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ASSESSMENT OF ASBESTOS STUDIES WITH RESPECT TO FIBER TYPE AND SIZE

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1.0 INTRODUCTION

It is well known that asbestos is not one but a family of fibrous minerals, each of which has distinctive physical and chemical characteristics. Minerals from various parts of the world and geologic formations often have dissimilar physical properties, even though they are classified under a specific mineralogic type. These differences are relevant to the understanding of the effects of asbestos on health, since the characteristics of the fibers have been fully defined in only a few experimental studies. The problem of evaluating the effects of different types of asbestos on health is compounded by the common practice of custom blending various minerals for a specific industrial application and the different analytical techniques for measurements of asbestos (mass versus fibers), etc.

The major pathologic effects of asbestos result from the inhalation of fibers suspended in the air. The occurrence of disease is influenced by the type of mineral and the dimensions of the fibers that constitute it, as well as by the concentration of fibers and the duration of exposure.

When nonfibrous compact dust particles are inhaled, the ones greater than about 5 μm in diameter are generally trapped in the nasal passage before reaching the respiratory system (Walton, 1982). However, the inhaled fibers align themselves parallel to the airways and act as spheres of approximately "equivalent" diameter (Gross, 1981; Timbrell et al., 1970). The "equivalent" or aerodynamic diameter of a particle is defined as the diameter of a sphere with a density of 1 g/cm^3 that has the same falling speed as the particle. There is no sharp cutoff of particle sizes determining their deposition site (Brain and Valberg, 1979).

2.0 INHALATION OF ASBESTOS BY FIBER TYPE

In occupational circumstances, the current method of quantitating asbestos air concentrations allows only for the enumeration of all fibers longer than 5 μm collected on a specified area of filter, utilizing phase-contract light microscopy (NIOSH, 1972). Such instrumentation does not allow for the identification of the fibers according to mineral type or size.

It is a well established fact that inhalation exposure of asbestos is associated with increased risks of lung tumors (bronchogenic carcinoma and peripheral adenocarcinoma), pleural and peritoneal mesothelioma, interstitial pulmonary fibrosis (asbestosis), pleural thickening and possibly other tumors, including those of the gastrointestinal tract and kidney. Investigators have induced lung tumors, mesotheliomas and fibrosis after administration of asbestos to animals. In some of these experimental studies in animals, the investigators have provided a description of the size and types of fibers used. For example, Lee et al. (1981) have shown that the inhalation of amosite (AM), fiber glass (FG) and potassium octatinate (Fybex) in rats and hamsters caused adenoma, carcinoma and mesothelioma over the three months of exposure. The reported length of Fybex fiber was >5 μm (Table 1).

Table 2 shows the occurrence of mesotheliomas appearing in rodents after injection of asbestiform fibers. This injection technique has been used

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TABLE 1 RESPIRATORY TRACT TUMORS IN RODENTS AFTER INHALATION OF ASBESTOS AND OTHER ASBESTIFORM FIBERS

Fiber Type[a]	No. of Tumors/ No. of Animals	Animal	Tumor Types	References
Am, FG (fine, Fybex (>5 μm length), PKT	Experiment 1 AM (3/16), FG (2/19, Fybex (1/21) in rats; Fybex (1/12) in hamsters	Rat, guinea pig, hamster	Adenoma, carcinoma, mesothelioma	Lee et al., 1981
Alumina (med. length, 35 to 62 μm; diam., 1 to 5 μm) versus CH (UICC)	Alumnia = 0/60 CH = 5/38	Rat	Ademona, squamous cell, adeno-carcinoma	Piggott et al., 1981

(a) AM = amosite, FG = fiberglass, Fybex = potassium octatinate, PKT = pigmentary potassium titante, CH (UICC) = Chrysotile (International Institute Against Cancer).

Adapted from NAS Report, 1984.

