite, actinolite, and amphibole.

While this researcher concentrated his efforts on the possible contamination in one particular building, it must be emphasized that the possibility of contamination
exists in a large number of buildings. Reitze (1972) states that the first use of asbestos containing spray materials for fireproofing buildings was in 1958 and by 1970 well over half of all large multi-storied office buildings constructed in this country were sprayed with an asbestos containing material. Through damage or erosion it is possible that small quantities of asbestos fibres find their way into the breathing zones of the millions of people who occupy these buildings during their working day.

This present study was undertaken to ascertain the possibility of asbestos contamination in the air of a modern office building, Los Angeles City Hall East. Contamination was suspected because an asbestos containing material was sprayed on the steel infrastructure of the building and in the air plenums for fireproofing. To test this possibility the building was inspected and the air was sampled for asbestos fibres. The results of this survey were compared with the results from two nearby buildings; City Hall and City Hall South. A visual inspection concluded that these nearby buildings did not incorporate asbestos containing materials.

The possibility of asbestos exposure to the inhabitants of this building provided the impetus for this study. Inhalation of asbestos fibres can lead to a number of diseases such as asbestosis, cancer of the lung, and mesothelioma. This association between asbestos exposure and disease has been well established and will be examined
in the subsequent chapters.

A survey of each of these buildings will be an enormous undertaking, requiring the commitment of a great number of people, resources, and time. This study is intended as a contribution to this growing area of concern, in hopes that its findings may help insure the health and safety of these buildings' occupants.

Hypothesis

The levels of asbestos fibres in the air of Los Angeles City Hall East do not exceed the present threshold-limit-value.
II

HEALTH EFFECTS OF ASBESTOS

The health effects associated with the inhalation of asbestos fibres are well established and documented. What follows is a concise description of the health effects and the published studies which contributed to their understanding.

Asbestosis

Asbestosis is a consistent pathological change in the lung, characterized by interstitial, septal, peribronchiolar or perivascular fibrosis which is eventually visualized by radiography (ACGIH-AIHA Aerosol Hazards Evaluation Committee, 1975). It is accompanied by the formation of intra-alveolar ferruginous bodies. Sufferers show reduced pulmonary and vital functions as indicated by forced vital capacity and forced expiratory volume in one second. Selikoff (1965) reports that dyspnea is the main complaint. Wright (1969) emphasizes that the term "asbestosis" has recently been corrupted to include such manifestations as pleural thickening, pleural plaques, and even the simple presence of ferruginous bodies. These inclusions blur the conception of the disease.

The first reported association between asbestos exposure and diffuse pulmonary fibrosis was by Murray (1907). Cooke (1927), who reported fibrosis of the lung due to
inhalation of asbestos dust, was another pioneer. Merewether and Price (1930) demonstrated that asbestosis was a threat to the workers in the asbestos textile trade. Lanza (1938) showed that once established, usually 20-40 years after the first exposure, asbestosis progresses even after the exposures have ceased.

The manufacturers of asbestos containing products began to take substantial measures to reduce the concentrations of airborne fibres after the work of Merewether and Price. The report of Sayers and Dressen (1939) further stimulated the introduction of corrective measures, and until quite recently, served as a guide in establishing threshold-limit-values for asbestos containing environments.

It should be emphasized that asbestosis is still an appreciable occupational hazard. Scansetti (1975), in a recent study, has found asbestosis in asbestos cement workers.

**Respiratory Cancer**

One of the most serious diseases associated with occupational exposure is respiratory cancer. Before examining case studies and epidemiological evidence in this regard, it is necessary to discuss the environmental induction of cancer.

Jones and Grendon (1975) propose a theory for the production of environmental cancers. First, there is an alteration of cellular function by the carcinogen, followed
by reinforcing interaction by proximal altered cells. These interactions are responsible for the relationship between dose and time of cancer appearance. Next, organ changes produced by these cellular alterations reach a level at which they cause failure of those tissue organizing systems which normally prevent cancer development. The failure of the cancer suppressing mechanism extends from the organ of origin to the entire body. Finally, uncontrolled growth results in death from the malignancy or from intervening secondary causes.

How asbestos induces changes in cellular function is not completely understood. Gross (1967) suggested that the presence of trace metals plays a role, and later (1973) found evidence that the locus of pathogenicity resides in the asbestos fibre's polyfilamentous structure. Selikoff (1968) offers strong evidence that the carcinogenic role of asbestos is solely that of a cocarcinogen. Lung tumors, according to Reeves (1976), seem to depend on the absorptive capacity of asbestos fibres, allowing other carcinogens (heavy metals, polycyclic hydrocarbons, cigarette smoke) to attain a critical focal concentration.

Although the biochemical role of asbestos in carcinogenesis is as mysterious as the disease itself, its association with respiratory cancer in an occupational context is the subject of a great body of published accounts. An association between asbestos and pulmonary carcinoma was first recognized by Lunch and Smith (1935).
Merewether (1949) demonstrated bronchogenic cancer in 13% of the asbestosis victims in the textile trade. Despite these early findings, it was not until fairly recently that an association with cancer was recognized.

