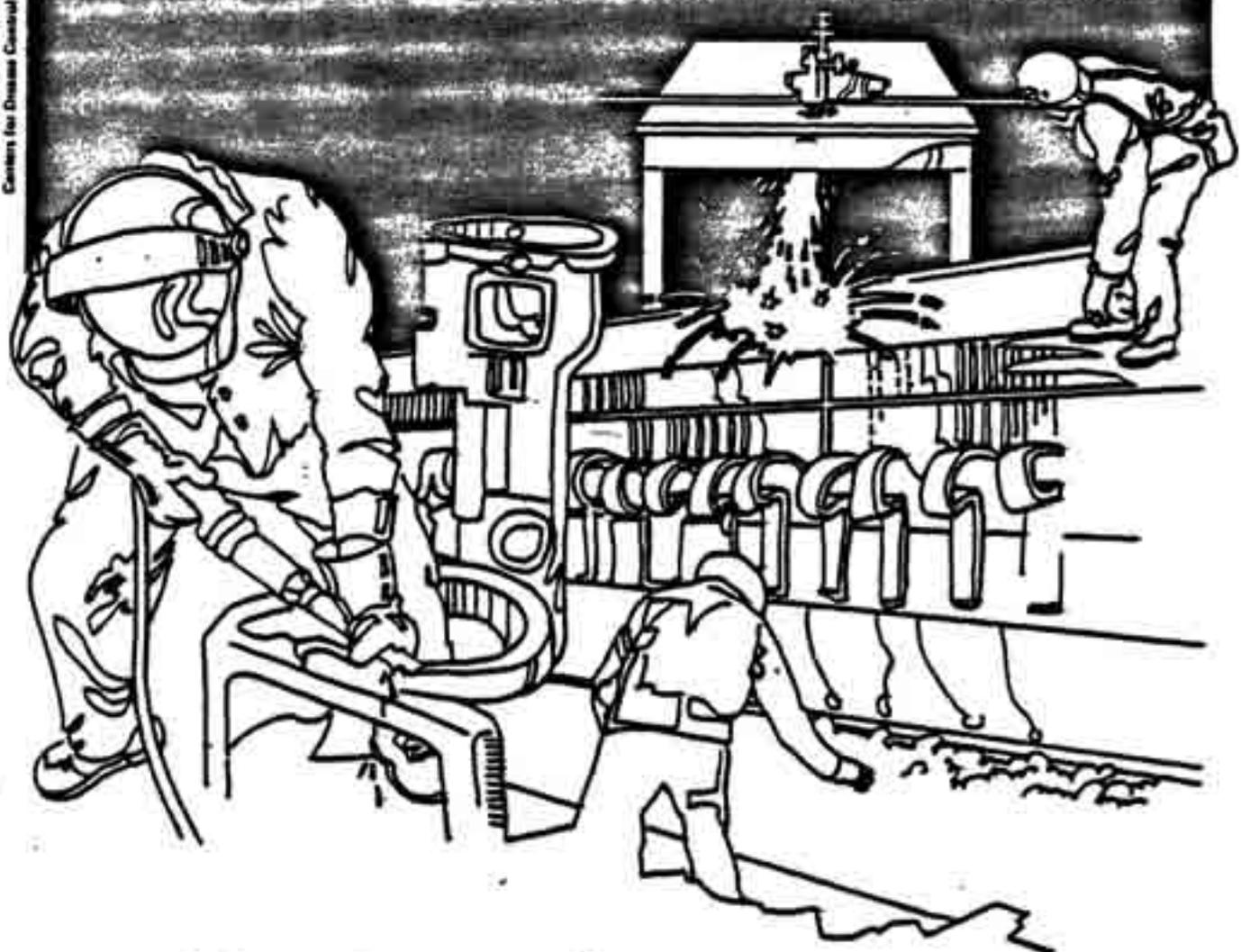


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U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES ■ Public Health Service  
Centers for Disease Control ■ National Institute for Occupational Safety and Health

# NIOSH



## Health Hazard Evaluation Report

HETA 84-262-1734  
FRICTION DIVISION PRODUCTS  
TRENTON, NEW JERSEY

## PREFACE

The Hazard Evaluations and Technical Assistance Branch of NIOSH conducts field investigations of possible health hazards in the workplace. These investigations are conducted under the authority of Section 20(a)(6) of the Occupational Safety and Health Act of 1970, 29 U.S.C. 669(a)(6) which authorizes the Secretary of Health and Human Services, following a written request from any employer or authorized representative of employees, to determine whether any substance normally found in the place of employment has potentially toxic effects in such concentrations as used or found.

The Hazard Evaluations and Technical Assistance Branch also provides, upon request, medical, nursing, and industrial hygiene technical and consultative assistance (TA) to Federal, state, and local agencies; labor; industry and other groups or individuals to control occupational health hazards and to prevent related trauma and disease.

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#### SUMMARY

On March 28, 1984, the National Institute of Occupational Safety and Health (NIOSH) received a request from the International Chemical Workers Union, representing employees at Friction Division Products. The request was assigned to the New Jersey Department of Health for investigation. After delays caused by plant access problems and a strike, the study was conducted in February and March 1986. The request stated concern about asbestos exposure in the plant and the potential for contamination of the home environment. The plant employs about 1230 production workers in the manufacture of auto and truck brake shoes. About 90% of the shoes produced include asbestos as a major raw material.

Chest X-rays of employees working for more than 10 years were reviewed by a NIOSH certified B-reader. Personal air sampling for asbestos was conducted in the plant on three days. Bulk samples were obtained from the clothing of workers leaving the plant to assess potential home contamination. Analysis was done by phase contrast microscopy (PCM) and on a few samples, transmission electron microscopy (TEM).

Seven of twenty individuals with greater than 10 years at the plant had X-ray findings consistent with asbestos exposure. Two had asbestosis, two had pleural thickening and one had a pleural plaque. Two had lung cancer.

Personal air sample results indicated asbestos TWA exposures in the range of 0.06 to 1.56 f/cc (fibers per cubic centimeter) and indicating significant contamination throughout the plant and on all operations. On the basis of sampling and analysis results it is suggested that the results are underestimates of the actual exposures present. The levels documented are above the OSHA Permissible Exposure Limit (PEL) of 0.2 f/cc, and the exposure limit recommended by NIOSH of 0.1 f/cc.

Samples obtained from work clothing as workers left the plant indicated the presence of asbestos.

Results of the air sampling and X-ray review indicate a significant risk of asbestos disease in the plant and a potential risk to families of employees. Review of the employer's occupational health program shows it to be out of compliance with most provisions of the new OSHA Asbestos Standard. Recommendations are given to improve plant conditions, lower the asbestos level, prevent home contamination, and improve the medical monitoring system.

On the basis of air sampling and X-ray review, it is concluded that a substantial health hazard exists for workers and potentially for their families from asbestos exposure at Friction Division. Increased attention to dust control at the plant is required to prevent the occurrence of additional asbestos related disease.

KEYWORDS: SIC 3292, friction products, asbestos, transmission electron microscopy, NIOSH Method 7400

## INTRODUCTION

On March 28, 1984 the International Chemical Workers Union submitted a request to NIOSH for a Health Hazard Evaluation on behalf of their members working at the Friction Division plant in Trenton, NJ. The Evaluation was assigned to the New Jersey Department of Health for investigation on June 20, 1984 under a cooperative agreement between the two agencies. The request cited concern about the nature and extent of asbestos exposure, the adequacy of current protective measures, and especially the potential health risk to family members from asbestos being carried home on work clothes.

On October 16, 1984 the State Health Department informed Friction Division of our intent to conduct a Health Hazard Evaluation. Meetings were held in the subsequent weeks and a walkthrough was conducted in January 1985. A series of written and oral communications followed during which permission to commence the study was requested. Since the requests were not answered, a warrant for access to the plant for the study was obtained and served on April 31, 1985. On that day, the local union at the plant went on strike. Since the plant was operating under abnormal conditions, the study was postponed, and the warrant was returned to the court on May 21, 1985.

In January 1986 the New Jersey Department of Health was notified by Local 155 that the plant's operations had returned to near normal. On February 27 the plant was approached unannounced to complete the investigation. After some delay, we were admitted to conduct sampling on the second shift. Additional air sampling, bulk sampling and review of engineering controls and work practices were conducted on March 10 and March 21.

## BACKGROUND

Friction Division began producing brakeshoes in 1969 under the management of Morton Thiokol. Before that time, no asbestos had been used in the plant. In 1973, all other operations were discontinued and many of the employees were laid off with the high seniority workers being retained. In 1983, the plant was bought by the current owners and has continued to produce friction products since that time.

Approximately 120 production workers currently work in the plant. Until the strike in 1985, all production employees were members of ICWU Local 155. During the strike, many non-union employees were hired. Union members have been slowly called back to work so that during our inspection approximately half the workforce were experienced union members and half had been working for only a short period.

Both drum-type and disc-type brake shoes are produced in separate manufacturing lines. Drum brake production begins in drum mixing where the raw materials are charged to a mixer. Depending on the particular mix being made, dry materials including carbon black, cement, hexamethyltetramine, zinc, barytes (barium sulfate), asbestos or polyamide fibers, phenolic resins and recycled grinding dust are added by pneumatic conveyor (vacuum tubes) directly to the mixer. Cashew shell resin is pumped in from drums. About forty percent of the mix is asbestos which is added through a debagger fitted with a conveyor at each end. After all

raw materials are added, the mixer is activated. The premix is then unloaded from the bottom of the mixer into bins.

Bins of premix are then transferred by fork truck to the adjacent roll forming machine. A continuous strip of preformed material is cut into lengths and stacked by hand into trucks. The preformed strips are then moved to the tables where they are hand loaded into steel trays and oven baked for several hours. After baking, the trays are unloaded and the shoes are ground on cam grinders and drilled to specifications.

Disc-type shoes are similarly formed. The disc preform area of the plant include two mixers and eight preform machines. The dry ingredients are loaded by vacuum into one of the mixers. The asbestos is again charged by a debagging machine. After mixing, the material is dropped from the mixer into a screw conveyor which conveys the premix overhead to hoppers which feed the preform machines. The preform machines press the premix into biscuits which are then hand loaded onto trucks for additional processing.

The biscuits are taken to the press area and pressed into their final form under heat (supplied by steam) and hydraulic pressure. The biscuits are then loaded into trays and oven baked for several hours to cure the resin system. When the trays are unloaded, the shoes are first brought to the tumbler to remove flash from the edge, and then sent for grinding and drilling to final specifications. The final product is then branded (marked with ink) and packed.

The plant has gradually been increasing its production of semimetallic (non-asbestos) disc brake shoes which are made in the same production area as the disc brakes. Although different ingredients are used, the process is very similar. A polyamide fiber is used as an asbestos substitute.

The company had conducted regular air monitoring for asbestos exposure until the time of the strike. Monitoring was conducted with only short term samples (approximately 1 hour) which were analyzed by the quality control lab at the plant. Their results indicate exposures in all parts of the plant at levels up to 0.3 f/cc (fibers per cubic centimeter) with occasional higher excursions.

A formal OSHA complaint was made by the ICWU in 1983 resulting in a health inspection of the plant completed on August 10, 1983. OSHA conducted limited air sampling (short term samples from 10-55 minutes duration) using NIOSH Method P&CAM 239 and found potential exposures up to 0.44 fibers/cc. No citations were issued.

A follow-up complaint was made to OSHA by the union to address areas not fully evaluated in the first inspection. During the second inspection, asbestos exposure in the preform area was between 1.27 and 2.11 f/cc (fibers per cubic centimeter) with a TWA of 1.33 f/cc. Coal tar pitch volatiles (from coke) and antimony exposures were measured on the semi-metallic mixer. Coal tar pitch volatiles were found at 0.036 mg/m<sup>3</sup> (milligrams per cubic meter), and antimony was found at 0.19 mg/m<sup>3</sup>. The OSHA PELs are 0.2 mg/m<sup>3</sup> for coal tar pitch volatiles and 0.5 mg/m<sup>3</sup> for

antimony. The inspection was interrupted by the strike and no citations were issued.

In 1981 the Local Union requested two occupational health professionals from Montefiore Medical Center to conduct a walkthrough of the plant, review the health and safety provisions and make specific recommendations. The recommendations made at that time included improvements in the ventilation system, personal protective equipment and dust handling procedures.

In 1983, the New Jersey State Department of Health conducted a walkthrough of the plant and reviewed company sampling data. A report was issued at that time that recommended improvements in the air sampling program, ventilation system, housekeeping and personal protective equipment. Provision of work clothes and separate locker facilities to prevent home contamination were strongly recommended.

## METHODS AND MATERIALS

### A. Medical

In order to ascertain whether past asbestos exposure at the plant has been sufficient to cause chest x-ray changes characteristic of asbestos exposure, current and recently retired (within a few months) workers with more than ten consecutive years of employment at the plant were identified. Of the 23 employees listed on the plant-wide seniority list as fulfilling these criteria, twenty were located and agreed to release their chest x-rays for examination.

Annual chest x-rays had been performed as part of the plant's medical surveillance program since 1975, and these films were obtained for the 20 employees. If more recent films were available from a hospital or a private physician, these films were also obtained. The most recent film of good quality was selected for interpretation by a NIOSH certified "B" x-ray reader, who is specially trained to examine chest x-rays for the effects of dust exposure.

### B. Environmental

During the walkthrough and the three sampling periods, workers were observed performing their jobs and potential sources of exposure during these procedures were noted. The ventilation system was qualitatively evaluated by observation and the use of smoke tubes.

Individuals from each area of the plant, with the exception of maintenance, were chosen for personal air monitoring. Personal sampling was conducted according to NIOSH Method 7400 on February 27 and March 10, 1986. All NIOSH recommendations for this method were followed including the use of graphite impregnated extension cowls (plastic tubes) wrapped with aluminum foil. Pumps were pre-and post-calibrated at 1.5 to 2 liters per minute. Filters were examined by phase contrast microscopy according to the set "A" counting rules in the New Jersey State Department of Health Laboratory which is proficient for asbestos analysis in the NIOSH PAT Program.

Because some problems with the method were experienced, a third day of sampling on March 21 was conducted using NIOSH Method P&CAM 239. Analysis was conducted the same way.

It was observed that samples collected according to Method 7400 had collected some of the airborne dust on the inside of the cowl instead of the filter face. In order to estimate the loss of asbestos to the cowl, an additional analysis of the cowls was conducted. After separating the cowl from the filter cassette, each cowl was placed in a beaker and the inside surface carefully washed with a directed stream of water. The wash water was then filtered through a 0.8 micron pore size mixed cellulose ester filter, dried and counted according to the set "A" counting rules. Thus an estimate of the total concentration in the air being measured was made.

On the first two sampling days, samples were run for 6 hours or more and the time weighted average (TWA) is based on the individual sampling time. As the dust loading observed was quite considerable, on the third day of sampling both a morning and afternoon sample was collected and a time weighted average calculated based on the total sampling time.

In order to identify in more detail the nature of the exposure at this plant, four samples were chosen for analysis by transmission electron microscopy (TEM). Counting was conducted by the New Jersey State Department of Health Laboratory.

In order to assess the potential for workers contaminating their homes by carrying asbestos home on clothing, samples were obtained from five individuals as they left the plant at the end of the day. Each sample was collected with the use of a personal sampling pump connected to a 37 mm filter with a short length of tygon tubing attached upstream of the filter cassette (closed face). Worker's shirts and pants were thus "vacuumed" for a one minute period. The dust sample was qualitatively analyzed by polarized light microscopy and x-ray diffraction for the presence of asbestos fibers in the collected dust sample.

#### EVALUATION CRITERIA

##### 1. General

As a guide to the evaluation of the hazards posed by workplace exposures, NIOSH field staff employ environmental evaluation criteria for assessment of a number of chemical and physical agents. These criteria are intended to suggest levels of exposure to which most workers may be exposed up to 10 hours per day, 40 hours per week for a working lifetime without experiencing adverse health effects. It is, however, important to note that not all workers will be protected from adverse health effects if their exposures are maintained below these levels.

In addition, some hazardous substances may act in combination with other workplace exposures, the general environment, or with medications or personal habits of the worker to produce health effects even if the occupational exposures are controlled at the level set by the evaluation criterion. These combined effects are often not considered in the

evaluation criteria. Finally, evaluation criteria may change over the years as new information on the toxic effects of an agent becomes available.

The primary sources of environmental evaluation criteria for the workplace are: 1) NIOSH Criteria Documents and recommendations, 2) the American Conference of Governmental Industrial Hygienists (ACGIH), Threshold Limit Values (TLV's), and 3) the US Department of Labor, OSHA PELs (Permissible Exposure Limits). Often, the NIOSH recommendations and ACGIH TLV's are lower than the corresponding OSHA standards. Both NIOSH recommendations and ACGIH TLV's usually are based on more recent information than are the OSHA standards. The OSHA standards also may be required to take into account the feasibility of controlling exposures in various industries where the agents are used; the NIOSH-recommended exposure limits, by contrast, are based primarily on concerns relating to the prevention of occupational disease. In evaluating the exposure levels and the recommendations for reducing these levels found in this report, it should be noted that industry is legally required to meet the levels specified by an OSHA standard.

A time-weighted average (TWA) exposure refers to the average airborne concentration of a substance during a normal 8 to 10 hour workday. Some substances have recommended short-term exposure limits or ceiling values which are intended to supplement the TWA where there are recognized toxic effects from high short-term exposure.

## 2. Asbestos Health effects:

Although the precise risk associated with particular levels of exposure to asbestos remains controversial, the fact that exposure to asbestos causes severe and often fatal disease is widely recognized by the scientific community and the general public.