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TABLE 2 MESOTHELIOMAS IN RODENTS APPEARING AFTER INJECTION OF ASBESTIFORM FIBERS

Mode of Administration	Dose, (mg)	(No. of Tumors/ No. of Animals) or % Tumors, by Fiber[a] Exposure	Animal	References
Intrapleural or Intrathoracic	1 time CR = 1, 10, 40 mg on glass pledget	CH(15/30), AM (15/30), CR (14/30), milled CR (8/30), FG (1-25 μm diameter, 1/30), FG (0.06-3 μm diameter, 4/60, CR (at 1 mg/ 2/40; at 10 mg, 11/40, pledget alone (0/40)	Rat	Stanton and Wrench, 1972
	40 on glass pledget	17 samples of FG tested; greatest tumor incidence observed for FG >8 μm length, <1.5 μm diameter.	Rat	Stanton et al., 1977
	40, 1 time	CR, CH, FG, aluminum oxide all <5 μm diameter, >50% tumors.	Rat	Stanton and Lavard, 1978
	40, 1 time	Most fibers <0.25 μm diameter, >8 μm length were tumorigenic, but induction also observed for fibers <1.5 μm diameter, >4 μm length; 72 experiments.	Rat	Stanton et al., 1981

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(a) CH = chrysotile, CR = crocidolite, AM = amosite, FG = fibrous glass, GF = glass fiber, SFCH = superfine chrysotile.

Adapted from NAS Report, 1984.

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Table 2 - continued

Mode of Administration	Dose, (mg)	(No. of Tumors/ No. of Animals) or % Tumors, by Fiber Exposure	Animal	References
	0.5, 1, 2, 4, 8, (SFCH, CR); rest, 20, 1 time	Dose response: tumors observed with SFCH, CH, milled CH, AM, AN, CR, brucite ceramic fiber, barium sulfate, FG, glass powder, aluminum oxide. Tumors were induced with nonfibrous materials, but more were seen with fibers >10 μm length, <5 μm diameter.	Rat	Wagner et al., 1973
	20, 1 time	CH (45%); leached (0-3%); CR (54%). Leached fibers were shorter, thicker and there were fewer per unit weight.	Rat	Monchaux et al., 1981
	1, 10, 25	CR at 1 mg (2/50), CR at 10 mg (10/50), AM at 10 mg (3/50), CH at 1 mg (0/50), CH at 10 mg (4/50), CH at 25 mg (9/50), AM at 1 mg (0/50), AM at 10 mg (4/50), talc at 25 mg (0/50), control (0/100), milled CH at 25 mg (<0.37 μm length, <0.07 μm diameter, 0/150), fibrous nemalite at 25 mg (0/50), silicon dioxide at 10 mg (4/40), FG (50 μm diameter, 0/50).	Hamster	Smith and Hubert, 1974

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Table 2 - continued

Mode of Administration	Dose, (mg)	(No. of Tumors/ No. of Animals) or % Tumors, by Fiber Exposure	Animal	References
	25, 1 time	Group 1: FC 0.1 μm diameter, 82% >20 μm length (5/60); Group 2: FC (0.3 μm diameter, 46% >20 μm length (2/60); Group 3: FC (1.23 μm diameter, 34% >20 μm (2/60). None in three groups of FC where 2% >10 μm length.	Hamster	Smith et al., 1980
Intraperitoneal	0.5, 2, 5, 10	Diversity of mineral fibers <20 μm diameter, <0.25 μm length; GF induction of tumors reduced with hydrogen chloride and NaOH treatment.	Rat	Pott et al., 1982

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most frequently in reported studies because of its reproducibility (NAS, 1984). Stanton et al. (1977, 1981) reported that tumor incidence was greatest for fibrous glass >8 μm in length. Wagner et al. (1973) observed in their experiments that fibers >10 μm in length were more tumorgenic than nonfibrous materials. From the data presented in Table 2, it may be stated that exposure to long (>8 μm) fibers results in the appearance of mesotheliomas. Nonfibrous particles, including cleavage fragments, do not generally cause tumors.

Fibrosis, associated with asbestos and asbestiform fibers, has been experimentally produced in various animal studies. Table 3 shows those studies for which fiber types have been reported by the investigators. The important features of these experiments can be summarized by stating that inhalation and pleural injection studies implicate the increased fibrogenic potential of longer (>10 μm) fibers of both asbestos and fibrous glass.

Fredricks (1979) also provides some interesting data concerning morphological aspects, namely the size and shape of fiber content in human lung dusts. The author observed that most of the fibers in the lung of the one asbestos worker were shorter than 20 μm in length and thinner than 1 μm. However, the majority of fibers in the samples of the analyzed groups (normal, mesothelioma cases and asbestosis plus mesothelioma) were shorter than 30 μm and thinner than 2 μm, the longest fibers were found to be 180 μm.

In summary, even though the interpretation of the experimental results of many asbestos and asbestiform studies regarding pathogenicity of various fiber types is complicated (because only the mass of asbestos administered was mentioned), the data presented in the preceding section suggest the following:

1. Respiratory tract tumors are observed in rats and hamster following inhalation exposure of Fybex (potassium octatinate) > 5 μm length (Lee et al, 1981; Table 1).