Doll (1955) conducted the first epidemiological study which indicated increased mortality from lung cancer in asbestos workers. Braun (1958) found a slightly elevated risk of lung cancer in asbestos miners, and Dunn (1960) found an elevated risk of lung cancer in California asbestos insulators.

In 1961, the Journal of the American Medical Association stated that "in the American literature there is no evidence that there is a relationship between asbestos and lung cancer." Evidence was provided shortly thereafter by Mancuso (1963) who found a relative risk (the ratio of the incidence rate of those exposed to the incidence of those not exposed) of respiratory cancer more than three times greater than expected in asbestos workers. Shortly thereafter Selikoff (1964) published data suggesting that insulation workers had nearly ten times the risk of dying of lung cancer than the average American man. Enterline (1965) found elevated risks of respiratory cancer among asbestos products workers. Asbestos insulators in San Francisco were found to have elevated risks of lung cancer by Cooper (1968). Subsequent studies and follow-ups by McDonald (1971) on asbestos miners; Enterline (1973) on retired asbestos products workers; Wagoner (1972) on manufacturers of brake
linings and textiles; and Selikoff (1973) on manufacturers and applicators of asbestos insulation have all reported elevated relative risks of respiratory cancer ranging from 1.4 to 8.2 times higher than normal.

Enterline (1976) in reviewing many of these studies, points out a number of shortcomings. These studies generally suffer from the lack of information regarding first exposures, the supplementing of death certificates with other information in study populations (but not in control populations), improper groups, lack of exposure data, overlapping exposure and follow up periods in dose response studies, and failure to adjust for competing causes of death. Despite these pitfalls there has been great progress in knowledge about the health effects of asbestos.

Some information relating exposure dose to health effect has accumulated. Knox (1968) in a continuation of the study by Doll (1955) showed that the incidence of lung cancer decreases with progressively smaller total exposures to asbestos. Newhouse (1969), also in an asbestos textile population, reported no increase in incidence of bronchogenic cancer in a low to moderately exposed group, whereas in a heavily exposed group the incidence increased eightfold. In a series of studies, Mancuso and El-Attar (1967) suggested that cancer risk is lower with lower asbestos exposures. These observations infer a dose relationship between bronchogenic cancer and whatever effect asbestos fibres have in its causation (Wright, 1969).
Mesothelioma

Mesothelioma is a rare cancer of the pleural and peritoneal membranes, so rare that it is not separately coded in the International Classification of Causes of Death. Only three cases were reported among 31,652 cancer deaths in a 1959-62 study (Selikoff, 1965). It is a particularly insidious asbestos-related disease because its latent period has been reported in the literature to be anywhere between 20-30 years.

Weiss (1953) was the first to suggest a relationship between mesothelioma and asbestos exposure. Wagner (1960) reported 33 cases of pleural mesothelioma occurring after exposure to crocidolite in the Northwest Cape Province South Africa. Many of these individuals had never worked with asbestos. Their exposure was associated with living near asbestos mines, mills, or roadways along which asbestos fibre was transported. Newhouse and Thompson (1965), in a review of 76 cases of mesothelioma in the London Hospital, found that roughly half were former employees of an asbestos products manufacturing facility. Eleven lived within one-half mile of the asbestos factory and nine lived with workmen employed in the factory. Champion (1971) reported two cases, one of which was exposed from the fibre-laden workclothes of his father.

Animal studies by Stanton (1972) and Wagner (1973) indicate that the development of mesothelioma with asbestos
exposure may not be due to its chemical composition, but rather to its morphology. The carcinogenicity of these fibres appear to be related to the structural shapes of the materials rather than to physiochemical properties. Reeves (1976) suggests that mesothelial tumors might arise in response to mechanical irritation by fibres which may become lodged during lymphatic spread. The pleura and peritoneum are subject to constant respiratory movement and are therefore vulnerable.

Selikoff (1965), in a review of the problem at that time, concluded that mesothelioma must be added to the risks of asbestos inhalation, and join lung cancer and possibly cancer of the stomach and colon as significant complications of such exposures. His own studies of insulation workers showed 22 deaths from mesothelioma among 532 asbestos workers who were exposed to mixed asbestos insulation materials.

Bruckman (1975) points out that a serious implication exists in the risk of developing mesothelioma from non-occupational exposures. While current cases are most likely associated with exposures twenty, thirty, or forty years ago when world consumption of asbestos was only 500,000 tons per year; neoplasms associated with today's annual production of over 4,000,000 tons will not be evident until the 1990's.

The etiological relationship between asbestos exposure and mesothelioma is generally accepted, although
the evidence is not complete. The literature is weak in terms of information regarding exposure values, fibre variety and size, and extent of occupational exposure.