Numerous studies of workers exposed to asbestos show significant risks of developing diseases including asbestosis (scarring of the lung tissue), lung cancer, gastrointestinal (stomach and bowel) cancer and mesothelioma, (a rare cancer of the lining of the chest or abdominal cavity)<sup>1,2,3,4</sup>. One of the key aspects of asbestos-related disease is that it develops many years after an individual is first exposed to asbestos.

Lung cancer in asbestos workers may develop as soon as 10 years after first exposure but usually develops more than 20 years after first exposure. The disease is usually fatal. There is a strong dose-response effect between asbestos exposure and lung cancer. The higher the level of exposure, and the longer the exposure continues, the more likely it is that lung cancer will develop. Also, the more asbestos exposure an individual has, the sooner the cancer is likely to develop.

The occurrence of lung cancer in asbestos-exposed individuals is also strongly related to smoking. Although the exact disease rates are debated, a smoker who is not exposed to asbestos has about a 10-fold increased risk of developing lung cancer. A non-smoker who is exposed to

asbestos has about a 5-fold increased risk. However, a smoker who is exposed to asbestos has about a 50-fold increased risk of lung cancer. In addition to reducing or stopping the exposure, the best thing an individual exposed to asbestos can do to reduce the risk of lung cancer is to stop smoking.

Mesothelioma is a rapidly fatal cancer of the lining of the chest or abdominal cavity which is found almost exclusively in asbestos workers. It occurs at least 25 years and usually more than 40 years after exposure. There is no relationship between cigarette smoking and mesothelioma. This disease may develop in people with very brief periods of exposure, sometimes as little as 6 months, and in people with very little exposure, such as family members of asbestos workers.

Asbestosis (scarring of the lung tissue) is a non-cancerous lung disease caused by asbestos exposure. It may develop after about 5 years in very heavily exposed workers but generally is not seen until after 15 years of exposure. In general, asbestosis is seen in individuals exposed for a long period of time to relatively high concentrations. Severe cases of asbestosis will lead to severe shortness of breath and may result in death.

Some individuals with asbestos exposure will develop other non-malignant (non-cancerous) changes in their chest such as pleural (outer lining of lung) calcifications or thickening. This thickening of the lung lining found among asbestos exposed workers does not cause either lung symptoms or disability.

### 3. Level of Exposure and Risk

On June 20, 1986 OSHA published new General Industry and Construction Standards (Appendix A) and a Preamble for occupational exposure to asbestos. The old standard of 2 fibers per cc over an 8 hour day was lowered to 0.2 fibers per cc. This new permissible exposure limit (PEL) was effective on July 21, 1986 for General Industry which includes the plant which is the subject of this report.

In the preamble to the new asbestos standard,<sup>6</sup> OSHA has estimated mortality from exposures to varying concentrations of asbestos for different time periods (Appendix B). Exposure of 100,000 individuals to an asbestos fiber concentration of 0.2 f/cc for a 20 year exposure is estimated to yield 278 lung cancers, 146 mesotheliomas and 27.8 gastrointestinal cancers for a total of 451.8 excess deaths per 100,000 exposed individuals, (4.5 per 1,000; .45 per 100).

<sup>1</sup> NIOSH recommends controlling exposure to asbestos to 0.1 fiber per cc. This recommendation is based on NIOSH's belief that carcinogens should be regulated to the "lowest feasible level" and that 0.1 f/cc was, at the time, the lowest level at which asbestos could be easily measured.

#### 4. Home contamination

Family members of asbestos workers and residents of neighborhood with asbestos plants have also been shown to be at increased risk of asbestos related diseases <sup>7,8,9,10</sup>. It is postulated that much of the family member risk is a result of workers bringing contaminated clothing home for washing.

### RESULTS

#### 1. Medical

Sixteen of the twenty individuals who had their chest x-ray reviewed had worked at the plant for more than 40 years. The remaining four had worked at the plant between 20 and 30 years. Thus, all of the twenty had been potentially exposed to asbestos since it was introduced into the plant in 1969 (i.e., for 16 years).

Of the 20 x-ray films examined, seven showed changes consistent with the effects of asbestos exposure. Two individuals had x-ray evidence of asbestosis (1/0 or greater on the ILO classification); one of these also had a unilateral pleural thickening also characteristic of asbestos exposure. Three individuals showed no evidence of asbestos-related disease in the lung tissue but did have x-ray changes indicative of asbestos exposure; two of these had pleural thickening of the chest wall, one bilateral and one unilateral; one had a calcified plaque on the diaphragm.

In addition, two individuals had lung cancer evident on their x-rays. Both of these individuals had been previously diagnosed and were under medical treatment for their cancer at the time of the study. Since medical histories were not obtained, we cannot determine the likelihood that these cancers are related to asbestos exposure. However, given the strong association between asbestos and lung cancer, it is certainly possible that these cancers are work-related.

#### 2. Environmental

##### General Plant Conditions

Dust is found everywhere in the plant, and in certain areas such as Preform and Drum Lining, raw materials collect in piles on the floor and on machinery.

The ventilation system, although large and potentially effective is not well maintained and is, therefore, functioning significantly below its design potential. The ventilation system was partially disconnected from the preform machine enclosures. Operators use the flexible exhaust hoses for clean-up and often fail to reconnect them to the machine enclosures. Some duct connection points had been left unsealed providing additional leakage from the system. Enclosures around the preform machines are not sealed at key points, thus allowing asbestos premix to constantly stream

out into the workroom air. Seals on both the Disc and Drum mixers are deteriorated so that a constant cloud of dust emanates from the machines during operation.

The debagging machine in the disc premix area does not function properly. The bag routinely jams in the machine and the operator is required to open the side door, lean into the machine to shake the bag loose, remove it and deposit it into the waste bag.

On the final day of our visit, the debagger had broken down and was not running. However, enough premix had been made on the previous shift to last through about half of the day shift while we were present. (Mix #608001, 6080003, 6080004 for a total of 1600 lbs of asbestos). According to plant personnel, charging of the raw asbestos had been done directly by hand from a step ladder into the mixer hatch with no hopper or ventilated charge port present. Excessive asbestos exposure would be expected in such an operation.

During mixing, dust clouds were visibly emanating from both the mixer seals and from the debagger. No exhaust ventilation was placed on the system during operation. Similar problems were seen on the Drum Line Mixer from which visible dust escaped during mixing.

Enclosures on grinding and drilling machines have numerous leaks and dust clouds are visible from these points. On the double disk grinders, compressed air is blown into the vented enclosure to remove grinding dust from the shoe as it passes through. Dust emanates from these enclosures through leaks and the port through which the shoe is ejected. Capture hoods on the Canadian drills were seen filled with heavy particles blocking all air flow. Other drill hoods were disconnected from the exhaust ducts, rendering them useless.

Three times daily during breaks, an operator clears the bag house by shutting down the ventilation system, shaking down the bags and removing the collected dust in drums. Local exhaust hoods on the bag house blast gates are inoperable when the system is shut off. A large cloud of fine dust is released during this procedure in the vicinity of the operator. Air sampling during this time indicated an exposure of 1.73 fibers/cc over the 77 minutes sampling time.

The plant undergoes vacuuming and sweeping throughout the shift with the use of brooms, squeegees, vacuum cleaners and a sweeper cart. Although the employees have been told not to use the brooms, they are still available and thus used. The vacuums and sweeper are very old. Holes were seen in the filter bags and clouds of dust were observed emanating from the equipment. There were no HEPA filters on the vacuum exhaust. It is probable that the use of this outdated equipment is increasing the airborne dust level through re-entrainment of the asbestos.

The lunch room is adjacent to the plant with no physical or ventilation isolation, and it is thus contaminated with asbestos. A wall exhaust fan was present in the lunch room area. If this fan were to exhaust air from the room, it would draw further contamination from the plant into this area. Our one area sample in the lunch room found airborne asbestos at 0.07 f/cc.

One janitor is responsible for cleaning the rest rooms and the lunch room. Employees complained of conditions in the bathrooms so unsanitary that they are unwilling to use them. Dust was visible on piping and toilet facilities, indicating contamination and lax cleaning service. Adequate shower facilities exist for male employees but no facilities are provided for female employees.

The quality control laboratory is located in the production area and has no local exhaust ventilation equipment. Employees working in the lab were observed using compressed air to clean the dust build up on the room's air conditioner, thus creating a cloud of dust in the room. They were also observed knocking brake shoes together to remove dust from them before making test measurements.

Numerous other problems were noted in the plant but are not directly addressed in this report because they were not the subject of the HHE request and because of the immediacy of the asbestos problem. Other potential hazards noted include:

- a. antimony and other exposures from semi-metallic mixing;
- b. a severe eye and respiratory tract irritant was noted which may have been formaldehyde emanating from the curing ovens; ventilation of ovens should be further investigated;
- c. fire extinguishers were all expired;
- d. employees were working with the steel racks soon after they were removed from the ovens potentially causing burns and other safety hazards;
- e. full racks were lifted up and down from floor level by one person; a job that was previously done by two. This procedure may present a significant lifting hazard.

#### Personal Protective Equipment

At the outset of this investigation, work uniforms were supplied for maintenance and preform area workers but for no other plant employees. The policy was recently altered so that work uniforms are now available for any employee, if they choose to contribute money toward the maintenance of the uniform. Cleaning is conducted by a uniform supply service, which picks up soiled clothes each Friday and returns clean uniforms to a set of clean lockers during the following week. Each participating employee receives five shirts and three pairs of pants. Each employee is assigned one locker in the lunch room in which the clean uniforms are left and one locker in the wash room. The wash room locker is used for storage of both used uniforms and street clothes.

A few individuals wore tyvec lab coats and two employees had tyvec coveralls. The lab coats have been supplied by the company for employees who request them.

At the time of our initial plant walkthrough, a respiratory protection program had been established and was conducted by the plant nurse. 3M 8710 respirators (TC-21C-132, approved for respiratory protection against dusts and mists having an exposure limit measured as a

time weighted average not less than 0.5 mg/m<sup>3</sup> and asbestos) were supplied to employees and they were instructed in their proper use. A booklet was produced explaining correct use of the respirators and specifying jobs requiring the use of respiratory protection. Since the nurse resigned, the respirator program has not been pursued and new employees have not been properly instructed on respirator use.

During our investigation, most but not all employees were seen wearing the disposable masks. There was no supervision of proper use, and many employees were seen wearing masks improperly, i.e., with one strap, hanging around chin or neck, with wide gaps around nose, etc.

#### Routine Air Monitoring

Air monitoring for asbestos exposure has been conducted regularly by the company since 1975. The program consisted of periodic personal sampling on selected jobs in the plant. Samples were short-term, generally under one hour. Sampling was conducted by the nurse and analyzed by PCM by the quality control manager at the plant who has not been trained in asbestos fiber counting by NIOSH. The laboratory does not participate in NIOSH's PAT program. Since the beginning of our investigation, no sampling has been conducted.

#### Bulk Samples

Two bulk samples of premixed material, two floor dust samples and one sample of the insulation in the tumbler area quonset hut were obtained for analysis on 1/8/85. The two premix materials were found to be 30% and 32% chrysotile. Floor dust from the tumbler area was 24% chrysotile and from the preform area was 63% chrysotile. The quonset insulation material was identified as cellulose, containing no asbestos.

#### Air Sampling Methods

As described in the Methods Section, dust was noted on the inside of the extension cowls used during sampling by NIOSH Method 7400 after sampling on the first two days. The results of the wash procedure on six samples are given in Table I. An average of 38.7 percent (range 23.1 - 49.7) of the total fiber count was found on the cowl and not on the filter. Thus, samples collected with the cowls are probably underestimates of the true exposures by approximately 40%. In addition, the filters were heavily loaded with particulates which masks the asbestos fibers and results in further underestimates of fiber concentration.

#### Personal Air Sampling Results

Sample results by Department from 2/27/86 second shift, and 3/10/86, first shift are given in Table II. Since all of these samples were taken using extension cowls and the filters were also overloaded with

particulate, they are probably underestimates of the true exposure level.

Exposures documented ranged from 0.06 f/cc in branding/packing and disc tables to 0.66 f/cc on drills. All monitored job titles had exposure over the NIOSH recommended limit of 0.1 f/cc except for the disc table loading and unloading and all but this sample and brand/packing exceeded the OSHA PEL of 0.2 f/cc.

Exposure results from 3/21/86 are presented in Table III. These samples were collected on 37 mm cassettes with no extension cowl (method P&CAM 239). Results on 3/21/86 ranged from 0.09 to 1.56 f/cc. The highest exposure jobs were on the tumbler, preform machines, the disc area tables, and in the drum shoe area (including mixer, roll mill operator and drum tables). All jobs measured were over the NIOSH recommended limit of 0.1 f/cc, as well as the OSHA PEL of 0.2 f/cc.

For results of the electron microscopy analysis of fiber size distribution, see Appendix C.

#### Potential Home Contamination

The potential for home contamination and exposure of household contacts was addressed by vacuuming clothing of five workers as they left the plant after the work shift. All five samples were positive for chrysotile indicating the potential for contamination of the home. The risk potential cannot be quantified from this assessment. However, since the asbestos was released during the vacuuming procedure it may also be released during normal wear, or washing procedures at home, and thus present a real hazard to workers' families.

#### DISCUSSION AND CONCLUSIONS

Conditions at the plant are poor and asbestos exposure is excessive in all areas, posing a significant health risk to employees. Lack of maintenance of the ventilation system, inadequate procedures for preventing asbestos becoming airborne, the use of outdated equipment and the continued production during periods when protective systems such as the debagger are not working, all contribute significantly to the high asbestos exposures.

The presence of asbestosis in two of the 20 workers whose x-rays were examined strongly suggests that hazardous levels of asbestos exposure have occurred at the plant. These two workers had been employed at the facility for over 40 years and exposed to asbestos at the plant since 1969; thus, although their occupational histories before that time were not obtained, there is little likelihood of their both having sufficient exposure from previous jobs to have caused these lung changes.

The presence of pleural thickening and pleural plaques in one of the workers with asbestosis and three additional workers provides further evidence that these workers have had significant asbestos exposure in the past. Once again, all these employees have worked at the facility for

more than 40 years, thus it is most likely that the asbestos exposure causing these x-ray changes occurred at Friction Division.

The current study was not designed to determine whether there is an excess of asbestos-related cancer among current and former employees. Thus we have not determined whether the occurrence of two cancers among these 20 employees represents more than would be expected on the basis of age, sex, and smoking status. Nevertheless, the levels documented at the plant and the finding of asbestos-related lung changes strongly indicates sufficient exposure to constitute a cancer hazard.

The exposure levels documented in the plant were greater than the current OSHA standard. Work on the equipment should begin immediately to bring the levels down, within compliance with the new asbestos standard, and with the NIOSH recommended standard of 0.1 fibers/cc over 8 hours.

Our air sampling results indicate that there is no single source of asbestos contamination in the plant. High levels were found in all areas including drum mix, preform, grinding, tables and presses. Although the heaviest concentration of visible airborne dust and some of the highest measured levels were in the preform area, all areas require additional dust suppression.

Evidence from contamination on our sampling cowl, and the comparison of the heavily loaded filters from 2/27 and 3/10 with the lighter dust loads collected on 3/21 suggest that our results may be underestimates of the levels actually present at the plant.

The employer's occupational health program fails to meet most provisions of the new OSHA Asbestos Standard. Exposure monitoring, regulated areas, compliance program, personal protective equipment, hygiene facilities and practices, hazard communication, housekeeping and medical surveillance must all be greatly improved.

A potential for home contamination with asbestos dust from work clothes was documented. Asbestos fibers were present on work clothes after the shift, and they were easily removed from the cloth with a mild vacuum. Since previous studies have identified disease in family members of asbestos workers, we conclude that the presence of asbestos on clothes poses a hazard to workers' families.

## RECOMMENDATIONS

### A. Medical

1. Since the risk of lung cancer in smokers exposed to asbestos is far greater than that associated with smoking or asbestos exposure alone, all employees should be encouraged to stop smoking.
2. The current medical surveillance program should be modified. Chest x-rays should be interpreted by a certified B-reader. All individual medical information should be confidential, known

only to the employee and medical personnel, unless the findings are felt to be caused by work or might affect an employee's ability to perform his/her work. Only aggregate data without personal identifiers should be distributed to management and other workers.

A revised medical monitoring program should be established consistent with the OSHA requirements described in 1910.1001 (1) (page 22737 of Appendix A).