2. Inhalation exposure to long (>10 μm) fibers results in the appearance of mesotheliomas (rats). Nonfibrous particles, including cleavage fragments, do not generally cause tumors.

3. Inhalation and pleural injection studies implicate the increased fibrogenic potential of longer (> 10 μm) fibers of both asbestos and fibrous glass (rats).

3.0 INGESTION OF ASBESTOS BY FIBER TYPE

There are few ingestion studies in which mineral and fiber characterization of asbestos fibers are reported (Table 4). The results of bioassays of amosite (median length 4.37 μm, range 0.85 - 995 μm), and chrysotile short-range (SR, median length 0.66 μm, range 0.088 to 51.1) or intermediate-range (IR, median length 0.82 μm, range 0.104-783) did not demonstrate any carcinogenicity in hamsters when ingested over the lifetime period (McConnell et al. 1983). In another ingestion study in animals, McConnell et al. (1983) demonstrated that amosite asbestos with a median length of 4.37 μm (range 0.85-995) was not carcinogenic when ingested at a level of 1% in the diet by male and female rats.

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TABLE 3 DEVELOPMENT OF FIBROSIS IN ANIMALS AFTER INHALATION OR INTRATRACHEAL INSTILLATION OF ASBESTOS AND OTHER ASBESTIFORM FIBERS

Mode of Administration	Fiber Type[a]	Concentration (mg/m^3)[b]	Animal	Latency (months)	Observations	Reference
Inhalation, instillation	GW 20-50 μm length and short fibers	ND[c]	Guinea pig	ND	No fibrosis	Schepers and Delahant, 1955
	CH, CR, AN, AM, TR, brucite, all long (20-50 μm) versus short (<5 μm)	ND ≤ 3 years	Rat, guinea pig, mouse, cat, dog	16 (guinea pig) 14 cat	Fibrous reaction: guinea pig>rabbit=cat=rat> mouse and dog. Long CR fibers: fibrosis; long AM, CR, brucite + peribronchiolitis; long TR + bronchiolar fibrosis; AN + no fibrosis; no fibrosis with short fibers.	Vorwald et al., 1951
Combined inhalation and instillation	FG (0.5 μm diameter, 5-20 μm length)	100 24 months	Rat, hamster	Not applicable	Mild macrophage infiltration without fibrosis.	Cross et al., 1970, 1974
Instillation	Sized CR, CH, FG, synthetic fluoroamphibole	3-25, 2-6 times	Guinea pig	24	Minimal peribronchiolar fibrosis only with fibers >10 μm length.	Kuschner and Wright, 1976

(a) CH = chrysotile; CR = crocidolite; AN= anthophyllite; AM = amosite; FG = fibrous glass; TR = tremolite; GW = glass wool.
(b) Applied to inhalation exposures. Dose expressed differently for other types of exposure.
(c) ND = No details given in report.

Adapted from NAS report, 1984.

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TABLE 4 DIGESTIVE TRACT TUMORS IN RODENTS AFTER ADMINISTRATION OF 1% IN DIET OF ASBESTOS

Fiber Type	Dose in Diet Life-time, %	Fiber Size Length/Diameter		Digestive Tract Tumors		Animal	Reference
		Short Range, μm	Intermediate Range, μm	Short Range	Intermediate Range		
Chrysotile	1	0.088-51.1/ 0.019-1.57	0.104-783/ 0.019-11.5	Not detected	Not detected	Hamsters	McConnell et al., 1983
Amosite	1	--	0.85-995/ 0.064-12.4	--	Not detected	Hamsters	McConnell et al., 1983
Amosite	1	--	0.85-995/ 0.064-12.4	--	Not detected	Rats	McConnell et al., 1983
Chrysotile	1	0.088-51.1/ 0.019-1.67	0.104-783.4/ 0.019-11.5	Not detected	Not detected in females. Benign epithelial nodules in 9/250 males	Rats	NTP draft report, 1984

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Recently, the NTP (1984, draft) has reported the results of a study on the carcinogenic potential of the ingestion of chrysolite short range (98% < 10 μm) and intermediate-range (65% >10 μm with 14% > 100 μm) fibers. The results of the study showed no evidence of carcinogenicity for the SR fibers in either male or female rats, and no evidence of carcinogenicity for the IR fibers in the female rats. However, for the male rats ingesting the intermediate-range fibers at 1% of the diet, benign epithelial neoplasms (adenomatous polyps) were observed in the large intestine at the incidence of 9/250. Based on these findings, the NTP concluded that there was "some" evidence of carcinogenicity in male rats exposed to IR chrysotile fibers.