**Risks to General Populations**

Evidence has recently accumulated that some researchers, notably Thomson (1963, 1965) and Selikoff (1967, 1972), interpret as indicating a health risk to the general (non-occupationally exposed) public from exposures to ambient background asbestos contamination of urban and rural air. It is necessary to investigate this interpretation since contamination levels of asbestos fallout in buildings may approximate urban contamination levels.

In the previous section, some studies were presented that indicated that mesothelioma has occurred in occupationally exposed populations and some marginally exposed individuals. Can these studies of specific populations be extrapolated to the point where an increased risk of mesothelioma is predicted in general populations? The roles played by fibre types, the possibilities of cocarcinogenesis, dosage level and fibre shape and size are so far from being clear in specialized occupational settings "as to give little assurance that they can be transferred in any meaningful way to the non-occupational related or general public populations" (Wright, 1969).

The significance of the "curious bodies," tiny, iron-colored bodies found in the lungs of asbestos workers,
first described by Murray (1906), is also open to various interpretations. Gloyne (1929) described asbestos bodies and stated that their formation was the result of a tissue reaction to a foreign body as a benign irritant. Many studies have since appeared indicating their presence at autopsy of former urban dwellers. Thomson (1963) reported asbestos bodies in 30% of men and 20% of women in Cape Town South Africa. Cauan (1965) reported finds of 47% and 34% respectively in adults who had no known connection with an asbestos industry. Angivel and Thurbeck (1966) found a 57% incidence of asbestos bodies in men and a 34% incidence in women who lived in Montreal. Meurman (1966) found an overall prevalence of 70% in the urban element of a regional survey in Finland. Utidjian, et al. (1968) report ferruginous bodies in 99% of men and 96.5% of women in a similar study. Selikoff (1972) found asbestos bodies in 48.3% of 3,000 consecutive autopsies. Ghadgavan and Koss (1976) found 91.1% of their Baltimore necropsy population harbored asbestos bodies in their lungs. The biological importance of this finding, the authors said, is certain and speculative. Utidjian suggests that asbestos bodies are found in proportion to the intensiveness of the search.

That the above studies have defined the bodies in morphologically similar terms is undeniable. That asbestos is responsible for and exists at the cores of all the bodies cannot be uncritically accepted. Crally (1968) lists at least twenty mineral substances that are fibre in nature
that may be widely disseminated in the environment of the general public and that produce bodies of identical appearance, although Meurman (1966) believes that bodies in longitudinal fission visible by light microscopy are almost certainly asbestos. Gross (1968) suggested the term "ferruginous body" unless the central core can be positively identified, which Selikoff (1972) attempted with electron microscopy in a small percentage of his samples.

Granted the presence of ferruginous or possibly asbestos, bodies in these populations, are they evidence of a potential hazard? Botham and Holt's studies (1968) with animals have suggested that once a fibre is coated it is no longer pathogenic and that only uncoated fibres produce pathological effects. Utidjian's (1968) conclusion is that there is no evidence that the presence of ferruginous or asbestos bodies in the lungs of non-occupationally exposed individuals in urban industrial communities is making any contribution to pulmonary disease, either inflammatory or neoplastic. A recent study seems to support this conclusion. Breedin and Buss (1976) found no apparent difference in the incidence or quantity of ferruginous bodies in the lungs of a group with various pulmonary neoplasms and a randomly selected group.

Attention has been focused on another phenomenon said to be the result of past exposure to asbestos fibre. Pleural plaques, with or without calcification, are a matter of considerable interest. Extensive plaque formation in
populations living in regions where asbestos is mined or used have been reported by Kiviluoto (1960) and Raunia (1966) in Finland, Rous (1970) in Czechoslovakia and Burlikov (1970) in Bulgaria.

What is the significance of these findings? Wright (1969) points out that the plaques have limited predictability in marking previous asbestos exposure since the plaques have other causes and their absence does not preclude asbestos exposure. The two largest concentrations of pleural plaques, in Finland (Raunia, 1966) and Quebec (Timbrell, 1969), show no related excessive frequencies of respiratory cancer or mesothelioma (McDonald, 1974). The ACGIH-AIHA (1975) observes that even large calcified plaques have little effect on respiratory function.

Some researchers are disturbed at the presence of background levels of fibres in communities with no asbestos mines or manufacturing operations. Holt and Young (1973) report that asbestos fibres have been found in London, Reading, Rochdale, Prague, Pilson, Johannesburg and Reyjavik. In Rochdale, the only one of these cities with important asbestos industry, Richards and Badami (1971), have determined an upper limit of 100 nanograms per cubic meter (ng/m$^3$). Selikoff (1972) reports chrysotile content in ambient air around New York City and vicinities, as well as in Philadelphia, Ridgewood, and Port Allegany ranging from 10 to 100 ng/m$^3$. These sources point out that the asbestos found is usually in fibril form, 2,000 Å or smaller.
in length. Gross (1974) has concluded that the pathogenicity of short fibres (less than five microns) is negligible. There is no evidence that these ambient levels have resulted in a single neoplasm.