## B. Environmental

1. Current and past employees should be educated on the health risks of asbestos exposure. A hazard communication program should be established following the OSHA requirements in 1910.1001 (j) (page 22736 of Appendix A).
2. Asbestos exposure should be reduced to ensure that exposures are consistently under the OSHA PEL of 0.2 f/cc and the NIOSH recommended limit of 0.1 f/cc. Numerous strategies must be employed to contain the dust since there is no one primary source of exposure. All operations in the plant appear to contribute to the high dust levels. The following recommendations should be implemented and their effectiveness evaluated by additional air sampling. Re-engineering of the operation and all dust control equipment may ultimately be required to reduce asbestos exposure at this facility to acceptable levels. A compliance program should be written which meets the OSHA requirements of 1910.1001 (f)(2) (page 22735 of Appendix A).
  - a. Establish, demarcate and restrict access to regulated areas where exposure to asbestos exceeds the OSHA PEL in accordance with 1910.1001 (e) (page 22734 of Appendix A).
  - b. Set up an active preventive maintenance program for all key pieces of asbestos handling equipment. Seal all potential sources of dust leakage and inspect equipment periodically to ensure that leaks do not reappear.
  - c. Apply exhaust ventilation to the mixers and improve the exhaust system applied to the debagging machines.
  - d. Clear ducts and ventilation hoods of collected debris after every shift. Ensure that all ventilation equipment present is properly set up.
  - e. Prohibit operation of the mixers without the debagger in properly functioning condition, unless properly constructed vented charge ports are constructed. Overhaul or replace the debagger to prevent jamming which requires employees to enter the machine.
  - f. Unless the enclosures around the DD grinders can be entirely sealed, the use of compressed air for dust clearing should be discontinued. Brushes may be set

- up with strong, directed exhaust ports close to the surface of the shoe to remove dust as it moves through the machine.
- g. Set up an independent dust collection system to operate local exhaust vents on the bag houses during cleaning procedures.
  - h. Remove all brooms from the plant to prevent their use. Discontinue use and remove the vacuum cleaners currently in the plant and replace with units with HEPA (high efficiency particulate air) filtered exhausts. Expand dust collection procedures to include all surfaces of plant.
  - i. Isolate the lunch room from the plant by physical barriers such as walls and an independent ventilation system. Conduct a thorough cleaning of all surfaces in the rest areas. Apply a sealant to walls and floor surfaces to promote continued thorough cleaning. Provide additional janitorial services to maintain adequate sanitary facilities.
  - j. Set up down draft vented tables for the tray breaking jobs.
  - k. Implement a housekeeping program meeting the requirements of 1910.1001 (k) (page 22737 of Appendix A).

### 3. Personal Protective Equipment and Policies

- a. Provide clean uniforms or disposable coveralls and gloves, head coverings and foot coverings daily to all employees. As these are necessary to prevent home contamination, wearing of such protective clothing should be required by management. In order to ensure full compliance with this policy, options such as fully paying for the laundry service should be considered. Street clothes should not be stored with soiled work clothes. Each individual should be provided with a clean locker in which to store personal belongings. Soiled work clothes should either be kept in a separate locker or deposited in a closed, impermeable container at the end of each work shift. If clothes are used for only one shift, two weeks worth of uniforms will need to be provided, with laundering once per week.

As required by 1910.1001 (h)(3)(iv) (page 22736 of Appendix A) the employer must inform the laundry service of the hazards of asbestos and the precautions needed to prevent exposure to laundry employees.

- b. Shower facilities should be supplied for female employees in accordance with 1910.1001 (i)(2) (page 22736 of Appendix A). Showering after work should be encouraged by providing clean facilities with separate stalls for privacy.

- c. The respiratory protection program should be reinstated to provide adequate training on the proper use of respiratory protection to all employees and to fulfill all requirements of the OSHA Respiratory Protection Standard (1910.134).
- d. The use of disposable respirators such as the 3M 8710 now in use is not adequate protection for asbestos and is not permitted under the new OSHA Standard, 1910.1001 (g) (page 22735 of Appendix A). If the provisions of this section are followed, a half-mask air-purifying respirator equipped with high-efficiency filters is the minimum type of respirator which could be selected. However, powered air purifying respirators with high-efficiency filters would offer more protection and greater employee comfort. Such respirators are required by OSHA when an employee chooses to use this type of respirator.

#### 4. Air Monitoring

A program of periodic monitoring of asbestos exposure should be established to provide information to employees and management on the adequacy of control systems. Samples should be taken in each area of the plant using the methods and schedule required by OSHA in 1901.1001 (d) (page 22733 of Appendix A). All monitoring should be observed by employees as required by 1910.1001 (n) (page 22738 of Appendix A).

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1. ICWU, Akron, Ohio
2. ICWU, Local 155, Trenton, New Jersey
3. Friction Division Products, Trenton, New Jersey
4. NIOSH, Region II
5. OSHA, Region II

For the purpose of informing affected employees, copies of this report shall be posted by the employer in a prominent place accessible to the employees for a period of 30 calendar days.

TABLE I  
 ASBESTOS CONTAMINATION ON EXTENSION COWLS  
 USING NIOSH METHOD 7400

Sample #	Sample Time (Min.)	Filter (f/cc)	Cowl (f/cc)	Total (F/cc)	% on Cowl
1	184	0.18	0.18	0.36	49.7
2	193	0.51	0.31	0.82	37.8
3	379	0.24	0.22	0.46	47.0
4	371	0.37	0.29	0.66	44.3
5	346	0.57	0.17	0.74	23.1
6	389	<u>0.49</u>	<u>0.21</u>	<u>0.70</u>	<u>30.1</u>
Mean		0.39	0.23	0.62	38.7

TABLE II  
EXPOSURE RESULTS BY JOB TITLE  
(Fibers/cc)  
2/27/86 - 3/10/86

Job Title	N*	Range	TWA**
Branding/Packing	2	0.06 - 0.27	0.17
Drill Operator	3	0.34 - 0.66	0.53
Grinder Operator	2	0.14 - 0.27	0.20
Preformer	4	0.16 - 0.49	0.28
Pre-mix Mixer (Disc)	2	0.26 - 0.37	0.32
Press Operator	2	0.39 - 0.54	0.46
Tables (Disc/Oven-Rack Loading and Unloading)	2	0.06 - 0.07	0.07
Tumbler	1	0.57 - 0.57	0.57

\* Number of samples in Job Title.

\*\* Time Weighted Average based on total sampling time which was greater than 6 hours. Six of eight samples are greater than the OSHA PEL of 0.2 f/cc.

TABLE III  
EXPOSURE RESULTS BY JOB TITLE  
(fibers/cc)  
3/21/86

Job Title	N*	Range	TWA**
Drills	2	0.09 - 0.76	0.43
Drum Area	3	0.45 - 0.93	0.67
Tables (disc)	2	0.17 - 1.56	0.87
Grinder	1	0.52 - 0.52	0.52
Preformer	2	1.22 - 1.37	1.30
Mixer (disc)	1	0.61 - 0.61	0.61
Preform (Maint)	1	0.65 - 0.65	0.65
Tumbler	1	1.10 - 1.10	1.10

\* Number of samples in Job Title.

\*\* Time Weighted Average based on total sampling time which was greater than 6 hours. All are greater than the OSHA PEL of 0.2 f/cc.

APPENDIX A

29 CFR 1910.1001  
Asbestos, tremolite, anthophyllite,  
and actinolite

at 1 p.m. E.D.T. on June 17, 1986 which shall be the time of issuance of this document as provided by 29 CFR § 1911.16. The time of issuance is the earliest moment that petitions for review may be filed with United States Courts of Appeals.

Signed at Washington, DC, this 12th day of June, 1986.

John A. Pendergrass,

Assistant Secretary for Occupational Safety and Health.

### XIII. Amended Standards

#### PART 1910—[AMENDED]

Part 1910 of Title 29 of the Code of Federal Regulations is hereby amended as follows:

1. The authority citation for Subpart B of Part 1910 continues to read as follows:

Authority: Secs. 4, 6, and 8 of the Occupational Safety and Health Act, 29 U.S.C. 653, 655, 657; Walsh-Healey Act, 41 U.S.C. 35 et seq.; Service Contract Act of 1965, 41 U.S.C. 351 et seq.; Pub. L. 91-54, 40 U.S.C. 333, Pub. L. 85-742, 33 U.S.C. 941; National Foundation on Arts and Humanities Act, 20 U.S.C. 951 et seq.; Secretary of Labor's Orders 12-71 (36 FR 8754), 8-76 (41 FR 25059), or 9-83 (48 FR 35738); and 29 CFR Part 1911.

2. Paragraph (a) of § 1910.19 is hereby revised to read as follows:

#### § 1910.19 Special provisions for air contaminants.

(a) *Asbestos, tremolite, anthophyllite, and actinolite dust.* Section 1910.1001 shall apply to the exposure of every employee to asbestos, tremolite, anthophyllite, and actinolite dust in every employment and place of employment covered by §§ 1910.13, 1910.14, 1910.15, or 1910.16, in lieu of any different standard on exposure to asbestos, tremolite, anthophyllite, and actinolite dust which would otherwise be applicable by virtue of any of those sections.

#### Subpart Z—[Amended]

3. The authority citation for Subpart Z of Part 1910 is revised as follows:

Authority: Secs. 6 and 8, Occupational Safety and Health Act, 29 U.S.C. 655, 657; Secretary of Labor's Orders Nos. 12-71 (36 FR 8754), 8-76 (41 FR 25059), or 9-83 (48 FR 35738), as applicable; and 29 CFR Part 1911.

Section 1910.1000 Tables Z-1, Z-2, Z-3 also issued under 5 U.S.C. 553.

Section 1910.1000 not issued under 29 CFR Part 1911, except for "Arsenic" and "Cotton Dust" listings in Table Z-1.

Section 1910.1002 not issued under 29 U.S.C. 655 or 29 CFR Part 1911; also issued under 5 U.S.C. 553.

Sections 1910.1003 through 1910.1018 also issued under 29 U.S.C. 653.

Section 1910.1025 also issued under 29 U.S.C. 653 and 5 U.S.C. 506.

Section 1910.1043 also issued under 5 U.S.C. 551 et seq.

Sections 1910.1045 and 1970.1047 also issued under 29 U.S.C. 653.

Sections 1910.1499 and 1910.1500 also issued under 5 U.S.C. 553.

4. Section 1910.1001 is hereby revised to read as follows:

#### § 1910.1001 Asbestos, tremolite, anthophyllite, and actinolite.

(a) *Scope and application.* (1) This section applies to all occupational exposures to asbestos, tremolite, anthophyllite, and actinolite, in all industries covered by the Occupational Safety and Health Act, except as provided in paragraph (a)(2) of this section.

(2) This section does not apply to construction work as defined in 29 CFR 1910.12(b). [Exposure to asbestos, tremolite, anthophyllite, and actinolite in construction work is covered by 29 CFR 1926.58.]

(b) *Definitions.* "Action level" means an airborne concentration of asbestos, tremolite, anthophyllite, actinolite, or a combination of these minerals, of 0.1 fiber per cubic centimeter (f/cc) of air calculated as an eight (8)-hour time-weighted average.

"Asbestos" includes chrysotile, amosite, crocidolite, tremolite asbestos, anthophyllite asbestos, actinolite asbestos, and any of these minerals that have been chemically treated and/or altered.

"Assistant Secretary" means the Assistant Secretary of Labor for Occupational Safety and Health, U.S. Department of Labor, or designee.

"Authorized person" means any person authorized by the employer and required by work duties to be present in regulated areas.

"Director" means the Director of the National Institute for Occupational Safety and Health, U.S. Department of Health and Human Services, or designee.

"Employee exposure" means that exposure to airborne asbestos, tremolite, anthophyllite, actinolite, or a combination of these minerals that would occur if the employee were not using respiratory protective equipment.

"Fiber" means a particulate form of asbestos, tremolite, anthophyllite, or actinolite, 5 micrometers or longer, with a length-to-diameter ratio of at least 3 to 1.

"High-efficiency particulate air (HEPA) filter" means a filter capable of trapping and retaining at least 99.97

percent of 0.3 micrometer diameter mono-disperse particles

"Regulated area" means an area established by the employer to demarcate areas where airborne concentrations of asbestos, tremolite, anthophyllite, actinolite, or a combination of these minerals exceed, or can reasonably be expected to exceed, the permissible exposure limit.

"Tremolite, anthophyllite, or actinolite" means the non-asbestos form of these minerals, and any of these minerals that have been chemically treated and/or altered.

(c) *Permissible exposure limit (PEL).* The employer shall ensure that no employee is exposed to an airborne concentration of asbestos, tremolite, anthophyllite, actinolite, or a combination of these minerals in excess of 0.2 fiber per cubic centimeter of air as an eight (8)-hour time-weighted average (TWA) as determined by the method prescribed in Appendix A of this section, or by an equivalent method.

(d) *Exposure monitoring.*—(1) *General.* (i) Determinations of employee exposure shall be made from breathing zone air samples that are representative of the 8-hour TWA of each employee.

(ii) Representative 8-hour TWA employee exposures shall be determined on the basis of one or more samples representing full-shift exposures for each shift for each employee in each job classification in each work area.

(2) *Initial monitoring.* (i) Each employer who has a workplace or work operation covered by this standard, except as provided for in paragraphs (d)(2)(ii) and (d)(2)(iii) of this section, shall perform initial monitoring of employees who are, or may reasonably be expected to be exposed to airborne concentrations at or above the action level.

(ii) Where the employer has monitored after December 20, 1985, and the monitoring satisfies all other requirements of this section, the employer may rely on such earlier monitoring results to satisfy the requirements of paragraph (d)(2)(i) of this section.

(iii) Where the employer has relied upon objective data that demonstrates that asbestos, tremolite, anthophyllite, actinolite, or a combination of these minerals is not capable of being released in airborne concentrations at or above the action level under the expected conditions of processing, use, or handling, then no initial monitoring is required.

(3) *Monitoring frequency (periodic monitoring) and patterns.* After the initial determinations required by

paragraph (d)(2)(i) of this section, samples shall be of such frequency and pattern as to represent with reasonable accuracy the levels of exposure of the employees. In no case shall sampling be at intervals greater than six months for employees whose exposures may reasonably be foreseen to exceed the action level.

(4) *Changes in monitoring frequency.* If either the initial or the periodic monitoring required by paragraphs (d)(2) and (d)(3) of this section statistically indicates that employee exposures are below the action level, the employer may discontinue the monitoring for those employees whose exposures are represented by such monitoring.

(5) *Additional monitoring.* Notwithstanding the provisions of paragraphs (d)(2)(ii) and (d)(4) of this section, the employer shall institute the exposure monitoring required under paragraphs (d)(2)(i) and (d)(3) of this section whenever there has been a change in the production, process, control equipment, personnel or work practices that may result in new or additional exposures above the action level or when the employer has any reason to suspect that a change may result in new or additional exposures above the action level.

(6) *Method of monitoring.* (i) All samples taken to satisfy the monitoring requirements of paragraph (d) shall be personal samples collected following the procedures specified in Appendix A.

(ii) All samples taken to satisfy the monitoring requirements of paragraph (d) shall be evaluated using the OSHA Reference Method (ORM) specified in Appendix A of this section, or an equivalent counting method.

(iii) If an equivalent method to the ORM is used, the employer shall ensure that the method meets the following criteria:

(A) Replicate exposure data used to establish equivalency are collected in side-by-side field and laboratory comparisons; and

(B) The comparison indicates that 90% of the samples collected in the range 0.5 to 2.0 times the permissible limit have an accuracy range of plus or minus 25 percent of the ORM results with a 95% confidence level as demonstrated by a statistically valid protocol; and

(C) The equivalent method is documented and the results of the comparison testing are maintained.

(iv) To satisfy the monitoring requirements of paragraph (d) of this section, employers must use the results of monitoring analysis performed by laboratories which have instituted quality assurance programs that include

the elements as prescribed in Appendix A.

(7) *Employee notification of monitoring results.* (i) The employer shall, within 15 working days after the receipt of the results of any monitoring performed under the standard, notify the affected employees of these results in writing either individually or by posting of results in an appropriate location that is accessible to affected employees.

(ii) The written notification required by paragraph (d)(7)(i) of this section shall contain the corrective action being taken by the employer to reduce employee exposure to or below the PEL, wherever monitoring results indicated that the PEL had been exceeded.

(e) *Regulated Areas.—(1) Establishment.* The employer shall establish regulated areas wherever airborne concentrations of asbestos, tremolite, anthophyllite, actinolite, or a combination of these minerals are in excess of the permissible exposure limit prescribed in paragraph (c) of this section.

(2) *Demarcation.* Regulated areas shall be demarcated from the rest of the workplace in any manner that minimizes the number of persons who will be exposed to asbestos, tremolite, anthophyllite, or actinolite.

(3) *Access.* Access to regulated areas shall be limited to authorized persons or to persons authorized by the Act or regulations issued pursuant thereto.

(4) *Provision of respirators.* Each person entering a regulated area shall be supplied with and required to use a respirator, selected in accordance with paragraph (g)(2) of this section.

(5) *Prohibited activities.* The employer shall ensure that employees do not eat, drink, smoke, chew tobacco or gum, or apply cosmetics in the regulated areas.

(f) *Methods of compliance.—(1)*

*Engineering controls and work practices.* (i) The employer shall institute engineering controls and work practices to reduce and maintain employee exposure to or below the exposure limit prescribed in paragraph (c) of this section, except to the extent that such controls are not feasible.

(ii) Wherever the feasible engineering controls and work practices that can be instituted are not sufficient to reduce employee exposure to or below the permissible exposure limit prescribed in paragraph (c) of this section, the employer shall use them to reduce employee exposure to the lowest levels achievable by these controls and shall supplement them by the use of respiratory protection that complies

with the requirements of paragraph (g) of this section.

(iii) For the following operations, wherever feasible engineering controls and work practices that can be instituted are not sufficient to reduce the employee exposure to or below the permissible exposure limit prescribed in paragraph (c) of this section, the employer shall use them to reduce employee exposure to or below 0.5 fiber per cubic centimeter of air (as an eight-hour time-weighted average) and shall supplement them by the use of any combination of respiratory protection that complies with the requirements of paragraph (g) of this section, work practices and feasible engineering controls that will reduce employee exposure to or below the permissible exposure limit prescribed in paragraph (c) of this section: Coupling cutoff in primary asbestos cement pipe manufacturing; sanding in primary and secondary asbestos cement sheet manufacturing; grinding in primary and secondary friction product manufacturing; carding and spinning in dry textile processes; and grinding and sanding in primary plastics manufacturing.