In summary, the results of bioassays of amosite asbestos (median length of 4.37 μm) and chrysotile asbestos (<10 μm in length) do not show carcinogenic potential in hamsters and rats when fed at 1% in the diet over the lifetime period. However, there is some evidence of carcinogenic potential associated with chrysotile asbestos >10 μm in length, in male rats over the lifetime exposure.

4.0 EPIDEMIOLOGICAL ASBESTOS INGESTION STUDIES BY FIBER TYPE

Marsh (1983) reviewed and evaluated epidemiological studies of ingested asbestos conducted in five areas of the United States and Canada for the definitiveness and applicability regarding the development of ambient water quality standards. Several methodologic weaknesses and limitations were found in each study, leading to the determination that no individual study or aggregation of studies exist that would establish risk levels from ingested asbestos. The author considered that one of the factors that may have attributed to considerable discrepancies might have been the characteristic of asbestos exposures in drinking water in various study populations. The type of asbestos and other pertinent information are provided in Table 5. It is seen from the table that the chrysotile asbestos was present in water supplies of four of the five study populations.

Millette et al. (1980) in a review of the results of over 1,500 asbestos analyses from water supplies suggest that the average length of chrysotile fibers found in an asbestos cement distribution system was 4 μm, while the average fiber length of chrysotile fibers contributed to a water supply by natural errosion was 1 μm. Some size characteristics of asbestos fibers found in various water supplies are given in the Table 6.

5.0 DISCUSSION

Lee et al. (1981) have shown that the inhalation of amosite, fiberglass and potassium octatinate in rats and hamsters caused adenoma, carcinoma and mesothelioma. The reported length of potassium octatinate fiber was >5 μm.

In other studies, Stanton et al. (1977, 1981) reported that tumor incidence in animals was greatest for fibrous glass >8 μm in length. Similarly, Wagner et al. (1973) also observed in their experiments that fibers >10 μm in length were more tumorgenic than nonfibrous material in animals (rats).

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TABLE 5 CHARACTERISTICS OF ASBESTOS EXPOSURES IN DRINKING WATER IN VARIOUS STUDY POPULATIONS

Characteristic	Duluth, MN	Connecticut	Quebec	Bay Area, CA	Utah	Puget Sound, WA
Type of asbestos	Amphibole	Chrysotile	Chrysotile	Chrysotile	Chrysotile	Chrysotile
Number of fibers/L[a,b]	1.0-30.0 - 10^6	BDL-0.7 - 10^6	1.1-1,300 - 10^6	0.025-35 - 10^6	NA[b]	7.3-206.5 - 10^6
Population exposed	100,000	576,800	420,000	3,000,000	24,000	200,000
Maximum duration of exposure, yr	15-20	23-44	>50	>40	20-30	>40

(a) BDL = Below detectable limit.
(b) NA = Data not available.

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TABLE 6 SOME SIZE CHARACTERISTICS OF ASBESTOS FIBERS FOUND IN VARIOUS WATER SUPPLIES

Source	Type of fiber	Number of fibers measured	Average length, μm	Average width, μm	Average aspect ratio[a]	Maximum length found μm
Reservoir with natural erosion (WA)	Chrysotile	289	0.8	0.034	25:1	3
Reservoir with natural erosion (CA)	Chrysotile	644	1.3	0.04	39:1	10
Cistern with asbestos tile roof (VI)	Chrysotile	342	2.3	0.04	62:1	25
Distribution sites from five asbestos cement pipe systems (SC, PA, FL)	Chrysotile	1,440	4.3	0.044	121:1	80
Lake Superior (MN)	Amphibole	468	1.5	0.18	11:1	14

(a) Aspect ratio: Length/width.

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Data concerning fiber size in human lung dust in asbestos exposed workers (Fredrick, 1979) showed that the majority of fibers in the samples of the analyzed groups were in the range of 10 to 30 μm in length.

Lifetime asbestos ingestion bioassays for carcinogenicity in animals by McConnell et al. (1983) and NTP (draft 1984) provide some interesting information on the asbestos fiber size and its carcinogenicity in animals. McConnell et al. (1983) reported no evidence of carcinogenicity of the gastrointestinal tract in hamsters following administration of diet containing 1% amosite (median length 4.37 μm) or chrysotile asbestos consisting of short-range (median length 0.66 μm) or intermediate-range (median length 0.82 μm) fibers. The investigators also reported that ingestion of amosite consisting of a median length of 4.37 μm resulted in no gastrointestinal tract carcinogenicity in rats.