This author is in agreement with Wright (1969) who states "that the risk to the general public posed by the mostly intermittent exposure to low concentrations of asbestos likely to be present in the ambient air has been exaggerated beyond the limits imposed by the known facts." However, the goal should always be to reduce the exposure levels of known carcinogens as low as possible.
III
THE RECOMMENDED STANDARD

A new OSHA standard went into effect on July 1, 1976. It changed the June 1972 standard, which limited worker exposure to an eight-hour time-weighted average (TWA) of five asbestos fibres longer than 5 micrometers per cubic centimeter (f/cm³) of air, to an eight-hour TWA of 2 f/cm³. This includes a ceiling limit of 10f/cm³ for any fifteen-minute period. An eight-hour average exposure value of 1 f/cm³ means that a worker breathing 15 liters per minute for eight hours inhales some $10^7$ fibres every workday (Gee and Bouhuys, 1971). The standard also includes recommendations for environmental monitoring, medical surveillance, labeling, personal protection equipment and clothing, employee appraisal, and record-keeping requirements.

The standard has been criticized on several grounds. The criticisms are that it was designed primarily to prevent asbestosis and not cancer, that the epidemiological studies upon which it was based contained too little data on exposure values, and that the environmental data that was collected was obtained through a variety of techniques and expressed in terms other than f/cm³. There is also a general lack of data that would define a threshold for carcinogenic substances, other than zero, which would assume prevention of mesothelioma in all workers. As asbestos associated diseases have long latent periods,
twenty years or more, Gee and Bouhuys (1971) believe that a more sweeping decision on the control of asbestos must be made now, on the basis of "reasonable probability" rather than after a delay for a more precise definition of dose-response relations.

The standard includes a provision that the minimum countable fibre size be five micrometers in length. Ruby and Buchan (1974) believe that the absence of available clinical and environmental data concerning size distributions of asbestos fibres make it unscientific to permit the institution of any minimum fibre size as a criteria.

A TWA of zero would have a major impact on the operations and expenses of the asbestos industry. It may also be unnecessary. Jones and Grendon (1974) maintain that low dose exposure of carcinogens may be virtually without risk because the expected life span of those exposed is exceeded by the time necessary for low concentrations of altered cells to develop into cancers.

But how low is low? This is a question which at least two researchers have addressed. Bruckman and Rubino (1975) propose a standard of 30 ng/m$^3$ which they feel is not unreasonable even though they estimate it is one-thousandth of the current OSHA standard.

Even the most stringent standards are only as good as they are enforced. The carcinogenic nature of asbestos requires the most diligent control no matter what the
standard. Industry should seek to control any sources of environmental contamination to the maximum extent, the overriding concern being the health of those exposed, especially the workers.

Because of recent developments of clinical data on the carcinogenicity of asbestos, a proposed revision of the OSHA standard was published in the Federal Register in October, 1975 (Job Safety and Health, 1976). It would reduce the TWA to .5 f/cm$^3$ and reduce the ceiling limit value to 5 f/cm$^3$. February 9, 1976, was the last date to file public comments. Since that time, NIOSH has proposed to OSHA to lower the TWA to .1 f/cm$^3$ and the ceiling value to .5 f/cm$^3$, according to the Journal of Environmental Health (January-February, 1977).
IV
ASBESTOS IN BUILDINGS

According to Reitze, et al. (1972), the use of sprayed asbestos-containing insulation was developed in Britain in 1932 and was introduced in the United States in 1935. Sprayed asbestos-fibre containing materials have four major uses in the construction industry: thermal insulation, acoustical and decorative purposes, condensation control (because of the unique wicking effect of asbestos fibres) and fireproofing. Asbestos also increases lubricity in spray application. Its use as fireproofing in City Hall East is the major concern of this present investigation.

Since 1950, when Underwriters Laboratories approved asbestos-containing spray insulation for fireproofing, its use has steadily increased. In 1968 over 40,000 tons of this material was used for this purpose, and by 1970 over half of all large multi-story buildings made use of this agent in their construction.

The method of application determines in part the extent to which the asbestos may become a hazard. In the dry method, the dry material is agitated and blown by hose to a nozzle which directs the material through a stream of water jets. In the wet method, the material is premixed with water and the resulting slurry is sprayed on the surface to be coated. The dry method produces a fibrous type matrix that is considerably more friable, and therefore
more likely to cause air contamination than the wet method which produces a harder, cementitious coating.

The Environmental Protection Agency banned the use of products that contain greater than 1% asbestos in 1973 because of dangers to workers involved with its manufacture, mixing and application. Selikoff (1972) also points out that the application process caused widespread contamination of urban centers. But possible environmental exposures to asbestos may still occur. Spray asbestos fibres from the surface of the coated areas may erode and contaminate the building air supply system. There is also the potential environmental contamination that may result from future alterations and eventual demolition of such buildings.