(iv) *Local exhaust ventilation.* Local exhaust ventilation and dust collection systems shall be designed, constructed, installed, and maintained in accordance with good practices such as those found in the American National Standard Fundamentals Governing the Design and Operation of Local Exhaust Systems, ANSI Z9.2-1979.

(v) *Particular tools.* All hand-operated and power-operated tools which would produce or release fibers of asbestos, tremolite, anthophyllite, actinolite, or a combination of these minerals so as to expose employees to levels in excess of the exposure limit prescribed in paragraph (c) of this section, such as, but not limited to, saws, scorers, abrasive wheels, and drills, shall be provided with local exhaust ventilation systems which comply with paragraph (f)(1)(iv) of this section.

(vi) *Wet methods.* Insofar as practicable, asbestos, tremolite, anthophyllite, or actinolite shall be handled, mixed, applied, removed, cut, scored, or otherwise worked in a wet state sufficient to prevent the emission of airborne fibers so as to expose employees to levels in excess of the exposure limit prescribed in paragraph (c) of this section, unless the usefulness of the product would be diminished thereby.

(vii) *Materials containing asbestos, tremolite, anthophyllite, or actinolite shall not be applied by spray methods.*

(viii) Particular products and operations. No asbestos cement, mortar, coating, grout, plaster, or similar material containing asbestos, tremolite, anthophyllite, or actinolite shall be removed from bags, cartons, or other containers in which they are shipped, without being either wetted, or enclosed, or ventilated so as to prevent effectively the release of airborne fibers of asbestos, tremolite, anthophyllite, actinolite, or a combination of these minerals so as to expose employees to levels in excess of the limit prescribed in paragraph (c) of this section.

(ix) Compressed air. Compressed air shall not be used to remove asbestos, tremolite, anthophyllite, or actinolite or materials containing asbestos, tremolite, anthophyllite, or actinolite, unless the compressed air is used in conjunction with a ventilation system designed to capture the dust cloud created by the compressed air.

(2) *Compliance program.* (i) Where the PEL is exceeded, the employer shall establish and implement a written program to reduce employee exposure to or below the limit by means of engineering and work practice controls as required by paragraph (f)(1) of this section, and by the use of respiratory protection where required or permitted under this section.

(ii) Such programs shall be reviewed and updated as necessary to reflect significant changes in the status of the employer's compliance program.

(iii) Written programs shall be submitted upon request for examination and copying to the Assistant Secretary, the Director, affected employees and designated employee representatives.

(iv) The employer shall not use employee rotation as a means of compliance with the PEL.

(g) *Respiratory protection—(1) General.* The employer shall provide respirators, and ensure that they are used, where required by this section. Respirators shall be used in the following circumstances:

(i) During the interval necessary to install or implement feasible engineering and work practice controls;

(ii) In work operations, such as maintenance and repair activities, or other activities for which engineering and work practice controls are not feasible;

(iii) In work situations where feasible engineering and work practice controls are not yet sufficient to reduce exposure to or below the exposure limit; and

(iv) In emergencies.

(2) *Respirator selection.* (i) Where respirators are required under this section, the employer shall select and provide at no cost to the employee, the

appropriate respirator as specified in Table 1. The employer shall select respirators from among those jointly approved as being acceptable for protection by the Mine Safety and Health Administration (MSHA) and by the National Institute for Occupational Safety and Health (NIOSH) under the provisions of 30 CFR Part 11.

(ii) The employer shall provide a powered, air-purifying respirator in lieu of any negative pressure respirator specified in Table 1 whenever:

(A) An employee chooses to use this type of respirator; and

(B) This respirator will provide adequate protection to the employee.

TABLE 1.—RESPIRATORY PROTECTION FOR ASBESTOS, TREMOLITE, ANTHOPHYLLITE, AND ACTINOLITE FIBERS

Airborne concentration of asbestos, tremolite, anthophyllite, actinolite, or a combination of these minerals	Required respirator
Not in excess of 2 f/cc (10 X PEL)	1. Half-mask, air-purifying respirator equipped with high-efficiency filters.
Not in excess of 10 f/cc (50 X PEL)	1. Full facepiece air-purifying respirator equipped with high-efficiency filters.
Not in excess of 20 f/cc (100 X PEL)	1. Any powered air-purifying respirator equipped with high-efficiency filters. 2. Any supplied-air respirator operated in continuous flow mode.
Not in excess of 200 f/cc (1000 X PEL)	1. Full facepiece supplied-air respirator operated in pressure demand mode.
Greater than 200 f/cc (> 1,000 X PEL) or unknown concentration.	1. Full facepiece supplied air respirator operated in pressure demand mode equipped with an auxiliary positive pressure self-contained breathing apparatus.

NOTE: 1. Respirators assigned for higher environmental concentrations may be used at lower concentrations.  
2. A high-efficiency filter means a filter that is at least 99.97 percent efficient against mono-dispersed particles of 0.3 micrometers or larger.

(3) *Respirator program.* (i) Where respiratory protection is required, the employer shall institute a respirator program in accordance with 29 CFR 1910.134(b), (d), (e), and (f).

(ii) The employer shall permit each employee who uses a filter respirator to change the filter elements whenever an increase in breathing resistance is detected and shall maintain an adequate supply of filter elements for this purpose.

(iii) Employees who wear respirators shall be permitted to leave the regulated area to wash their faces and respirator facepieces whenever necessary to prevent skin irritation associated with respirator use.

(iv) No employee shall be assigned to tasks requiring the use of respirators if, based upon his or her most recent examination, an examining physician determines that the employee will be unable to function normally wearing a

respirator, or that the safety or health of the employee or other employees will be impaired by the use of a respirator. Such employee shall be assigned to another job or given the opportunity to transfer to a different position whose duties he or she is able to perform with the same employer, in the same geographical area and with the same seniority, status, and rate of pay the employee had just prior to such transfer, if such a different position is available.

(4) *Respirator fit testing.* (i) The employer shall ensure that the respirator issued to the employee exhibits the least possible facepiece leakage and that the respirator is fitted properly.

(ii) For each employee wearing negative pressure respirators, employers shall perform either quantitative or qualitative face fit tests at the time of initial fitting and at least every six months thereafter. The qualitative fit tests may be used only for testing the fit of half-mask respirators where they are permitted to be worn, and shall be conducted in accordance with Appendix C. The tests shall be used to select facepieces that provide the required protection as prescribed in Table 1.

(b) *Protective work clothing and equipment—(1) Provision and use.* If an employee is exposed to asbestos, tremolite, anthophyllite, actinolite, or a combination of these minerals above the PEL, or where the possibility of eye irritation exists, the employer shall provide at no cost to the employee and ensure that the employee uses appropriate protective work clothing and equipment such as, but not limited to:

(i) Coveralls or similar full-body work clothing;

(ii) Gloves, head coverings, and foot coverings; and

(iii) Face shields, vented goggles, or other appropriate protective equipment which complies with § 1910.133 of this Part.

(2) *Removal and storage.* (i) The employer shall ensure that employees remove work clothing contaminated with asbestos, tremolite, anthophyllite, or actinolite only in change rooms provided in accordance with paragraph (i)(1) of this section.

(ii) The employer shall ensure that no employee takes contaminated work clothing out of the change room, except those employees authorized to do so for the purpose of laundering, maintenance, or disposal.

(iii) Contaminated work clothing shall be placed and stored in closed containers which prevent dispersion of the asbestos, tremolite, anthophyllite, and actinolite outside the container.

(iv) Containers of contaminated protective devices or work clothing which are to be taken out of change rooms or the workplace for cleaning, maintenance or disposal, shall bear labels in accordance with paragraph (j)(2) of this section.

(3) *Cleaning and replacement.* (i) The employer shall clean, launder, repair, or replace protective clothing and equipment required by this paragraph to maintain their effectiveness. The employer shall provide clean protective clothing and equipment at least weekly to each affected employee.

(ii) The employer shall prohibit the removal of asbestos, tremolite, anthophyllite, and actinolite from protective clothing and equipment by blowing or shaking.

(iii) Laundering of contaminated clothing shall be done so as to prevent the release of airborne fibers of asbestos, tremolite, anthophyllite, actinolite, or a combination of these minerals in excess of the permissible exposure limit prescribed in paragraph (c) of this section.

(iv) Any employer who gives contaminated clothing to another person for laundering shall inform such person of the requirement in paragraph (h)(3)(iii) of this section to effectively prevent the release of airborne fibers of asbestos, tremolite, anthophyllite, actinolite, or a combination of these minerals in excess of the permissible exposure limit.

(v) The employer shall inform any person who launders or cleans protective clothing or equipment contaminated with asbestos, tremolite, anthophyllite, or actinolite, of the potentially harmful effects of exposure to asbestos, tremolite, anthophyllite, or actinolite.

(vi) Contaminated clothing shall be transported in sealed impermeable bags, or other closed, impermeable containers, and labeled in accordance with paragraph (j) of this section.

(i) *Hygiene facilities and practices—*

(1) *Change rooms.* (i) The employer shall provide clean change rooms for employees who work in areas where their airborne exposure to asbestos, tremolite, anthophyllite, actinolite, or a combination of these minerals is above the permissible exposure limit.

(ii) The employer shall ensure that change rooms are in accordance with § 1910.141(e) of this part, and are equipped with two separate lockers or storage facilities, so separated as to prevent contamination of the employee's street clothes from his protective work clothing and equipment.

(2) *Showers.* (i) The employer shall ensure that employees who work in

areas where their airborne exposure is above the permissible exposure limit shower at the end of the work shift.

(ii) The employer shall provide shower facilities which comply with § 1910.141(d)(3) of this part.

(iii) The employer shall ensure that employees who are required to shower pursuant to paragraph (i)(2)(i) of this section do not leave the workplace wearing any clothing or equipment worn during the work shift.

(3) *Lunchrooms.* (i) The employer shall provide lunchroom facilities for employees who work in areas where their airborne exposure is above the permissible exposure limit.

(ii) The employer shall ensure that lunchroom facilities have a positive pressure, filtered air supply, and are readily accessible to employees.

(iii) The employer shall ensure that employees who work in areas where their airborne exposure is above the permissible exposure limit wash their hands and faces prior to eating, drinking or smoking.

(iv) The employer shall ensure that employees do not enter lunchroom facilities with protective work clothing or equipment unless surface asbestos, tremolite, anthophyllite, and actinolite fibers have been removed from the clothing or equipment by vacuuming or other method that removes dust without causing the asbestos, tremolite, anthophyllite, or actinolite to become airborne.

(j) *Communication of hazards to employees—(1) Warning signs.* (i) Posting. Warning signs shall be provided and displayed at each regulated area. In addition, warning signs shall be posted at all approaches to regulated areas so that an employee may read the signs and take necessary protective steps before entering the area.

(ii) Sign specifications. The warning signs required by paragraph (j)(1)(i) of this section shall bear the following information:

**DANGER  
ASBESTOS  
CANCER AND LUNG DISEASE  
HAZARD  
AUTHORIZED PERSONNEL ONLY  
RESPIRATORS AND PROTECTIVE  
CLOTHING  
ARE REQUIRED IN THIS AREA**

(iii) Where minerals in the regulated area are only tremolite, anthophyllite or actinolite, the employer may replace the term "asbestos" with the appropriate mineral name.

(2) *Warning labels.* (i) Labeling. Warning labels shall be affixed to all raw materials, mixtures, scrap, waste, debris, and other products containing

asbestos, tremolite, anthophyllite, or actinolite fibers, or to their containers.

(ii) Label specifications. The labels shall comply with the requirements of 29 CFR 1910.1200(f) of OSHA's Hazard Communication standard, and shall include the following information:

**DANGER  
CONTAINS ASBESTOS FIBERS  
AVOID CREATING DUST  
CANCER AND LUNG DISEASE  
HAZARD**

(iii) Where minerals to be labeled are only tremolite, anthophyllite, or actinolite, the employer may replace the term "asbestos" with the appropriate mineral name.

(3) *Material safety data sheets.* Employers who are manufacturers or importers of asbestos, tremolite, anthophyllite, or actinolite or asbestos, tremolite, anthophyllite, or actinolite products shall comply with the requirements regarding development of material safety data sheets as specified in 29 CFR 1910.1200(g) of OSHA's Hazard Communication standard, except as provided by paragraph (j)(4) of this section.

(4) The provisions for labels required by paragraph (j)(2) or for material safety data sheets required by paragraph (j)(3) do not apply where:

(i) Asbestos, tremolite, anthophyllite, or actinolite fibers have been modified by a bonding agent, coating, binder, or other material provided that the manufacturer can demonstrate that during any reasonably foreseeable use, handling, storage, disposal, processing, or transportation, no airborne concentrations of fibers of asbestos, tremolite, anthophyllite, actinolite, or a combination of these minerals in excess of the action level will be released or

(ii) Asbestos, tremolite, anthophyllite, actinolite, or a combination of these minerals is present in a product in concentrations less than 0.1%.

(5) *Employee information and training.* (i) The employer shall institute a training program for all employees who are exposed to airborne concentrations of asbestos, tremolite, anthophyllite, actinolite, or a combination of these minerals at or above the action level ensure their participation in the program.

(ii) Training shall be provided prior to or at the time of initial assignment and at least annually thereafter.

(iii) The training program shall be conducted in a manner which the employee is able to understand. The employer shall ensure that each employee is informed of the following:

(A) The health effect associated with asbestos, tremolite, anthophyllite, or actinolite exposure;

(B) The relationship between smoking and exposure to asbestos, tremolite, anthophyllite, and actinolite in producing lung cancer;

(C) The quantity, location, manner of use, release, and storage of asbestos, tremolite, anthophyllite, or actinolite, and the specific nature of operations which could result in exposure to asbestos, tremolite, anthophyllite, or actinolite;

(D) The engineering controls and work practices associated with the employee's job assignment;

(E) The specific procedures implemented to protect employees from exposure to asbestos, tremolite, anthophyllite, or actinolite, such as appropriate work practices, emergency and clean-up procedures, and personal protective equipment to be used;

(F) The purpose, proper use, and limitations of respirators and protective clothing;

(G) The purpose and a description of the medical surveillance program required by paragraph (1) of this section;

(H) A review of this standard, including appendices.

(iv) Access to information and training materials.

(A) The employer shall make a copy of this standard and its appendices readily available without cost to all affected employees.

(B) The employer shall provide, upon request, all materials relating to the employee information and training program to the Assistant Secretary and the training program to the Assistant Secretary and the Director.

(k) *Housekeeping.* (1) All surfaces shall be maintained as free as practicable of accumulations of dusts and waste containing asbestos, tremolite, anthophyllite, or actinolite.

(2) All spills and sudden releases of material containing asbestos, tremolite, anthophyllite, or actinolite shall be cleaned up as soon as possible.

(3) Surfaces contaminated with asbestos, tremolite, anthophyllite, or actinolite may not be cleaned by the use of compressed air.

(4) Vacuuming. HEPA-filtered vacuuming equipment shall be used for vacuuming. The equipment shall be used and emptied in a manner which minimizes the reentry of asbestos, tremolite, anthophyllite, or actinolite into the workplace.

(5) Shoveling, dry sweeping and dry clean-up of asbestos, tremolite, anthophyllite, or actinolite may be used only where vacuuming and/or wet cleaning are not feasible.

(6) Waste disposal. Waste, scrap, debris, bags, containers, equipment, and clothing contaminated with asbestos, tremolite, anthophyllite, or actinolite consigned for disposal, shall be collected and disposed of in sealed impermeable bags, or other closed, impermeable containers.

(l) *Medical surveillance*—(1) *General.*—(i) *Employees covered.* The employer shall institute a medical surveillance program for all employees who are or will be exposed to airborne concentrations of fibers of asbestos, tremolite, anthophyllite, actinolite, or a combination of these minerals at or above the action level.

(ii) *Examination by a physician.* (A) The employer shall ensure that all medical examinations and procedures are performed by or under the supervision of a licensed physician, and shall be provided without cost to the employee and at a reasonable time and place.

(B) Persons other than licensed physicians, who administer the pulmonary function testing required by this section, shall complete a training course in spirometry sponsored by an appropriate academic or professional institution.

(2) *Preplacement examinations.* (i) Before an employee is assigned to an occupation exposed to airborne

concentrations of asbestos, tremolite, anthophyllite, or actinolite fibers, a preplacement medical examination shall be provided or made available by the employer.

(ii) Such examination shall include, as a minimum, a medical and work history; A complete physical examination of all systems with emphasis on the respiratory system, the cardiovascular system and digestive tract; completion of the respiratory disease standardized questionnaire in Appendix D, Part 1; a chest roentgenogram (posterior-anterior 14x17 inches); pulmonary function tests to include forced vital capacity (FVC) and forced expiratory volume at 1 second (FEV<sub>1.0</sub>); and any additional tests deemed appropriate by the examining physician. Interpretation and classification of chest roentgenograms shall be conducted in accordance with Appendix E.

(3) *Periodic examinations.* (i) Periodic medical examinations shall be made available annually.

(ii) The scope of the medical examination shall be in conformance with the protocol established in paragraph (1)(2)(ii), except that the frequency of chest roentgenograms shall be conducted in accordance with Table 2, and the abbreviated standardized questionnaire contained in Appendix D, Part 2, shall be administered to the employee.

TABLE 2.—FREQUENCY OF CHEST ROENTGENOGRAMS

Years since first exposure	Age of employee		
	15 to 35	35+ to 45	45+
0 to 10	Every 5 years	Every 5 years	Every 5 years
10+	Every 5 years	Every 2 years	Every 1 year

(4) *Termination of employment examinations.* (i) The employer shall provide, or make available, a termination of employment medical examination for any employee who has been exposed to airborne concentrations of fibers of asbestos, tremolite, anthophyllite, actinolite, or a combination of these minerals at or above the action level.