In a recent report, the NTP (draft 1984) showed that intermediate-range chrysotile asbestos consisting of median length fibers of 0.82 μm (65% > 10 μm; 14% ≥ 100μm) was associated with causing benign epithelial neoplasms (adenomatous polyps) in the large intestine of male rats when fed at 1% in the diet. The short-range chrysotile asbestos (median length 0.66 μm; 98% < 10 μm in length) had no effects on male or female rats.

In summary, an attempt is made to assess the size characteristics of asbestos/asbestiform fibers and their pathologic effects of various exposures. This report has delineated the various pathologic effects of asbestos/asbestiform fibers associated with inhalation, ingestion exposure, and plural injection. It is recognized that these studies were not carried out under rigid experimental conditions, and yet, even with these qualifications, the results of the experiments conclude that asbestos fiber > 10um in length play a significant role in producing various effects. The implications of this assessment are presented in Appendix 1.

6.0 REFERENCES

Brian JD and Vulberg PA. 1979. Deposition of aerosol in the respiratory tract. Am. Rev. Respir. Dis. 120:1325-1373.

Fredricks KH. 1979. Morphological aspects of fibers. In: Dust and Disease. Lemen and Dement. Pathotox. Pub. pp. 51-64.

Gross P. 1981. Consideration of the aerodynamic equivalent diameter of respirable mineral fibers. Am. Ind. Hyg. Assoc. J. 42:449-452.

Gross P, deTrevill RPT, Cralley LJ, Granquist WT and Pundsack FL. 1970. The pulmonary response to fibrous dusts of diverse compositions. Am Ind. Hyg. Assoc. J. 125:125-132.

Gross P, Harley RA, Swinburne LM, Davis JMG and Greene WB. 1974. Ingested mineral fibers. Do they penetrate tissue or cause cancer? Arch. Environ. Health 29:341-347.

Kuschner M and Wright GW. 1976. The effects of intratrachial instillation of glass fiber of varying size in guiena pigs. In: Occupational Exposure of fibrous Glass-Proceedings of a Symposium. No. 76-151. National Institute for Occupational Safety and Health, Washington, DC. pp. 151-158.

Lee KP, Barras CE, Griffith FD, Waritz RS and Zapir CA. 1981. Comparative pulmonary responses to inhaled inorganic fibers with asbestos and fiberglass. Environ. Res. 24:167-191.

March EM. 1983. Critical review of epidemiologic studies related to ingested asbestos. Environ. Hlth. Persp. 53:49-56.

McConnell EE, Rutter HA, Ulland B and Moore JA. 1983. Chronic effects of dietary exposure ot amosite asbestos and tremolite in F344 Rats. Environ. Hlth. Persp. 53:27-44.

McConnnell EE, Shefner AM, Rusi JH and Moore JA. 1983. Chronic effects of dietary exposure to amosite and chrysotile asbestos in Syrian golden hamsters. Environ. Hlth. Persp. 53:11-25.

Millette JR, Clark PJ, Pansing MF and Twyman JD. 1980. Concentration and size of asbestos in water supplies. Environ. Hlth Persp. 34:13-25.

Monchaux G, Bignon J, Jarrand C, Lafoma J, Sebasten P, Masse R, Hirsch A and Goni J. 1981. Mesotheliomas in rats following inoculation with acid-leached chrysotile asbestos and other mineral fibers. Carcinogenesis 2:229-236.

NAS. 1984. National Academy of Sciences. Asbestiform fibers: non-occupation health risk.

National Institute for Occupational Safety and Health. 1972. Criteria for a recommended standards. Occupational Exposure in Asbestos. HSM 72-10267. U.S. Government Printing Office, Washington, DC.

National Toxicology Program. (draft 1984). NTP technical report on the toxicology and carcinogenesis studies of chrysotile asbestos. NTP Publication No. 84-2551, NTP-83-173.

Piggott GH, Gaskell BA and Ishonael J. 1981. Effects of long-term inhalation of alumina fibers in rats. Br. J. Exp. Pathol. 62:323-331.

Pott F, Schlipkoter HW, Ziem U, Spurny K and Huth F. 1982. New results from implantation experiments with mineral fibers. Presented at the Biological Effects of Man-Made Mineral Fibers, Occupational Health Conference, Copenhagen, April 20, 1982. World Health Organization.