**Literature Review**

Byrom, Hodgson and Holmes (1969) conducted a survey in Great Britain of asbestos contamination in typical situations where asbestos-based building materials were used. This survey included over sixty buildings. In over 90% of the buildings, the asbestos concentrations did not exceed 0.04 f/cm³ (one-tenth the level regarded as acceptable for occupational exposure in Great Britain at that time). Also, more than 40% of the concentrations were of the same order as the levels in buildings where no asbestos had been used. The researchers concluded that the buildings were not likely to constitute a hazard to the health of their occupants.
Lumley, Harries and O'Kelly (1971) surveyed a different type of building in Great Britain: storehouses insulated with crocidolite and amosite asbestos sprays. Crocidolite insulated storehouses had fibre counts ranging from .26 f/cm$^3$ during periods of no activity to a mean high of 11.29 f/cm$^3$ when there was a great deal of activity (disturbing fallen asbestos on boxes on the floor). In storehouses insulated with amosite asbestos the mean concentrations ranged from 1.9 f/cm$^3$ (no activity) to a high of 350 f/cm$^3$ when the unprotected sprayed material was brushed. These researchers concluded that the sprayed asbestos insulation constituted a potential hazard to the building occupants. They recommended sealing the insulation and protecting the sealed insulation from damage.

The hazards of sprayed crocidolite asbestos insulation on the steelwork of a small boiler compressor house was described by Lee and Smith (1974). The asbestos surfaces were friable and small areas of damage, from leaning ladders on the insulation, were noted. During work periods, the researchers found a mean contamination level of .18 f/cm$^3$. The vibration from machinery on the upper floor was considered to be a prime cause for the contamination observed. A lower count of .06 f/cm$^3$ resulted when the plant was not operating. It was decided to seal the exposed surfaces of the insulation with a self-setting gypsum-based composition with a layer of hessian scrim between coats for reinforcement. After drying, two coats of paint were
applied. The workers wore protective dust respirators and protective clothing, which were removed in special changing rooms during this sealing operation. Other protection included a vacuum cleaner for the clothes, polythene bags for soiled clothes, and the use of warning notices and a security guard. After the sealant was applied, fibre counts during work periods were very low; 0.04 f/cm³. Workers in the area were informed of the need to prevent future damage of the sealant and permanent warning notices were posted.

Sawyer (1975) described the problems of asbestos contamination in the Yale Art and Architecture Building. Soon after the sprayed application of a mixture containing 25% asbestos fibres on the building's ceiling, the exposed and friable surface began gradual disintegration. Maintenance and engineering activity necessitated direct contact with the ceiling and subsequent fibre release. Sawyer concluded that the contamination occurred in three general modes: persistent low level fallout resulted in a mean count of 0.02 f/cm³; occasional high intensity concentrations, 15.54 f/cm³, resulted from direct contact; repeated re-entrainment and dispersal from surfaces where the dust had settled ranged from 0.02 f/cm³ during general activity to 4.02 f/cm³ during custodial dry dusting. The decision was reached to remove the insulation and the building was evacuated.

Special precautions to protect the workers and prevent subsequent contamination to nearby areas were taken.
These precautions included half-face mechanical filter respirators, pre-spraying the ceiling with a mixture of water and a surfactant to prevent dust formation, shielding working spaces with polyethylene sheets, decontamination rooms, and the sealing of the removed insulation material into air-tight drums for dispersal. The contamination during this work sequence ranged from 6.45 f/cm³ during the gross clean-up to 0.00 f/cm³ during the final wet mopping. Post removal sampling resulted in fibre levels in the building that equaled city background levels: 3.00 f/cm³.

Nicholson, Rohl and Weisman (1976) investigated asbestos contamination of building air supply systems in nineteen modern office buildings. Their results are difficult to compare with previous studies because of different analytical techniques. Their membrane filter samples were ashed, weighed, examined by electron microscopy, and reported in nanograms per cubic meter. The researchers decided that a building could be considered contaminated when the average level inside the building was at least three times greater and 10 ng/m³ higher than concentrations measured outside in the ambient environment. Four buildings fireproofed with a fibrous asbestos spray were found to be contaminated.

Several additional investigators have conducted unpublished surveys regarding this same problem. Notani (personal communication, 1976) surveyed a number of buildings for the Los Angeles County Personnel Department.
Health Division. The Long Beach Courthouse and the Los Angeles Sheriff's Crime Lab were the most notable buildings where contamination was found. Fibre levels in the Crime Lab ranged from 1.7 - 2.2 f/cm$^3$ (Zuieback, personal communication, 1977). Where contamination was evident, vinyl acrylic polymer paint was applied on the asbestos surfaces as a sealant.

Brown (personal communication, 1976) recommended removal of the asbestos containing ceiling of a UCLA dormitory at a cost of $800,000. During the process he utilized the wetting technique he later recommended to Sawyer.

Young (1972) reported on the contamination of a Wyoming school building. Since then, recent newspaper accounts have reported concern with asbestos ceilings in school buildings in New Jersey (Los Angeles Times, 1977) and California (Los Angeles Times, 1977). The California State Department of Health is also conducting a survey of buildings incorporating asbestos-based materials (Los Angeles Times, 1977).