(ii) The medical examination shall be in accordance with the requirements of the periodic examinations stipulated in paragraph (1)(3) of this section, and shall be given within 30 calendar days before or after the date of termination of employment.

(5) *Recent examinations.* No medical examination is required of any employee, if adequate records show that the employee has been examined in accordance with any of the preceding

paragraphs [(1)(2)–(1)(4)] within the past 1 year period.

(6) *Information provided to the physician.* The employer shall provide the following information to the examining physician:

(i) A copy of this standard and Appendices D and E.

(ii) A description of the affected employee's duties as they relate to the employee's exposure.

(iii) The employee's representative exposure level or anticipated exposure level.

(iv) A description of any personal protective and respiratory equipment used or to be used.

(v) Information from previous medical examinations of the affected employee that is not otherwise available to the examining physician.

(7) *Physician's written opinion.* (i) The employer shall obtain a written signed opinion from the examining physician. This written opinion shall contain the results of the medical examination and shall include:

(A) The physician's opinion as to whether the employee has any detected medical conditions that would place the employee at an increased risk of material health impairment from exposure to asbestos, tremolite, anthophyllite, or actinolite;

(B) Any recommended limitations on the employee or upon the use of personal protective equipment such as clothing or respirators; and

(C) A statement that the employee has been informed by the physician of the results of the medical examination and of any medical conditions resulting from asbestos, tremolite, anthophyllite, or actinolite exposure that require further explanation or treatment.

(ii) The employer shall instruct the physician not to reveal in the written opinion given to the employer specific findings or diagnoses unrelated to occupational exposure to asbestos, tremolite, anthophyllite, or actinolite.

(iii) The employer shall provide a copy of the physician's written opinion to the affected employee within 30 days from its receipt.

(m) *Recordkeeping.*—(1) *Exposure measurements.* (i) The employer shall keep an accurate record of all measurements taken to monitor employee exposure to asbestos, tremolite, anthophyllite, or actinolite as prescribed in paragraph (c) of this section.

(ii) This record shall include at least the following information:

(A) The date of measurement;

(B) The operation involving exposure to asbestos, tremolite, anthophyllite, or actinolite which is being monitored;

(C) Sampling and analytical methods used and evidence of their accuracy;

(D) Number, duration, and results of samples taken;

(E) Type of respiratory protective devices worn, if any; and

(F) Name, social security number and exposure of the employees whose exposure are represented.

(iii) The employer shall maintain this record for at least thirty (30) years, in accordance with 29 CFR 1910.20.

(2) *Objective data for exempted operations.* (i) Where the processing, use, or handling of products made from or containing asbestos, tremolite, anthophyllite, or actinolite is exempted from other requirements of this section under paragraph (d)(2)(iii) of this section, the employer shall establish and maintain an accurate record of objective

data reasonably relied upon in support of the exemption.

(ii) The record shall include at least the following:

(A) The product qualifying for exemption;

(B) The source of the objective data;

(C) The testing protocol, results of testing, and/or analysis of the material for the release of asbestos, tremolite, anthophyllite, or actinolite;

(D) A description of the operation exempted and how the data support the exemption; and

(E) Other data relevant to the operations, materials, processing, or employee exposures covered by the exemption.

(iii) The employer shall maintain this record for the duration of the employer's reliance upon such objective data.

*Note.*—The employer may utilize the services of competent organizations such as industry trade associations and employee associations to maintain the records required by this section.

(3) *Medical surveillance.* (i) The employer shall establish and maintain an accurate record for each employee subject to medical surveillance by paragraph (l)(1)(i) of this section, in accordance with 29 CFR 1910.20.

(ii) The record shall include at least the following information:

(A) The name and social security number of the employee;

(B) Physician's written opinions;

(C) Any employee medical complaints related to exposure to asbestos, tremolite, anthophyllite, or actinolite; and

(D) A copy of the information provided to the physician as required by paragraph (l)(6) of this section.

(iii) The employer shall ensure that this record is maintained for the duration of employment plus thirty (30) years, in accordance with 29 CFR 1910.20.

(4) *Training.* The employer shall maintain all employee training records for one (1) year beyond the last date of employment of that employee.

(5) *Availability.* (i) The employer, upon written request, shall make all records required to be maintained by this section available to the Assistant Secretary and the Director for examination and copying.

(ii) The employer, upon request shall make any exposure records required by paragraph (m)(1) of this section available for examination and copying to affected employees, former employees, designated representatives and the Assistant Secretary, in accordance with 29 CFR 1910.20 (e)-(e) and (g)-(i).

(iii) The employer, upon request, shall make employee medical records required by paragraph (m)(2) of this section available for examination and copying to the subject employee, to anyone having the specific written consent of the subject employee, and the Assistant Secretary, in accordance with 29 CFR 1910.20.

(6) *Transfer of records.* (i) The employer shall comply with the requirements concerning transfer of records set forth in 29 CFR 1910.20(h).

(ii) Whenever the employer ceases to do business and there is no successor employer to receive and retain the records for the prescribed period, the employer shall notify the Director at least 90 days prior to disposal of records and, upon request, transmit them to the Director.

(n) *Observation of monitoring.*—(1) *Employee observation.* The employer shall provide affected employees or their designated representatives an opportunity to observe any monitoring of employee exposure to asbestos, tremolite, anthophyllite, or actinolite conducted in accordance with paragraph (d) of this section.

(2) *Observation procedures.* When observation of the monitoring of employee exposure to asbestos, tremolite, anthophyllite, or actinolite requires entry into an area where the use of protective clothing or equipment is required, the observer shall be provided with and be required to use such clothing and equipment and shall comply with all other applicable safety and health procedures.

(o) *Dates.*—(1) *Effective date.* This standard shall become effective July 21, 1986. The requirements of the asbestos standard issued in June 1972 (37 FR 11318), as amended, and published in 29 CFR 1910.1001 (1985) remain in effect until compliance is achieved with the parallel provisions of this standard.

(2) *Start-up dates.* All obligations of this standard commence on the effective date except as follows:

(i) *Exposure monitoring.* Initial monitoring required by paragraph (d)(2) of this section shall be completed as soon as possible but no later than October 20, 1986.

(ii) *Regulated areas.* Regulated areas required to be established by paragraph (e) of this section as a result of initial monitoring shall be set up as soon as possible after the results of that monitoring are known and not later than November 17, 1986.

(iii) *Respiratory protection.* Respiratory protection required by paragraph (g) of this section shall be

provided as soon as possible but no later than the following schedule:

(A) Employees whose 8-hour TWA exposure exceeds 2 fibers/cc—July 21, 1986.

(B) Employees whose 8-hour TWA exposure exceeds the PEL but is less than 2 fibers/cc—November 17, 1986.

(C) Powered air-purifying respirators provided under paragraph (g)(2)(ii)—January 18, 1987.

(iv) *Hygiene and lunchroom facilities.* Construction plans for changerooms, showers, lavatories, and lunchroom facilities shall be completed no later than January 18, 1987; and these facilities shall be constructed and in use no later than July 20, 1987. However, if as part of the compliance plan it is predicted by an independent engineering firm that engineering controls and work practices will reduce exposures below the permissible exposure limit by July 20, 1988, for affected employees, then such facilities need not be completed until 1 year after the engineering controls are completed, if such controls have not in fact succeeded in reducing exposure to below the permissible exposure limit.

(v) *Employee information and training.* Employee information and training required by paragraph (f)(5) of this section shall be provided as soon as possible but no later than October 20, 1986.

(vi) *Medical surveillance.* Medical examinations required by paragraph (1) of this section shall be provided as soon as possible but no later than November 17, 1986.

(vii) *Compliance program.* Written compliance programs required by paragraph (T)(2) of this section as a result of initial monitoring shall be completed and available for inspection and copying as soon as possible but no later than July 20, 1987.

(viii) *Methods of compliance.* The engineering and work practice controls as required by paragraph (f)(1) shall be implemented as soon as possible but no later than July 20, 1988.

(p) *Appendices.* (1) Appendices A, C, D, and E to this section are incorporated as part of this section and the contents of these Appendices are mandatory. (2) Appendices B, F, G and H to this section are informational and are not intended to create any additional obligations not otherwise imposed or to detract from any existing obligations.

**Appendix A to § 1910.1001—Osha Reference Method—Mandatory**

This mandatory appendix specifies the procedure for analyzing air samples for asbestos, tremolite, anthophyllite, and actinolite and specifies quality control

procedures that must be implemented by laboratories performing the analysis. The sampling and analytical methods described below represent the elements of the available monitoring methods (such as the NIOSH 7400 method) which OSHA considers to be essential to achieve adequate employee exposure monitoring while allowing employers to use methods that are already established within their organizations. All employers who are required to conduct air monitoring under paragraph (f) of the standard are required to utilize analytical laboratories that use this procedure, or an equivalent method, for collecting and analyzing samples.

**Sampling and Analytical Procedure**

1. The sampling medium for air samples shall be mixed cellulose ester filter membranes. These shall be designated by the manufacturer as suitable for asbestos, tremolite, anthophyllite, and actinolite counting. See below for rejection of blanks.

2. The preferred collection device shall be the 25-mm diameter cassette with an open-faced 50-mm extension cowl. The 37-mm cassette may be used if necessary but only if written justification for the need to use the 37-mm filter cassette accompanies the sample results in the employee's exposure monitoring record.

3. An air flow rate between 0.5 liter/min and 2.5 liters/min shall be selected for the 25-mm cassette. If the 37-mm cassette is used, an air flow rate between 1 liter/min and 2.5 liters/min shall be selected.

4. Where possible, a sufficient air volume for each air sample shall be collected to yield between 100 and 1,300 fibers per square millimeter on the membrane filter. If a filter darkens in appearance or if loose dust is seen on the filter, a second sample shall be started.

5. Ship the samples in a rigid container with sufficient packing material to prevent dislodging the collected fibers. Packing material that has a high electrostatic charge on its surface (e.g., expanded polystyrene) cannot be used because such material can cause loss of fibers to the sides of the cassette.

6. Calibrate each personal sampling pump before and after use with a representative filter cassette installed between the pump and the calibration device.

7. Personal samples shall be taken in the "breathing zone" of the employee (i.e., attached to or near the collar or high near the worker's face).

8. Fiber counts shall be made by positive phase contrast using a microscope with an 8 to 10 X eyepiece and a 40 to 45 X objective for a total magnification of approximately 400 X and a numerical aperture of 0.85 to 0.75. The microscope shall also be fitted with a green or blue filter.

9. The microscope shall be fitted with a Walton-Beckett eyepiece graticule calibrated for a field diameter of 100 micrometers (+/- 2 micrometers).

10. The phase-shift detection limit of the microscope shall be about 3 degrees measured using the HSE phase shift test slide as outlined below.

a. Place the test slide on the microscope stage and center it under the phase objective.

b. Bring the blocks of grooved lines into focus.

Note.—The slide consists of seven sets of grooved lines (ca. 20 grooves to each block) in descending order of visibility from sets 1 to 7, seven being the least visible. The requirements for asbestos, tremolite, anthophyllite, and actinolite counting are that the microscope optics must resolve the grooved lines in set 3 completely, although they may appear somewhat faint, and that the grooved lines in sets 6 and 7 must be invisible. Sets 4 and 5 must be at least partially visible but may vary slightly in visibility between microscopes. A microscope that fails to meet these requirements has either too low or too high a resolution to be used for asbestos, tremolite, anthophyllite, and actinolite counting.

c. If the image deteriorates, clean and adjust the microscope optics. If the problem persists, consult the microscope manufacturer.

11. Each set of samples taken will include 10 percent blanks or a minimum of 2 blanks. The blank results shall be averaged and subtracted from the analytical results before reporting. Any samples represented by a blank having a fiber count in excess of 7 fibers/100 fields shall be rejected.

12. The samples shall be mounted by the acetone/Ariscetin method or a method with an equivalent index of refraction and similar clarity.

13. Observe the following counting rules:

a. Count only fibers equal to or longer than 5 micrometers. Measure the length of curved fibers along the curve.

b. Count all particles as asbestos, tremolite, anthophyllite, and actinolite that have a length-to-width ratio (aspect ratio) of 3:1 or greater.

c. Fibers lying entirely within the boundary of the Walton-Beckett graticule field shall receive a count of 1. Fibers crossing the boundary once, having one end within the circle, shall receive the count of one half (1/2). Do not count any fiber that crosses the graticule boundary more than once. Reject and do not count any other fibers even though they may be visible outside the graticule area.

d. Count bundles of fibers as one fiber unless individual fibers can be identified by observing both ends of an individual fiber.

e. Count enough graticule fields to yield 100 fibers. Count a minimum of 20 fields; stop counting at 100 fields regardless of fiber count.

14. Blind recounts shall be conducted at the rate of 10 percent.

**Quality Control Procedures**

1. Intra-laboratory program. Each laboratory and/or each company with more than one microscopist counting slides shall establish a statistically designed quality assurance program involving blind recounts and comparisons between microscopists to monitor the variability of counting by each microscopist and between microscopists. In a company with more than one laboratory, the program shall include all laboratories and shall also evaluate the laboratory-to-laboratory variability.

2. Interlaboratory program. Each laboratory analyzing asbestos, tremolite, anthophyllite, and actinolite samples for compliance determination shall implement an interlaboratory quality assurance program that as a minimum includes participation of at least two other independent laboratories. Each laboratory shall participate in round robin testing at least once every 8 months with at least all the other laboratories in its interlaboratory quality assurance group. Each laboratory shall submit slides typical of its own work load for use in this program. The round robin shall be designed and results analyzed using appropriate statistical methodology.

3. All individuals performing asbestos, tremolite, anthophyllite, and actinolite analysis must have taken the NIOSH course for sampling and evaluating airborne asbestos, tremolite, anthophyllite, and actinolite dust or an equivalent course.

4. When the use of different microscopes contributes to differences between counters and laboratories, the effect of the different microscope shall be evaluated and the microscope shall be replaced, as necessary.

5. Current results of these quality assurance programs shall be posted in each laboratory to keep the microscopists informed.

**Appendix B to § 1910.1001—Detailed Procedure for Asbestos Tremolite, Anthophyllite, and Actinolite Sampling and Analysis—Non-Mandatory**

This appendix contains a detailed procedure for sampling and analysis and includes those critical elements specified in Appendix A. Employers are not required to use this procedure, but they are required to use Appendix A. The purpose of Appendix B is to provide a detailed step-by-step sampling and analysis procedure that conforms to the elements specified in Appendix A. Since this procedure may also standardize the analysis and reduce variability, OSHA encourages employers to use this appendix.

*Asbestos, Tremolite, Anthophyllite, and Actinolite Sampling and Analysis Method*

Technique: Microscopy, Phase Contrast  
Analyte: Fibers (manual count)

Sample Preparation: Acetone/triacetin method

Calibration: Phase-shift detection limit about 3 degrees

Range: 100 to 1300 fibers/mm<sup>2</sup> filter area

Estimated limit of detection: 7 fibers/mm<sup>2</sup> filter area

Sampler: Filter (0.8–1.2 µm mixed cellulose ester membrane, 25-mm diameter)

Flow rate: 0.5 l/min to 2.5 l/min (25-mm cassette) 1.0 l/min to 2.5 l/min (37-mm cassette)

Sample volume: Adjust to obtain 100 to 1300 fibers/mm<sup>2</sup>

Shipment: Routine

Sample stability: Indefinite

Blanks: 10% of samples (minimum 2)

Standard analytical error: 0.25.

Applicability: The working range is 0.02 f/cc (1920-L air sample) to 1.25 f/cc (400-L air

sample). The method gives an index of airborne asbestos, tremolite, anthophyllite, and actinolite fibers but may be used for other materials such as fibrous glass by inserting suitable parameters into the counting rules. The method does not differentiate between asbestos, tremolite, anthophyllite, and actinolite and other fibers. Asbestos, tremolite, anthophyllite, and actinolite fibers less than ca. 0.25 µm diameter will not be detected by this method.

Interferences: Any other airborne fiber may interfere since all particles meeting the counting criteria are counted. Chainlike particles may appear fibrous. High levels of nonfibrous dust particles may obscure fibers in the field of view and raise the detection limit.

Reagents: 1. Acetone. 2. Triacetin (glycerol triacetate), reagent grade

Special precautions: Acetone is an extremely flammable liquid and precautions must be taken not to ignite it. Heating of acetone must be done in a ventilated laboratory fume hood using a flameless, spark-free heat source.

Equipment: 1. Collection device: 25-mm cassette with 50-mm extension cowl with cellulose ester filter, 0.8 to 1.2 µm pore size and backup pad.

Note: Analyze representative filters for fiber background before use and discard the filter lot if more than 5 fibers/100 fields are found.

1. Personal sampling pump, greater than or equal to 0.5 l/min, with flexible connecting tubing.

2. Microscope, phase contrast, with green or blue filter, 8 to 10X eyepiece, and 40 to 45X phase objective (total magnification ca 400X; numerical aperture = 0.65 to 0.75).

3. Slides, glass, single-frosted, pre-cleaned, 25 x 75 mm

4. Cover slips, 25 x 25 mm, no. 1 1/2 unless otherwise specified by microscope manufacturer.

5. Knife, No. 1 surgical steel, curved blade.

6. Tweezers.

7. Flask, Guth-type, insulated neck, 250 to 500 ml, (with single-holed rubber stopper and elbow-jointed glass tubing, 18 to 22 cm long).

8. Hotplate, spark-free, stirring type, heating mantle or infrared lamp and magnetic stirrer.

9. Syringe, hypodermic, with 22-gauge needle

10. Graticule, Walton-Beckett type with 100 µm diameter circular field at the specimen plane (area = 0.00785 mm<sup>2</sup>). (Type G-22).