Schepers GWH and Delahant. 1955. An experimental study of the effects of glass wool on animals lungs. Arch. Ind. Health 12:276-286.

Smith WE, Hubert DD and Sobel HJ. 1980. Dimensions of fibers in relation to biological activity. In: Biological Effects of Mineral Fibers. JC Wagner, ed. IARC Scientific Pub. No. 30. International Agency for Research on Cancer, Lyon, pp. 357-360.

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Smith WE and Hubert DD. 1974. The intrapleural root as a means for estimating carcinogenicity. In: Experimental Lung Cancer, Carcinogensis and Bioassays. E Karbe and JF Park, eds. Springen, New York, pp. 93-100.

Stanton MF and Layard M. 1978. The carcinogenicity of fibrous materials. In: Proceedings of the Workshop on Asbestos. National Bureau of Standards, Garthsburg, MD. pp. 142-151.

Stanton MF, Layard M, Tegaris A, Miller E, May M and Kent E. 1977. Carcinogenicity of fibrous glass: Pleural response in the rat in relation to fiber dimension. J Natl. Cancer Inst. 58:587-603.

Stanton MF, Layard M, Tegaris A, Miller E, May M, Morgan E and Smith A. 1981. Relation of particle dimension to carcinogenicity in amphibole asbestos and other fibrous materials. J. Natl. Cancer Ins. 67:165-175.

Stanton MF and Wrench C. 1972. Mechanisms of mesothelioma induction with asbestos and fibrous glass. J. Natl. Cancer Inst. 48:797-816.

Timbrell V. Beran NE, Davies AS and Munday DE. 1970. Hollow cast of lungs for experimental purposes. Nature 227:97-98.

Vorwald AJ, Dunkan TM and Pratt PC. 1951. Experimental studies of asbestos. Arch. Ind. Hyg. Occup. Med. 3:1-83.

Wagner JC, Berry G and Timbrell V. 1973. Mesothelioma in rats after inoculation with asbestos and other materials. Br. J. Cancer 28:173-185.

Walton WH. 1982. The nature, hazards and assessment of occupational exposure to airborne asbestos dust: A review. Ann Occup. Hyg. 25:117-247.

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APPENDIX I

IMPLICATIONS OF THE ASSESSMENT

The implications of the assessment that asbestos fibers > 10 μm in length are responsible for observed carcinogenicity in animals and humans leads to:

1. The explanation of why epidemiological ingestion studies showed no clear evidence of gastrointestinal tract cancer for those populations where asbestos was contained in the drinking water.

2. The determination of excess lifetime cancer risk, if any, from the ingestion of drinking water contaminated with chrysotile asbestos fibers > 10 μm in length.

The reasons for the lack of increased gastrointestinal tract cancers in those populations where drinking water contained asbestos (epidemiological studies) may be that the fibers present in these water supplies were < 10 μm in length. In support of this argument, the review by Marsh (1983) of 13 epidemiological studies provides the asbestos "type" present in these water supplies and Millelte et al. (1980) provides the size of the asbestos fiber present in some of those water supplies. Marsh (1983) has stated that the asbestos "type" present in the water supplies of four of the five areas was chrysotile asbestos. Millette et al. (1980) in their review of the results of over 1,500 asbestos analyses of water supplies of various areas (e.g., California, Washington, etc.), demonstrated that the average length of chrysotile asbestos in the asbestos cement distribution system was 4 μm, while the average fiber length of chrysotile asbestos contributed to a water supply by natural erosion was 1 μm. Therefore, these findings strongly suggest that the lack of increased gastrointestinal tract cancer in those populations where the drinking water contained asbestos might be due to the fact that the majority of chrysotile asbestos was well below 10 μm in length.

With regard to determining excess lifetime cancer risk from ingestion of chrysotile asbestos > 10 μm in length, the evidence that asbestos is carcinogenic to the gastrointestinal tract is limited. As such, the data base chosen to calculate the estimate of risk (gastrointestinal tract cancer) by ingestion is from a draft of the NTP (1984) ingestion study of intermediate range chrysotile asbestos > 10 μm in length. Using this study, the estimated levels which would result in increased lifetime cancer risks (fiber/liter) of 10^{-5}, 10^{-6} and 10^{-7} are: 7.1×10^{7}, 7.1×10^{6} and 7.1×10^{5} fiber/liter, respectively.

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