Discussion

Many of the studies reviewed here have used different methods of monitoring and analysis. While a direct comparison of fibre counts is not possible, it is clear that certain factors are associated with asbestos contamination in buildings.
In all circumstances where significant contamination has occurred, direct visible damage to the sprayed material was evident. Damage from maintenance or engineering activities or vibrations from nearby machinery operations contribute to shaking the fibres loose. Contamination is also more likely from products, such as fibrous spray insulation, in which the fibre is loosely bound as opposed to products in which the fibre is more firmly bound.

Where contamination is found, corrective action should be taken. This may be complete removal of the material, with appropriate safeguards to workers and surrounding areas, or appropriate sealing of the material.

A word concerning sealant is appropriate. Heslep (1972) notes that many areas of a building that may be coated with asbestos materials are subject to cutting, fitting, adjusting and various other maintenance activities in which the integrity of any sealant may be jeopardized. He maintains that there is no known sealant that would preclude the erosion of asbestos fibres under all these various conditions. The use of a sealant with "soft" deteriorating asbestos coatings may even accelerate deterioration as it adds weight to an already weakened material. It is also evident that considerable contamination will occur when and if these buildings are demolished.

Nicholson, et al. (1976) found no evidence for asbestos contamination in cementitious spray fireproofing. Prudence, however, suggests that the specific environments
should be inspected and monitored in order to verify that no hazard exists for the building occupants. It was therefore decided to monitor and analyze City Hall East for possible asbestos fallout with procedures recommended by NIOSH.
MATERIALS AND METHODS

The United States Public Health Service has established sampling and evaluation procedures for determining airborne asbestos dust exposures. Sampling and Evaluating Airborne Asbestos Dust, NIOSH's training manual (1973), served as the guide during the course of this investigation. The approved procedure is to collect the fibres on a membrane filter, dissolve the filter on a glass slide, and then count the fibres under a microscope.

Sampling Procedure

The first step in the procedure was the calibration of a portable rotameter: Brooks, type 1355 01CIFAN. The rotameter was calibrated using the standard bubble burette method, in which the travel of a soap bubble through the burette serves as a primary standard to compare to the reading on the rotameter. A rotameter was selected as a field calibration instrument because of its portability and convenience.

The rotameter was calibrated with the entire sampling apparatus in sequence. The sampling train consisted of approved MSA portable pumps, models G and S; 1/4" inner diameter rubber tubing; and a 37 mm Millipore field monitor, type MAWP 037AO filter, approved by NIOSH for monitoring airborne asbestos fibres, assembled and ready
Once the rotameter was calibrated and the sampling pump batteries charged, actual sampling in City Hall East was begun. To collect samples in the building occupants' breathing zones, special wooden stands were constructed to hold the pump and maintain the field monitor at 5'6" above the floor.

Each pump with completed sampling train, was set at just over 2 lpm with the rotameter. It was anticipated that the flow rate would drop due to battery discharge and indeed this was the case. Each pump and monitor, open-face down, were placed on the stand and sampling commenced. Initial flow rate and starting time were noted.

After the sampling period was completed, the rotameter was again connected to determine the final flow rate. The pump was then shut off; the monitor removed, plugged, taped and labeled. Sampling times ranged from 334 minutes to 461 minutes, with the average time being 388 minutes. These long sampling times were necessary because of the anticipated low concentrations of fibres. The initial and final flow rates were averaged and then multiplied times total minutes to determine total liters sampled. The average flow rate was 2 lpm. The labeled monitors were placed exposed side up in a plastic foam-lined box. When monitoring was completed the filters were brought to the Environmental Health Sciences Laboratory at CSUN for microscopic analysis.
Analysis Procedure

The filters were prepared for analysis in the following manner. Using a scalpel, a pie-wedge approximating one-eighth of the filter surface was cut from each filter. It was then placed sample side up, using a pair of fine-tipped tweezers, on a 1"x3" microscope slide, previously prepared with a small amount of mounting solution. The mounting solution consisted of dimethyl pthalate and diethyl oxalate (mixed in equal proportions) plus .05 gm/ml of clean filter material for proper viscosity. A number one and one-half cover slip was placed on the filter-media combination and lightly pressed until it made contact with the dissolving filter. The slide was then labeled and set aside for fifteen minutes to clear.

The microscope used for analysis was a Swift model M-1000 series, steroscopic compound microscope. It was adjusted for phase contrast microscopy and Koehler illumination. A Porton reticle was placed inside one of the eye-pieces and calibrated with a stage micrometer. The filter samples were examined under 400X magnification.

When counting and sizing the particles, random fields were selected from the wedge tip to the circumference of the filter sample, a field being the left half of the Porton reticle. It was necessary to count 100 consecutive field areas, as the fibre concentration was low. One wedge per cassette was counted.
The following rules were followed in counting the fibres. Only fibres greater than 5 microns and with an aspect ratio equal or greater than 3:1 were counted. Only fibres inside the field area were counted. These included fibres which crossed two pre-selected adjacent sides of the field, and had one end inside the field area.