Note.—the graticule is custom-made for each microscope.

11. HSE/NPL phase contrast test slide, Mark II.

12. Telescope, ocular phase-ring centering

13. Stage micrometer (0.01 mm divisions).

**Sampling**

1. Calibrate each personal sampling pump with a representative sampler in line.

2. Fasten the sampler to the worker's lapel as close as possible to the worker's mouth. Remove the top cover from the end of the cowl extension (open face) and orient face down. Wrap the joint between the extender and the monitor's body with shrink tape to prevent air leaks.

3. Submit at least two blanks (or 10% of the total samples, whichever is greater) for each

set of samples. Remove the caps from the field blank cassettes and store the caps and cassettes in a clean area (bag or box) during the sampling period. Replace the caps in the cassettes when sampling is completed.

4. Sample at 0.5 l/min or greater. Do not exceed 1 mg total dust loading on the filter. Adjust sampling flow rate, Q (l/min), and time to produce a fiber density, E (fibers/mm<sup>2</sup>), of 100 to 1300 fibers/mm<sup>2</sup> [ $3.85 \times 10^4$  to  $5 \times 10^5$  fibers per 25-mm filter with effective collection area ( $A_c = 385 \text{ mm}^2$ )] for optimum counting precision (see step 21 below). Calculate the minimum sampling time,

$t_{\text{min}} (\text{min})$  at the action level (one-half of the current standard), L (f/cc) of the fibrous aerosol being sampled:

$$t_{\text{min}} = \frac{(Ac)(E)}{(Q)(L)10^6}$$

5. Remove the field monitor at the end of sampling, replace the plastic top cover and small end caps, and store the monitor.

6. Ship the samples in a rigid container with sufficient packing material to prevent jostling or damage.

Note.—Do not use polystyrene foam in the shipping container because of electrostatic forces which may cause fiber loss from the sampler filter.

**Sample Preparation**

Note.—The object is to produce samples with a smooth (non-grainy) background in a medium with a refractive index equal to or less than 1.46. The method below collapses the filter for easier focusing and produces permanent mounts which are useful for quality control and interlaboratory comparison. Other mounting techniques meeting the above criteria may also be used, e.g., the nonpermanent field mounting technique used in P & CAM 239.

7. Ensure that the glass slides and cover slips are free of dust and fibers.

8. Place 40 to 60 ml of acetone into a Guth-type flask. Stopper the flask with a single-hole rubber stopper through which a glass tube extends 5 to 6 cm into the flask. The portion of the glass tube that exits the top of the stopper (8 to 10 cm) is bent downward in an elbow that makes an angle of 20 to 30 degrees with the horizontal.

9. Place the flask in a stirring hotplate or wrap in a heating mantle. Heat the acetone gradually to its boiling temperature (ca. 56 °C).

Caution.—The acetone vapor must be generated in a ventilated fume hood away from all open flames and spark sources. Alternate heating methods can be used, providing no open flame or sparks are present.

10. Mount either the whole sample filter or a wedge cut from the sample filter on a clean glass slide.

a. Cut wedges of ca. 25 percent of the filter area with a curved-blade steel surgical knife using a rocking motion to prevent tearing

b. Place the filter or wedge, dust side up, on the slide. Static electricity will usually keep the filter on the slide until it is cleared.

c. Hold the glass slide supporting the filter approximately 1 to 2 cm from the glass tube port where the acetone vapor is escaping from the heated flask. The acetone vapor stream should cause a condensation spot on the glass slide ca. 2 to 3 cm in diameter. Move the glass slide gently in the vapor stream. The filter should clear in 2 to 5 sec. If the filter curls, distorts, or is otherwise rendered unusable, the vapor stream is probably not strong enough. Periodically wipe the outlet port with tissue to prevent liquid acetone dripping onto the filter.

d. Using the hypodermic syringe with a 22-gauge needle, place 1 to 2 drops of tracetin on the filter. Gently lower a clean 25-mm square cover slip down onto the filter at a slight angle to reduce the possibility of forming bubbles. If too many bubbles form or the amount of tracetin is insufficient, the cover slip may become detached within a few hours.

e. Glue the edges of the cover slip to the glass slide using a lacquer or nail polish.

Note.—If clearing is slow, the slide preparation may be heated on a hotplate (surface temperature 50 °C) for 15 min to hasten clearing. Counting may proceed immediately after clearing and mounting are completed.

#### Calibration and Quality Control

11. Calibration of the Walton-Beckett graticule. The diameter,  $d_c$  (mm), of the circular counting area and the disc diameter must be specified when ordering the graticule.

a. Insert any available graticule into the eyepiece and focus so that the graticule lines are sharp and clear.

b. Set the appropriate interpupillary distance and, if applicable, reset the binocular head adjustment so that the magnification remains constant.

c. Install the 40 to 45 × phase objective.

d. Place a stage micrometer on the microscope object stage and focus the microscope on the graduate lines.

e. Measure the magnified grid length,  $L_m$  (mm), using the stage micrometer.

f. Remove the graticule from the microscope and measure its actual grid length,  $L_a$  (mm). This can best be accomplished by using a stage fitted with verniers.

g. Calculate the circle diameter,  $d_c$  (mm), for the Walton-Beckett graticule.

$$d_c = \frac{L_m \times D}{L_a}$$

Example.—If  $L_m = 108 \mu\text{m}$ ,  $L_a = 2.93 \text{ mm}$  and  $D = 100 \mu\text{m}$ , then  $d_c = 2.71 \text{ mm}$ .

h. Check the field diameter,  $D$  (acceptable range  $100 \text{ mm} \pm 2 \text{ mm}$ ) with a stage micrometer upon receipt of the graticule from the manufacturer. Determine field area ( $\text{mm}^2$ ).

12. Microscope adjustments. Follow the manufacturer's instructions and also the following:

a. Adjust the light source for even illumination across the field of view at the condenser iris.

Note.—Kohler illumination is preferred, where available.

b. Focus on the particulate material to be examined.

c. Make sure that the field iris is in focus, centered on the sample, and open only enough to fully illuminate the field of view.

d. Use the telescope ocular supplied by the manufacturer to ensure that the phase rings (annular diaphragm and phase-shifting elements) are concentric.

13. Check the phase-shift detection limit of the microscope periodically.

a. Remove the HSE/NPL phase-contrast test slide from its shipping container and center it under the phase objective.

b. Bring the blocks of grooved lines into focus.

Note.—The slide consists of seven sets of grooves (ca. 20 grooves to each block) in descending order of visibility from sets 1 to 7. The requirements for counting are that the microscope optics must resolve the grooved lines in set 3 completely, although they may appear somewhat faint, and that the grooved lines in sets 6 to 7 must be invisible. Sets 4 and 5 must be at least partially visible but may vary slightly in visibility between microscopes. A microscope which fails to meet these requirements has either too low or too high a resolution to be used for asbestos, tremolite, anthophyllite, and actinolite counting.

c. If the image quality deteriorates, clean the microscope optics and, if the problem persists, consult the microscope manufacturer.

14. Quality control of fiber counts.

a. Prepare and count field blanks along with the field samples. Report the counts on each blank. Calculate the mean of the field blank counts and subtract this value from each sample count before reporting the results.

Note 1.—The identity of the blank filters should be unknown to the counter until all counts have been completed.

Note 2.—If a field blank yields fiber counts greater than 7 fibers/100 fields, report possible contamination of the samples.

b. Perform blind recounts by the same counter on 10 percent of filters counted (slides relabeled by a person other than the counter).

15. Use the following test to determine whether a pair of counts on the same filter should be rejected because of possible bias. The statistic estimates the counting repeatability at the 95% confidence level. Discard the sample if the difference between the two counts exceeds  $2.77(F)s_r$ , where  $F$  = average of the two fiber counts and  $s_r$  = relative standard deviation, which should be derived by each laboratory based on historical in-house data.

Note.—If a pair of counts is rejected as a result of this test, recount the remaining samples in the set and test the new counts against the first counts. Discard all rejected paired counts.

16. Enroll each new counter in a training course that compares performance of counters on a variety of samples using this procedure.

Note.—To ensure good reproducibility, all laboratories engaged in asbestos, tremolite, anthophyllite, and actinolite counting are required to participate in the Proficiency Analytical Testing (PAT) Program and should routinely participate with other asbestos, tremolite, anthophyllite, and actinolite fiber counting laboratories in the exchange of field samples to compare performance of counters.

#### Measurement

17. Place the slide on the mechanical stage of the calibrated microscope with the center of the filter under the objective lens. Focus the microscope on the plane of the filter.

18. Regularly check phase-ring alignment and Kohler illumination.

19. The following are the counting rules:

a. Count only fibers longer than 5  $\mu\text{m}$ . Measure the length of curved fibers along the curve.

b. Count only fibers with a length-to-width ratio equal to or greater than 3:1.

c. For fibers that cross the boundary of the graticule field, do the following:

1. Count any fiber longer than 5  $\mu\text{m}$  that lies entirely within the graticule area.

2. Count as  $\frac{1}{2}$  fiber any fiber with only one end lying within the graticule area.

3. Do not count any fiber that crosses the graticule boundary more than once.

4. Reject and do not count all other fibers.

d. Count bundles of fibers as one fiber unless individual fibers can be identified by observing both ends of a fiber.

e. Count enough graticule fields to yield 100 fibers. Count a minimum of 20 fields. Stop at 100 fields regardless of fiber count.

20. Start counting from one end of the filter and progress along a radial line to the other end, shift either up or down on the filter, and continue in the reverse direction. Select fields randomly by looking away from the eyepiece briefly while advancing the mechanical stage. When an agglomerate covers ca.  $\frac{1}{4}$  or more of the field of view, reject the field and select another. Do not report rejected fields in the number of total fields counted.

Note.—When counting a field, continuously scan a range of focal planes by moving the fine focus knob to detect very fine fibers which have become embedded in the filter. The small-diameter fibers will be very faint but are an important contribution to the total count.

#### Calculations

21. Calculate and report fiber density on the filter,  $E$  (fibers/ $\text{mm}^2$ ), by dividing the total fiber count,  $F$ , minus the mean field blank count,  $B$ , by the number of fields,  $n$ , and the field area,  $A_f$  ( $0.00785 \text{ mm}^2$  for a properly calibrated Walton-Beckett graticule):

$$E = \frac{F-B}{n(A_f)} \text{ fibers}/\text{mm}^2$$

22. Calculate the concentration,  $C$  (I/oc),  $\circ$  fibers in the air volume sampled,  $V$  (L), using the effective collection area of the filter,  $A_e$  ( $385 \text{ mm}^2$  for a 25-mm filter):

$$C = \frac{[IAA]}{V(10^3)}$$

Note.—Periodically check and adjust the value of  $A_m$  if necessary.

**Appendix C to § 1910.3001—Qualitative and Quantitative Fit Testing Procedures—Mandatory**

**Qualitative Fit Test Protocols**

**I. Isoamyl Acetate Protocol**

**A. Odor Threshold Screening**

1. Three 1-liter glass jars with metal lids (e.g. Mason or Bell jars) are required.
2. Odor-free water (e.g. distilled or spring water) at approximately 25°C shall be used for the solutions.
3. The isoamyl acetate [IAA] (also known as isopentyl acetate) stock solution is prepared by adding 1 cc of pure IAA to 800 cc of odor free water in a 1-liter jar and shaking for 30 seconds. This solution shall be prepared new at least weekly.

4. The screening test shall be conducted in a room separate from the room used for actual fit testing. The two rooms shall be well ventilated but shall not be connected to the same recirculating ventilation system.

5. The odor test solution is prepared in a second jar by placing 0.4 cc of the stock solution into 500 cc of odor free water using a clean dropper or pipette. Shake for 30 seconds and allow to stand for two to three minutes so that the IAA concentration above the liquid may reach equilibrium. This solution may be used for only one day.

6. A test blank is prepared in a third jar by adding 500 cc of odor free water.

7. The odor test and test blank jars shall be labelled 1 and 2 for jar identification. If the labels are put on the lids they can be periodically peeled, dried off and switched to maintain the integrity of the test.

8. The following instructions shall be typed on a card and placed on the table in front of the two test jars (i.e. 1 and 2): "The purpose of this test is to determine if you can smell banana oil at a low concentration. The two bottles in front of you contain water. One of these bottles also contains a small amount of banana oil. Be sure the covers are on tight, then shake each bottle for two seconds. Unscrew the lid of each bottle, one at a time, and sniff at the mouth of the bottle. Indicate to the test conductor which bottle contains banana oil."

9. The mixtures used in the IAA odor detection test shall be prepared in an area separate from where the test is performed, in order to prevent olfactory fatigue in the subject.

10. If the test subject is unable to correctly identify the jar containing the odor test solution, the IAA qualitative fit test may not be used.

11. If the test subject correctly identifies the jar containing the odor test solution, the test subject may proceed to respirator selection and fit testing.

**B. Respirator Selection**

1. The test subject shall be allowed to pick the most comfortable respirator from a selection including respirators of various sizes from different manufacturers. The selection shall include at least five sizes of elastomeric half facepieces, from at least two manufacturers.

2. The selection process shall be conducted in a room separate from the fit-test chamber to prevent odor fatigue. Prior to the selection process, the test subject shall be shown how to put on a respirator, how it should be positioned on the face, how to set strap tension and how to determine a "comfortable" respirator. A mirror shall be available to assist the subject in evaluating the fit and positioning of the respirator. This instruction may not constitute the subject's formal training on respirator use, as it is only a review.

3. The test subject should understand that the employee is being asked to select the respirator which provides the most comfortable fit. Each respirator represents a different size and shape and, if fit properly and used properly will provide adequate protection.

4. The test subject holds each facepiece up to the face and eliminates those which obviously do not give a comfortable fit. Normally, selection will begin with a half-mask and if a good fit cannot be found, the subject will be asked to test the full facepiece respirators. (A small percentage of users will not be able to wear any half-mask.)

5. The more comfortable facepieces are noted; the most comfortable mask is donned and worn at least five minutes to assess comfort. All donning and adjustments of the facepiece shall be performed by the test subject without assistance from the test conductor or other person. Assistance in assessing comfort can be given by discussing the points in #6 below. If the test subject is not familiar with using a particular respirator, the test subject shall be directed to don the mask several times and to adjust the straps each time to become adept at setting proper tension on the straps.

6. Assessment of comfort shall include reviewing the following points with the test subject and allowing the test subject adequate time to determine the comfort of the respirator:

- Positioning of mask on nose.
  - Room for eye protection.
  - Room to talk.
  - Positioning mask on face and cheeks.
7. The following criteria shall be used to help determine the adequacy of the respirator fit:

- Chin properly placed.
- Strap tension.
- Fit across nose bridge.
- Distance from nose to chin.
- Tendency to slip.
- Self-observation in mirror.

8. The test subject shall conduct the conventional negative and positive-pressure fit checks (e.g. see ANSI Z88.2-1980). Before conducting the negative- or positive-pressure test the subject shall be told to "seal" the mask by rapidly moving the head from side-to-side and up and down, while taking a few deep breaths.

9. The test subject is now ready for fit testing.

10. After passing the fit test, the test subject shall be questioned again regarding the comfort of the respirator. If it has become uncomfortable, another model of respirator shall be tried.

11. The employee shall be given the opportunity to select a different facepiece and be retested if the chosen facepiece becomes increasingly uncomfortable at any time.

**C. Fit Test**

1. The fit test chamber shall be similar to a clear 55 gal drum liner suspended inverted over a 2 foot diameter frame, so that the top of the chamber is about 8 inches above the test subject's head. The inside top center of the chamber shall have a small hook attached.

2. Each respirator used for the fitting and fit testing shall be equipped with organic vapor cartridges or offer protection against organic vapors. The cartridges or masks shall be changed at least weekly.

3. After selecting, donning, and properly adjusting a respirator, the test subject shall wear it to the fit testing room. This room shall be separate from the room used for odor threshold screening and respirator selection, and shall be well ventilated, as by an exhaust fan or lab hood, to prevent general room contamination.

4. A copy of the following test exercises and rainbow passage shall be taped to the inside of the test chamber:

**Test Exercises**

- i. Breathe normally.
- ii. Breathe deeply. Be certain breaths are deep and regular.
- iii. Turn head all the way from one side to the other. Inhale on each side. Be certain movement is complete. Do not bump the respirator against the shoulders.
- iv. Nod head up-and-down. Inhale when head is in the full up position (looking toward ceiling). Be certain motions are complete and made about every second. Do not bump the respirator on the chest.
- v. Talking. Talk aloud and slowly for several minutes. The following paragraph is called the Rainbow Passage. Reading it will result in a wide range of facial movements, and thus be useful to satisfy this requirement. Alternative passages which serve the same purpose may also be used.
- vi. Jogging in place.
- vii. Breathe normally.

**Rainbow Passage**

When the sunlight strikes raindrops in the air, they act like a prism and form a rainbow. The rainbow is a division of white light into many beautiful colors. These take the shape of a long round arch, with its path high above, and its two ends apparently beyond the horizon. There is, according to legend, a boiling pot of gold at one end. People look but no one ever finds it. When a man looks for something beyond reach, his friends say he is looking for the pot of gold at the end of the rainbow.

5. Each test subject shall wear the respirator for at least 10 minutes before starting the fit test.

6. Upon entering the test chamber, the test subject shall be given a 6 inch by 3 inch piece of paper towel or other porous absorbent single ply material, folded in half and wetted with three-quarters of one cc of pure IAA. The test subject shall hang the wet towel on the hook at the top of the chamber.