The asbestos fibre concentration was calculated from the following formula:

\[
C = \frac{(AFC - BAFC) \cdot (\text{Filter Area})}{(\text{Field Area}) \cdot (\text{Volume}) \cdot 1000}
\]

\(C\) = Concentration in f/cm\(^3\)

\(AFC\) = Average fibre count for 100 field areas

\(BAFC\) = Background average fibre count of blank filter

Filter Area = 855 mm\(^2\)

Field Area = Area of counting field, .0031 mm\(^2\)

Volume = Volume of air sampled in liters

Estimation of Error

The joint ACGIH-AIHA Aerosol Hazards Evaluation Committee (1975) estimates a potential error of ± 30% for sampling results. This includes such sources of error as sampling flow rate calibration, error in measuring the area of the sample field and error in measuring the area of the viewing field.

Significant error is also associated with microscopy and variations between counters. Oritz, Ettinger and Fairchild (1975), in a study comparing count data from
several counters at a single facility, report a coefficient of variation of $\pm 20\%$ with maximum individual variations of $\pm 50\%$.

An additional limitation in this technique is the absence of a convenient absolute method for readily identifying asbestos by phase contrast microscopy (NIOSH, 1973). It is not possible, therefore, to conclude positively that all countable fibres are indeed asbestos.
VI

ASSESSMENT OF CITY HALL EAST

Los Angeles City Hall East was designed by the architectural firm of Stanton and Stockwell, who completed their plans in 1969. The construction firm of Montgomery Ross Fisher was contracted to build the structure. Construction commenced in 1971, and city employees moved into the building in 1974.

This investigation is primarily concerned with the erosion into the building's air supply system of asbestos fibres from the spray-lined plenum spaces in the building. To fully appreciate the potential problem it is necessary to describe the building's air supply system.

The air enters the building through openings on the 11th floor. There it goes through a media-type filter of high density fiberglass and a Farr HP gauze-backed paper filter for capturing fine dust. The air is supplied to occupied areas throughout the entire 16-story structure by fans on the 11th floor, which drive the air through sheet metal ducts.

Return air, however, is not ducted and passes through a plenum space formed by the hung ceiling of the room and the underside of the floor above. It is then carried back to the fan room through centrally located ducts where it is discharged. On hot days, above 80°F, the air is not discharged, but rather is mixed with 20% fresh air and
recirculated through the building.

The steelwork and plenum spaces in City Hall East have been sprayed with Zonolite Monokote #2, a registered trademark of Grace Construction Products. Monokote adds fire resistance to steel, concrete and other surface structures. It is an example of the materials that are supplied as sprayed slurries, commonly known as cementitious sprays, that often contain gypsum, Portland cement, vermiculite and 5-30% chrysotile asbestos fibre (Reitze, et al., 1972). Although the asbestos fibres in this product are not loosely bound, the possibility of erosion of the fibres into the breathing zone of the building occupants exists. Additionally, maintenance activities within the plenum space can damage the coating and contribute to contamination. This study concerns itself with the ambient levels of fibre present in breathing zones throughout the building.

To test the possibility of contamination, 10 samples of indoor air were obtained by the NIOSH prescribed method, and analyzed for asbestos fibres to obtain concentration data. Six of these samples were taken in office areas on the 1st, 4th, 7th, 8th, 11th and 13th floors. In addition, 4 samples were taken in the fan room on the 11th floor to sample the return air most recently in contact with the spray material. The fan room did not have a hung ceiling, and the fireproofing was exposed for inspection. There was some damage to the coating due to maintenance activities,
VII
SURVEY RESULTS

The filter samples were examined in the laboratory on January 20-27, 1977. The low concentrations of fibres in the air of the office buildings resulted in a low average of fibres per viewing field: .07. The background count on the blank filter was .00 f/cm³.

Airborne Fibre Levels in City Hall Buildings

Asbestos fibre levels in the three buildings were as follows:

<table>
<thead>
<tr>
<th>BUILDING</th>
<th>MEAN (f/cm³)</th>
<th>N</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>City Hall East</td>
<td>.028</td>
<td>10</td>
<td>.027</td>
</tr>
<tr>
<td>City Hall</td>
<td>.024</td>
<td>2</td>
<td>.071</td>
</tr>
<tr>
<td>City Hall South</td>
<td>.016</td>
<td>2</td>
<td>.056</td>
</tr>
</tbody>
</table>

Discussion and Conclusion

The OSHA standard for asbestos, effective July 1, 1976, and through the time period of this survey, is 2.0 f/cm³ TWA and 10.0 f/cm³ maximum excursion for any 15-minute period. The OSHA standards used in this study do not represent definite pathological benchmarks, but are used for comparison and as guidelines.