7. Allow two minutes for the IAA test concentration to be reached before starting the fit-test exercises. This would be an appropriate time to talk with the test subject, to explain the fit test, the importance of cooperation, the purpose for the head exercises, or to demonstrate some of the exercises.

8. Each exercise described in #4 above shall be performed for at least one minute.

9. If at any time during the test, the subject detects the banana-like odor of IAA, the test has failed. The subject shall quickly exit from the test chamber and leave the test area to avoid olfactory fatigue.

10. If the test is failed, the subject shall return to the selection room and remove the respirator, repeat the odor sensitivity test, select and put on another respirator, return to the test chamber, and again begin the procedure described in the c(4) through c(8) above. The process continues until a respirator that fits well has been found. Should the odor sensitivity test be failed, the subject shall wait about 5 minutes before retesting. Odor sensitivity will usually have returned by this time.

11. If a person cannot pass the fit test described above wearing a half-mask respirator from the available selection, full facepiece models must be used.

12. When a respirator is found that passes the test, the subject breaks the face seal and takes a breath before exiting the chamber. This is to assure that the reason the test subject is not smelling the IAA is the good fit of the respirator facepiece seal and not olfactory fatigue.

13. When the test subject leaves the chamber, the subject shall remove the saturated towel and return it to the person conducting the test. To keep the area from becoming contaminated, the used towels shall be kept in a self-sealing bag so there is no significant IAA concentration buildup in the test chamber during subsequent tests.

14. At least two facepieces shall be selected for the IAA test protocol. The test subject shall be given the opportunity to wear them for one week to choose the one which is more comfortable to wear.

15. Persons who have successfully passed this fit test with a half-mask respirator may be assigned the use of the test respirator in atmospheres with up to 10 times the PEL of airborne asbestos. In atmospheres greater than 10 times, and less than 100 times the PEL (up to 100 ppm), the subject must pass the IAA test using a full face negative pressure respirator. (The concentration of the IAA inside the test chamber must be increased by ten times for QLFT of the full facepiece.)

16. The test shall not be conducted if there is any hair growth between the skin the facepiece sealing surface.

17. If hair growth or apparel interferes with a satisfactory fit, then they shall be altered or

removed so as to eliminate interference and allow a satisfactory fit. If a satisfactory fit is still not attained, the test subject must use a positive-pressure respirator such as powered air-purifying respirators, supplied air respirator, or self-contained breathing apparatus.

18. If a test subject exhibits difficulty in breathing during the tests, she or he shall be referred to a physician trained in respirator diseases or pulmonary medicine to determine whether the test subject can wear a respirator while performing her or his duties.

19. Qualitative fit testing shall be repeated at least every six months.

20. In addition, because the sealing of the respirator may be affected, qualitative fit testing shall be repeated immediately when the test subject has:

- (1) Weight change of 20 pounds or more.
- (2) Significant facial scarring in the area of the facepiece seal.
- (3) Significant dental changes; i.e., multiple extractions without prosthesis, or acquiring dentures.
- (4) Reconstructive or cosmetic surgery, or
- (5) Any other condition that may interfere with facepiece sealing.

#### D. Recordkeeping

A summary of all test results shall be maintained in each office for 3 years. The summary shall include:

- (1) Name of test subject.
- (2) Date of testing.
- (3) Name of the test conductor.
- (4) Respirators selected (indicate manufacturer, model, size and approval number).
- (5) Testing agent.

#### II. Saccharin Solution Aerosol Protocol

##### A. Respirator Selection

Respirators shall be selected as described in section IB (respirator selection) above, except that each respirator shall be equipped with a particulate filter.

##### B. Taste Threshold Screening

1. An enclosure about head and shoulders shall be used for threshold screening (to determine if the individual can taste saccharin) and for fit testing. The enclosure shall be approximately 12 inches in diameter by 14 inches tall with at least the front clear to allow free movement of the head when a respirator is worn.

2. The test enclosure shall have a three-quarter inch hole in front of the test subject's nose and mouth area to accommodate the nebulizer nozzle.

3. The entire screening and testing procedure shall be explained to the test subject prior to conducting the screening test.

4. During the threshold screening test, the test subject shall don the test enclosure and breathe with open mouth with tongue extended.

5. Using a DeVilbiss Model 40 Inhalation Medication Nebulizer or equivalent, the test conductor shall spray the threshold check solution into the enclosure. This nebulizer shall be clearly marked to distinguish it from the fit test solution nebulizer.

6. The threshold check solution consists of 0.83 grams of sodium saccharin, USP in water. It can be prepared by putting 1 cc of

the test solution (see C 7 below) in 100 cc of water.

7. To produce the aerosol, the nebulizer bulb is firmly squeezed so that it collapses completely, then is released and allowed to fully expand.

8. Ten squeezes of the nebulizer bulb are repeated rapidly and then the test subject is asked whether the saccharin can be tasted.

9. If the first response is negative, ten more squeezes of the nebulizer bulb are repeated rapidly and the test subject is again asked whether the saccharin can be tasted.

10. If the second response is negative ten more squeezes are repeated rapidly and the test subject is again asked whether the saccharin can be tasted.

11. The test conductor will take note of the number of squeezes required to elicit a taste response.

12. If the saccharin is not tasted after 30 squeezes (Step 10), the saccharin fit test cannot be performed on the test subject.

13. If a taste response is elicited, the test subject shall be asked to take note of the taste for reference in the fit test.

14. Correct use of the nebulizer means that approximately 1 cc of liquid is used at a time in the nebulizer body.

15. The nebulizer shall be thoroughly rinsed in water, shaken dry, and refilled at least every four hours.

#### C. Fit Test

1. The test subject shall don and adjust the respirator without the assistance from any person.

2. The fit test uses the same enclosure described in IB above.

3. Each test subject shall wear the respirator for at least 10 minutes before starting the fit test.

4. The test subject shall don the enclosure while wearing the respirator selected in section IB above. This respirator shall be properly adjusted and equipped with a particulate filter.

5. The test subject may not eat, drink (except plain water), or chew gum for 15 minutes before the test.

6. A second DeVilbiss Model 40 Inhalation Medication Nebulizer is used to spray the fit test solution into the enclosure. This nebulizer shall be clearly marked to distinguish it from the screening test solution nebulizer.

7. The fit test solution is prepared by adding 83 grams of sodium saccharin to 100 cc of warm water.

8. As before, the test subject shall breathe with mouth open and tongue extended.

9. The nebulizer is inserted into the hole in the front of the enclosure and the fit test solution is sprayed into the enclosure using the same technique as for the taste threshold screening and the same number of squeezes required to elicit a taste response in the screening. (See B8 through B10 above.)

10. After generation of the aerosol read the following instructions to the test subject. The test subject shall perform the exercises for one minute each.

- i. Breathe normally.
- ii. Breathe deeply. Be certain breaths are deep and regular.

iii. Turn head all the way from one side to the other. Be certain movement is complete. Inhale on each side. Do not bump the respirator against the shoulders.

iv. Nod head up-and-down. Be certain motions are complete. Inhale when head is in the full up position (when looking toward the ceiling). Do not bump the respirator on the chest.

v. Talking. Talk loudly and slowly for several minutes. The following paragraph is called the Rainbow Passage. Reading it will result in a wide range of facial movements, and thus be useful to satisfy this requirement. Alternative passages which serve the same purpose may also be used.

vi. Jogging in place.

vii. Breathe normally.

#### Rainbow Passage

When the sunlight strikes raindrops in the air, they act like a prism and form a rainbow. The rainbow is a division of white light into many beautiful colors. These take the shape of a long round arch, with its path high above, and its two ends apparently beyond the horizon. There is, according to legend, a boiling pot of gold at one end. People look, but no one ever finds it. When a man looks for something beyond his reach, his friends say he is looking for the pot of gold at the end of the rainbow.

11. At the beginning of each exercise, the aerosol concentration shall be replenished using one-half the number of squeezes as initially described in C9.

12. The test subject shall indicate to the test conductor if at any time during the fit test the taste of saccharin is detected.

13. If the saccharin is detected the fit is deemed unsatisfactory and a different respirator shall be tried.

14. At least two facepieces shall be selected by the IAA test protocol. The test subject shall be given the opportunity to wear them for one week to choose the one which is more comfortable to wear.

15. Successful completion of the test protocol shall allow the use of the half mask tested respirator in contaminated atmospheres up to 10 times the PEL of asbestos. In other words this protocol may be used to assign protection factors no higher than ten.

16. The test shall not be conducted if there is any hair growth between the skin and the facepiece sealing surface.

17. If hair growth or apparel interfere with a satisfactory fit, then they shall be altered or removed so as to eliminate interference and allow a satisfactory fit. If a satisfactory fit is still not attained, the test subject must use a positive-pressure respirator such as powered air-purifying respirators, supplied air respirator, or self-contained breathing apparatus.

18. If a test subject exhibits difficulty in breathing during the tests, she or he shall be referred to a physician trained in respirator diseases or pulmonary medicine to determine whether the test subject can wear a respirator while performing her or his duties.

19. Qualitative fit testing shall be repeated at least every six months.

20. In addition, because the sealing of the respirator may be affected, qualitative fit

testing shall be repeated immediately when the test subject has:

(1) Weight change of 20 pounds or more.

(2) Significant facial scarring in the area of the facepiece seal.

(3) Significant dental changes: i.e., multiple extractions without prosthesis, or acquiring dentures.

(4) Reconstructive or cosmetic surgery, or

(5) Any other condition that may interfere with facepiece sealing.

#### D. Recordkeeping

A summary of all test results shall be maintained in each office for 3 years. The summary shall include:

(1) Name of test subject.

(2) Date of testing.

(3) Name of test conductor.

(4) Respirators selected (indicate manufacturer, model, size and approval number).

(5) Testing agent.

#### III. Irritant Fume Protocol

##### A. Respirator selection

Respirators shall be selected as described in section IB above, except that each respirator shall be equipped with a combination of high-efficiency and acid-gas cartridges.

##### B. Fit test

1. The test subject shall be allowed to smell a weak concentration of the irritant smoke to familiarize the subject with the characteristic odor.

2. The test subject shall properly don the respirator selected as above, and wear it for at least 10 minutes before starting the fit test.

3. The test conductor shall review this protocol with the test subject before testing.

4. The test subject shall perform the conventional positive pressure and negative pressure fit checks (see ANSI Z89.2 1980). Failure of either check shall be cause to select an alternate respirator.

5. Break both ends of a ventilation smoke tube containing stannic oxychloride, such as the MSA part #5645, or equivalent. Attach a short length of tubing to one end of the smoke tube. Attach the other end of the smoke tube to a low pressure air pump set to deliver 200 milliliters per minute.

6. Advise the test subject that the smoke can be irritating to the eyes and instruct the subject to keep the eyes closed while the test is performed.

7. The test conductor shall direct the stream of irritant smoke from the tube towards the facepiece area of the test subject. The person conducting the test shall begin with the tube at least 12 inches from the facepiece and gradually move to within one inch, moving around the whole perimeter of the mask.

8. The test subject shall be instructed to do the following exercises while the respirator is being challenged by the smoke. Each exercise shall be performed for one minute.

i. Breathe normally.

ii. Breathe deeply. Be certain breaths are deep and regular.

iii. Turn head all the way from one side to the other. Be certain movement is complete. Inhale on each side. Do not bump the respirator against the shoulders.

iv. Nod head up-and-down. Be certain motions are complete and made every second. Inhale when head is in the full up position (looking toward ceiling). Do not bump the respirator against the chest.

v. Talking. Talk aloud and slowly for several minutes. The following paragraph is called the Rainbow Passage. Reading it will result in a wide range of facial movements, and thus be useful to satisfy this requirement. Alternative passages which serve the same purpose may also be used.

#### Rainbow Passage

When the sunlight strikes raindrops in the air, they act like a prism and form a rainbow. The rainbow is a division of white light into many beautiful colors. These take the shape of a long round arch, with its path high above, and its two ends apparently beyond the horizon. There is, according to legend, a boiling pot of gold at one end. People look, but no one ever finds it. When a man looks for something beyond his reach, his friends say he is looking for the pot of gold at the end of the rainbow.

vi. Jogging in place.

vii. Breathe normally.

9. The test subject shall indicate to the test conductor if the irritant smoke is detected. If smoke is detected, the test conductor shall stop the test. In this case, the tested respirator is rejected and another respirator shall be selected.

10. Each test subject passing the smoke test (i.e. without detecting the smoke) shall be given a sensitivity check of smoke from the same tube to determine if the test subject reacts to the smoke. Failure to evoke a response shall void the fit test.

11. Steps B4, B6, B10 of this fit test protocol shall be performed in a location with exhaust ventilation sufficient to prevent general contamination of the testing area by the test agents.

12. At least two facepieces shall be selected by the IAA test protocol. The test subject shall be given the opportunity to wear them for one week to choose the one which is more comfortable to wear.

13. Respirators successfully tested by the protocol may be used in contaminated atmospheres up to ten times the PEL of asbestos.

14. The test shall not be conducted if there is any hair growth between the skin and the facepiece sealing surface.

15. If hair growth or apparel interfere with a satisfactory fit, then they shall be altered or removed so as to eliminate interference and allow a satisfactory fit. If a satisfactory fit is still not attained, the test subject must use a positive-pressure respirator such as powered air-purifying respirators, supplied air respirator, or self-contained breathing apparatus.

16. If a test subject exhibits difficulty in breathing during the tests, she or he shall be referred to a physician trained in respirator diseases or pulmonary medicine to determine whether the test subject can wear a respirator while performing her or his duties.

17. Qualitative fit testing shall be repeated at least every six months.

35. In addition, because the sealing of the respirator may be affected, qualitative fit testing shall be repeated immediately when the test subject has a:

- (1) Weight change of 20 pounds or more.
- (2) Significant facial scarring in the area of the facepiece seal.
- (3) Significant dental changes; i.e., multiple extractions without prosthesis, or acquiring dentures.
- (4) Reconstructive or cosmetic surgery, or
- (5) Any other condition that may interfere with facepiece sealing.

#### C. Recordkeeping

A summary of all test results shall be maintained in each office for 3 years. The summary shall include:

- (1) Name of test subject.
- (2) Date of testing.
- (3) Name of test conductor.
- (4) Respirators selected (indicate manufacturer, model, size and approval number).
- (5) Testing agent.

#### Quantitative Fit Test Procedures

##### 1. General.

a. The method applies to the negative-pressure nonpowered air-purifying respirators only.

b. The employer shall assign one individual who shall assume the full responsibility for implementing the respirator quantitative fit test program.

##### 2. Definition.

a. "Quantitative Fit Test" means the measurement of the effectiveness of a respirator seal in excluding the ambient atmosphere. The test is performed by dividing the measured concentration of challenge agent in a test chamber by the measured concentration of the challenge agent inside the respirator facepiece when the normal air purifying element has been replaced by an essentially perfect purifying element.

b. "Challenge Agent" means the air contaminant introduced into a test chamber so that its concentration inside and outside the respirator may be compared.

c. "Test Subject" means the person wearing the respirator for quantitative fit testing.

d. "Normal Standing Position" means standing erect and straight with arms down along the sides and looking straight ahead.

e. "Fit Factor" means the ratio of challenge agent concentration outside with respect to the inside of a respirator inlet covering (facepiece or enclosure).

##### 3. Apparatus.

a. *Instrumentation.* Corn oil, sodium chloride or other appropriate aerosol generation, dilution, and measurement systems shall be used for quantitative fit test.

b. *Test chamber.* The test chamber shall be large enough to permit all test subjects to freely perform all required exercises without distributing the challenge agent concentration or the measurement apparatus. The test chamber shall be equipped and constructed so that the challenge agent is effectively isolated from the ambient air yet uniform in concentration throughout the chamber.

c. When testing air-purifying respirators, the normal filter or cartridge element shall be

replaced with a high-efficiency particulate filter supplied by the same manufacturer.

d. The sampling instrument shall be selected so that a strip chart record may be made of the test showing the rise and fall of challenge agent concentration with each inspiration and expiration at fit factors of at least 2,000.

e. The combination of substitute air-purifying elements (if any), challenge agent, and challenge agent concentration in the test chamber shall be such that the test subject is not exposed in excess of PEL to the challenge agent at any time during the testing process.

f. The sampling port on the test specimen respirator shall be placed and constructed so that there is no detectable leak around the port, a free air flow, is allowed into the sampling line at all times and so there is no interference with the fit or performance of the respirator.

g. The test chamber and test set-up shall permit the person administering the test to observe one test subject inside the chamber during the test.

h. The equipment generating the challenge atmosphere shall maintain the concentration of challenge agent constant within a 10 percent variation for the duration of the test.

i. The time lag (interval between an event and its being recorded on the strip chart) of the instrumentation may not exceed 2 seconds.

j. The tubing for the test chamber atmosphere and for the respirator sampling port shall be the same diameter, length and material. It shall be kept as short as possible. The smallest diameter tubing recommended by the manufacturer shall be used.

k. The exhaust flow from the test chamber shall pass through a high-efficiency filter before release to the room.

l. When sodium chloride aerosol is used, the relative humidity inside the test chamber shall not exceed 50 percent.

##### 4. Procedural Requirements.

a. The fitting of half-mask respirators should be started with those having multiple sizes and a variety of interchangeable cartridges and canisters such as the MSA Comfo II-M, Norton M, Survivair M, A-O M, or Scott-M. Use either of the tests outlined below to assure that the facepiece is properly adjusted.

(1) *Positive pressure test.* With the exhaust port(s) blocked, the negative pressure of slight inhalation should remain constant for several seconds.