The standard t-test was used to establish the significance of the survey findings when compared to the OSHA standard. Comparison of building levels and the OSHA
standard yielded a significance test of \( p < 0.001 \).

It can therefore be concluded that the contamination level present in City Hall East is statistically insignificant when compared to the OSHA standard. These very low concentrations are not likely to be of long term biological significance. Comparison with the two nearby buildings which did not incorporate asbestos-based materials in their construction suggest that all three values represent a general ambient level of fibre concentration in downtown Los Angeles.

To test this interpretation, sampling was conducted on March 25, 1977, using the previously described techniques and equipment. Air samples were simultaneously obtained from the 11th floor fan room in City Hall East and from the outside ambient air near the 11th floor fan intake and at street level. The results were as follows:

<table>
<thead>
<tr>
<th>SOURCE</th>
<th>FIBRE CONCENTRATION (f/cm(^3))</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inside, 11th floor fan room</td>
<td>0.028</td>
</tr>
<tr>
<td>Outside, 11th floor</td>
<td>0.021</td>
</tr>
<tr>
<td>Street level</td>
<td>0.031</td>
</tr>
</tbody>
</table>

This data tends to support the interpretation that the fibre concentrations inside the buildings reflect a general ambient level of fibre concentration in downtown Los Angeles.

The hypothesis stated in the Introduction is hereby accepted: No significant levels of asbestos fibres were found in City Hall East.
Recommendations

Because occupants in the office building are in no danger of exposure to harmful asbestos fibre levels, sealant or removal is not recommended. But the possibility exists that maintenance or engineering personnel engaged in activities that include modifying, brushing against, or cutting and removing parts of the fireproofing coating may be in danger of exposure to intermittently high levels of asbestos fibres. Although quantification of this problem is beyond the scope of this study, these personnel should be informed of the nature of the problem before they contact the coating and should take proper precautions. These precautions might include the wearing of proper particulate-filter respirators, changing and bagging their clothes, and preventing the spread of the fibres to other areas by proper and thorough clean-up of debris, which should also be bagged and disposed of. Permanent reminders, in the form of warning signs, are recommended for the exposed spray areas in the fan room on the 11th floor.
REFERENCES

Primary Sources


Zuieback, S. Personal communication concerning fibre concentration level in Los Angeles County Sheriff's Crime Lab. California State University at Northridge, March, 1977.

Secondary Sources


APPENDIX

The raw data concerning fibre counts is as follows:

<table>
<thead>
<tr>
<th>DATE</th>
<th>LOCATION</th>
<th>LITERS</th>
<th>FIBRE COUNT (f/cm³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/19/77</td>
<td>CHE-Fan Room</td>
<td>840</td>
<td>.020</td>
</tr>
<tr>
<td>1/19/77</td>
<td>CHE-Fan Room</td>
<td>858</td>
<td>.047</td>
</tr>
<tr>
<td>1/19/77</td>
<td>CHE-Room 800</td>
<td>743</td>
<td>.022</td>
</tr>
<tr>
<td>1/19/77</td>
<td>CHE-Room 1330</td>
<td>662</td>
<td>.066</td>
</tr>
<tr>
<td>1/19/77</td>
<td>CHE-Room 425</td>
<td>792</td>
<td>.031</td>
</tr>
<tr>
<td>1/20/77</td>
<td>CHE-Fan Room</td>
<td>851</td>
<td>.012</td>
</tr>
<tr>
<td>1/20/77</td>
<td>CHE-Fan Room</td>
<td>845</td>
<td>.016</td>
</tr>
<tr>
<td>1/20/77</td>
<td>CHE-Room 1100</td>
<td>847</td>
<td>.026</td>
</tr>
<tr>
<td>1/20/77</td>
<td>CHE-Room 700</td>
<td>783</td>
<td>.021</td>
</tr>
<tr>
<td>1/24/77</td>
<td>CHE-Room 100</td>
<td>735</td>
<td>.015</td>
</tr>
<tr>
<td>1/24/77</td>
<td>CH-Room 1600</td>
<td>850</td>
<td>.019</td>
</tr>
<tr>
<td>1/24/77</td>
<td>CH-Room 500</td>
<td>1014</td>
<td>.029</td>
</tr>
<tr>
<td>1/24/77</td>
<td>CHS-Room 103</td>
<td>897</td>
<td>.012</td>
</tr>
<tr>
<td>1/24/77</td>
<td>CHS-Room 700</td>
<td>680</td>
<td>.020</td>
</tr>
<tr>
<td>3/25/77</td>
<td>CHE-OA 11th floor</td>
<td>780</td>
<td>.021</td>
</tr>
<tr>
<td>3/25/77</td>
<td>CHE-Fan Room</td>
<td>858</td>
<td>.028</td>
</tr>
<tr>
<td>3/25/77</td>
<td>CHE-OA Street level</td>
<td>787</td>
<td>.031</td>
</tr>
</tbody>
</table>

Key:

CHE  City Hall East
CH   City Hall
CHS  City Hall South
OA   Outside Ambient