(2) *Negative pressure test.* With the intake port(s) blocked, the negative pressure slight inhalation should remain constant for several seconds.

b. After a facepiece is adjusted, the test subject shall wear the facepiece for at least 5 minutes before conducting a qualitative test by using either of the methods described below and using the exercise regime described in 5.a., b., c., d., and e.

(1) *Isoamyl acetate test.* When using organic vapor cartridges, the test subject who can smell the odor should be unable to detect the odor of isoamyl acetate squirted into the air near the most vulnerable portions of the facepiece seal. In a location which is separated from the test area, the test subject shall be instructed to close her/his eyes

during the test period. A combination cartridge or canister with organic vapor and high-efficiency filters shall be used when available for the particular mask being tested. The test subject shall be given an opportunity to smell the odor of isoamyl acetate before the test is conducted.

(2) *Irritant fume test.* When using high-efficiency filters, the test subject should be unable to detect the odor of irritant fume (stannic chloride or titanium tetrachloride ventilation smoke tubes) squirted into the air near the most vulnerable portions of the facepiece seal. The test subject shall be instructed to close her/his eyes during the test period.

c. The test subject may enter the quantitative testing chamber only if she or he has obtained a satisfactory fit as stated in 4.b. of this Appendix.

d. Before the subject enters the test chamber, a reasonably stable challenge agent concentration shall be measured in the test chamber.

e. Immediately after the subject enters the test chamber, the challenge agent concentration inside the respirator shall be measured to ensure that the peak penetration does not exceed 5 percent for a half-mask and 1 percent for a full facepiece.

f. A stable challenge agent concentration shall be obtained prior to the actual start of testing.

(1) *Respirator restraining straps may not be overtightened for testing.* The straps shall be adjusted by the wearer to give a reasonably comfortable fit typical of normal use.

8. *Exercise Regime.* Prior to entering the test chamber, the test subject shall be given complete instructions as to her/his part in the test procedures. The test subject shall perform the following exercises, in the order given, for each independent test.

a. *Normal Breathing (NB).* In the normal standing position, without talking, the subject shall breathe normally for at least one minute.

b. *Deep Breathing (DB).* In the normal standing position the subject shall do deep breathing for at least one minute pausing so as not to hyperventilate.

c. *Turning head side to side (SS).* Standing in place the subject shall slowly turn his/her head from side between the extreme positions to each side. The head shall be held at each extreme position for at least 5 seconds. Perform for at least three complete cycles.

d. *Moving head up and down (UD).* Standing in place, the subject shall slowly move his/her head up and down between the extreme position straight up and the extreme position straight down. The head shall be held at each extreme position for at least 5 seconds. Perform for at least three complete cycles.

e. *Reading (R).* The subject shall read out slowly and loud so as to be heard clearly by the test conductor or monitor. The test subject shall read the "rainbow passage" at the end of this section.

f. *Grimace (G).* The test subject shall grimace, smile, frown, and generally contort the face using the facial muscles. Continue for at least 15 seconds.

g. *Bend over and touch toes (B)*. The test subject shall bend at the waist and touch toes and return to upright position. Repeat for at least 30 seconds.

h. *Jogging in place (J)*. The test subject shall perform jog in place for at least 30 seconds.

i. *Normal Breathing (NB)*. Same as exercise a.

#### *Rainbow Passage*

When the sunlight strikes raindrops in the air, they act like a prism and form a rainbow. The rainbow is a division of white light into many beautiful colors. These take the shape of a long round arch, with its path high above, and its two ends apparently beyond the horizon. There is, according to legend, a boiling pot of gold at one end. People look, but no one ever finds it. When a man looks for something beyond reach, his friends say he is looking for the pot of gold at the end of the rainbow.

6. The test shall be terminated whenever any single peak penetration exceeds 5 percent for half-masks and 1 percent for full facepieces. The test subject may be refitted and retested. If two of the three required tests are terminated, the fit shall be deemed inadequate. (See paragraph 4.h.)

#### *7. Calculation of Fit Factors.*

a. The fit factor determined by the quantitative fit test equals the average concentration inside the respirator.

b. The average test chamber concentration is the arithmetic average of the test chamber concentration at the beginning and of the end of the test.

c. The average peak concentration of the challenge agent inside the respirator shall be the arithmetic average peak concentrations for each of the nine exercises of the test which are computed as the arithmetic average of the peak concentrations found for each breath during the exercise.

d. The average peak concentration for an exercise may be determined graphically if there is not a great variation in the peak concentrations during a single exercise.

8. *Interpretation of Test Results.* The fit factor measured by the quantitative fit testing shall be the lowest of the three protection factors resulting from three independent tests.

#### *9. Other Requirements*

a. The test subject shall not be permitted to wear a half-mask or full facepiece mask if the minimum fit factor of 100 or 1,000, respectively, cannot be obtained. If hair growth or apparel interferes with a satisfactory fit, then they shall be altered or removed so as to eliminate interference and allow a satisfactory fit. If a satisfactory fit is still not attained, the test subject must use a positive-pressure respirator such as powered air-purifying respirators, supplied air respirator, or self-contained breathing apparatus.

b. The test shall not be conducted if there is any hair growth between the skin and the facepiece sealing surface.

c. If a test subject exhibits difficulty in breathing during the tests, she or he shall be referred to a physician trained in respirator diseases or pulmonary medicine to determine whether the test subject can wear a respirator while performing her or his duties.

d. The test subject shall be given the opportunity to wear the assigned respirator for one week. If the respirator does not provide a satisfactory fit during actual use, the test subject may request another ONFI which shall be performed immediately.

e. A respirator fit factor card shall be issued to the test subject with the following information:

- (1) Name.
- (2) Date of fit test.
- (3) Protection factors obtained through each manufacturer, model and approval number of respirator tested.
- (4) Name and signature of the person that conducted the test.

f. Filters used for qualitative or quantitative fit testing shall be replaced weekly, whenever increased breathing resistance is encountered, or when the test agent has altered the integrity of the filter media.

Organic vapor cartridges/canisters shall be replaced daily or sooner if there is any indication of breakthrough by the test agent.

10. In addition, because the sealing of the respirator may be affected, quantitative fit testing shall be repeated immediately when the test subject has a:

- (1) Weight change of 20 pounds or more.
- (2) Significant facial scarring in the area of the facepiece seal.
- (3) Significant dental changes, i.e., multiple extractions without prosthesis, or acquiring dentures.
- (4) Reconstructive or cosmetic surgery, or
- (5) Any other condition that may interfere with facepiece sealing.

#### *11. Recordkeeping.*

A summary of all test results shall be maintained in for 3 years. The summary shall include:

- (1) Name of test subject.
- (2) Date of testing.
- (3) Name of the test conductor.
- (4) Fit factors obtained from every respirator tested (indicate manufacturer, model, size and approval number).

#### **Appendix D to § 1910.1001—Medical Questionnaires: Mandatory**

This mandatory appendix contains the medical questionnaires that must be administered to all employees who are exposed to asbestos, tremolite, anthophyllite, actinolite, or a combination of these minerals above the action level, and who will therefore be included in their employer's medical surveillance program. Part 1 of the appendix contains the Initial Medical Questionnaire, which must be obtained for all new hires who will be covered by the medical surveillance requirements. Part 2 includes the abbreviated Periodical Medical Questionnaire, which must be administered to all employees who are provided periodic medical examinations under the medical surveillance provisions of the standard.

BILLING CODE 4510-26-48

PART 1  
INITIAL MEDICAL QUESTIONNAIRE

1. NAME \_\_\_\_\_  
 2. SOCIAL SECURITY # 1 2 3 4 5 6 7 8 9  
 3. CLOCK NUMBER 15 16 17 18 19 20 21  
 4. PRESENT OCCUPATION \_\_\_\_\_  
 5. PLANT \_\_\_\_\_  
 6. ADDRESS \_\_\_\_\_  
 7. \_\_\_\_\_ (Zip Code)

8. TELEPHONE NUMBER \_\_\_\_\_  
 9. INTERVIEWS \_\_\_\_\_  
 10. DATE 16 17 18 19 20 21  
 11. Date of Birth Month 22 Day 23 Year 24 25 26 27  
 12. Place of Birth \_\_\_\_\_

13. SEX  
 1. Male \_\_\_\_\_  
 2. Female \_\_\_\_\_  
 14. What is your marital status?  
 1. Single \_\_\_\_\_ 4. Separated/Divorced \_\_\_\_\_  
 2. Married \_\_\_\_\_  
 3. Widowed \_\_\_\_\_

15. Race  
 1. White \_\_\_\_\_ 4. Hispanic \_\_\_\_\_  
 2. Black \_\_\_\_\_ 5. Indian \_\_\_\_\_  
 3. Asian \_\_\_\_\_ 6. Other \_\_\_\_\_  
 16. What is the highest grade completed in school?  
 (For example 12 years in completion of high school)

OCCUPATIONAL HISTORY  
 17A. Have you ever worked full time (30 hours per week or more) for 6 months or more?  
 IF YES TO 17A:  
 B. Have you ever worked for a year or more in any dusty job?  
 1. Yes \_\_\_\_\_ 2. No \_\_\_\_\_  
 3. Does Not Apply \_\_\_\_\_

Specify job/industry \_\_\_\_\_ Total Years worked \_\_\_\_\_  
 Has dust exposure: 1. Mild \_\_\_\_\_ 2. Moderate \_\_\_\_\_ 3. Severe \_\_\_\_\_  
 C. Have you ever been exposed to gas or chemical fumes in your work?  
 Specify job/industry \_\_\_\_\_ Total Years worked \_\_\_\_\_  
 Was exposed: 1. Mild \_\_\_\_\_ 2. Moderate \_\_\_\_\_ 3. Severe \_\_\_\_\_  
 D. What has been your usual occupation or job--the one you have worked at the longest?  
 1. Job occupation \_\_\_\_\_  
 2. Number of years employed in this occupation \_\_\_\_\_  
 3. Position/job title \_\_\_\_\_  
 4. Business, field or industry \_\_\_\_\_

(Record on lines the years in which you have worked in any of these industries, e.g. 1960-1965)  
 Have you ever worked:  
 E. In a mine? \_\_\_\_\_ YES \_\_\_\_\_ NO \_\_\_\_\_  
 F. In a quarry? \_\_\_\_\_ YES \_\_\_\_\_ NO \_\_\_\_\_  
 G. In a foundry? \_\_\_\_\_ YES \_\_\_\_\_ NO \_\_\_\_\_  
 H. In a pottery? \_\_\_\_\_ YES \_\_\_\_\_ NO \_\_\_\_\_  
 I. In a cotton, flax or hemp mill? \_\_\_\_\_ YES \_\_\_\_\_ NO \_\_\_\_\_  
 J. With asbestos? \_\_\_\_\_ YES \_\_\_\_\_ NO \_\_\_\_\_

18. PAST MEDICAL HISTORY  
 A. Do you consider yourself to be in good health?  
 If "NO" state reason \_\_\_\_\_ YES \_\_\_\_\_ NO \_\_\_\_\_  
 B. Have you any defect of vision? \_\_\_\_\_ YES \_\_\_\_\_ NO \_\_\_\_\_  
 If "YES" state nature of defect \_\_\_\_\_  
 C. Have you any hearing defect? \_\_\_\_\_ YES \_\_\_\_\_ NO \_\_\_\_\_  
 If "YES" state nature of defect \_\_\_\_\_

- 1. Yes  2. No
- 1. Yes  2. No
- 3. Does Not Apply
- Age in Years
- Does Not Apply
- 1. Yes  2. No

3A. May Paesct  
 IF YES TO 3A:  
 B. Was it confirmed by a doctor?  
 C. At what age did it start?  
 23A. Have you ever had chronic bronchitis?  
 IF YES TO 23A:  
 B. Do you still have it?

- a. Epilepsy (or fits, seizures, convulsions)?
- b. Rheumatic fever?
- c. Kidney disease?
- d. Bladder disease?
- e. Diabetes?
- f. Janadice?

- 1. Yes  2. No
- 3. Does Not Apply
- 1. Yes  2. No
- 3. Does Not Apply
- Age in Years
- Does Not Apply
- 1. Yes  2. No

23A. Have you ever had chronic bronchitis?  
 IF YES TO 23A:  
 B. Do you still have it?  
 C. Was it confirmed by a doctor?  
 D. At what age did it start?  
 24A. Have you ever had emphysema?  
 IF YES TO 24A:  
 B. Do you still have it?

19. CHEST, COAGS AND CHEST ILLNESSES  
 19A. If you get a cold, does it usually go to your chest? (Usually means more than 1/3 the time)  
 1. Yes  2. No   
 3. Don't get colds   
 20A. During the past 3 years, have you had any chest illnesses that have kept you off work, indoors at home, or in bed?  
 1. Yes  2. No

- 1. Yes  2. No
- 3. Does Not Apply
- 1. Yes  2. No
- 3. Does Not Apply
- Age in Years
- Does Not Apply
- 1. Yes  2. No

24A. Have you ever had emphysema?  
 IF YES TO 24A:  
 B. Do you still have it?  
 C. Was it confirmed by a doctor?  
 D. At what age did it start?  
 25A. Have you ever had asthma?  
 IF YES TO 25A:  
 B. Do you still have it?

20. Did you produce phlegm with any of these chest illnesses?  
 1. Yes  2. No   
 3. Does Not Apply   
 C. In the last 3 years, how many such illnesses with (increased) phlegm did you have which lasted a week or more?  
 Number of illnesses   
 No such illnesses   
 21. Did you have any lung trouble before the age of 16?  
 1. Yes  2. No

- 1. Yes  2. No
- 3. Does Not Apply
- 1. Yes  2. No
- 3. Does Not Apply
- Age in Years
- Does Not Apply
- 1. Yes  2. No

25A. Have you ever had asthma?  
 IF YES TO 25A:  
 B. Do you still have it?  
 C. Was it confirmed by a doctor?  
 D. At what age did it start?  
 E. If you no longer have it, at what age did it stop?

22. Have you ever had any of the following?  
 1A. Attacks of bronchitis?  
 IF YES TO 1A:  
 B. Was it confirmed by a doctor?  
 C. At what age was your first attack?  
 2A. Pneumonia (include bronchopneumonia)?  
 IF YES TO 2A:  
 B. Was it confirmed by a doctor?  
 C. At what age did you first have it?

- 1. Yes  2. No
- 3. Does Not Apply
- 1. Yes  2. No
- 3. Does Not Apply
- Age in Years
- Does Not Apply
- Age stopped
- Does Not Apply
- 1. Yes  2. No

26. Have you ever had:  
 A. Any other chest illnesses?  
 If yes, please specify \_\_\_\_\_

- 1. Yes  2. No
- 3. Does Not Apply
- Age in Years
- Does Not Apply
- 1. Yes  2. No
- 3. Does Not Apply
- Age in Years
- Does Not Apply

H. Please specify cause of death \_\_\_\_\_

**COUGH**

32A. Do you usually have a cough? (Count a cough with first smoke or on first going out of doors. Exclude clearing of throat.) (If no, skip to question 32C.)

1. Yes — 2. No —

32B. Do you usually cough as much as 4 to 4 times a day 4 or more days out of the week?

1. Yes — 2. No —

32C. Do you usually cough at all on getting up or first thing in the morning?

1. Yes — 2. No —

32D. Do you usually cough at all during the rest of the day or at night?

1. Yes — 2. No —

IF YES TO ANY OF ABOVE (32A, B, C, or D), ANSWER THE FOLLOWING. IF NO TO ALL, CHECK SOME BOX ABOVE AND SKIP TO NEXT PAGE

32E. Do you usually cough like this on most days for 3 consecutive months or more during the year?

1. Yes — 2. No —  
3. Does not apply —

32F. For how many years have you had the cough?

Number of years  
Does not apply —

1. Yes — 2. No —

32A. Do you usually bring up phlegm from your chest? (Count phlegm with the first smoke or on first going out of doors. Exclude phlegm from the nose. Count swallowed phlegm.) (If no, skip to 32C)

1. Yes — 2. No —

32B. Do you usually bring up phlegm like this as much as twice a day 4 or more days out of the week?

1. Yes — 2. No —

32C. Do you usually bring up phlegm at all on getting up or first thing in the morning?

1. Yes — 2. No —

32D. Do you usually bring up phlegm at all during the rest of the day or at night?

1. Yes — 2. No —

IF YES TO ANY OF THE ABOVE (32A, B, C, or D), ANSWER THE FOLLOWING:  
IF NO TO ALL, CHECK SOME BOX ABOVE AND SKIP TO 34A.

32E. Do you bring up phlegm like this on most days for 3 consecutive months or more during the year?

1. Yes — 2. No —  
3. Does not apply —

B. Any chest operations? \_\_\_\_\_

IF yes, please specify \_\_\_\_\_

1. Yes — 2. No —

C. Any chest injuries? \_\_\_\_\_

IF yes, please specify \_\_\_\_\_

1. Yes — 2. No —

37A. Has a doctor ever told you that you had heart trouble?

1. Yes — 2. No —

IF YES TO 37A:

37B. Have you ever had treatment for heart trouble in the past 10 years?

1. Yes — 2. No —  
3. Does Not Apply —

38A. Has a doctor ever told you that you had high blood pressure?

1. Yes — 2. No —

IF YES TO 38A:

38B. Have you had any treatment for high blood pressure (hypertension) in the past 10 years?

1. Yes — 2. No —  
3. Does Not Apply —

39. When did you last have your chest X-rayed? (Year) 25 26 27 28

30. Where did you last have your chest X-rayed. (If known)? \_\_\_\_\_

What was the outcome? \_\_\_\_\_

**FAMILY HISTORY**

31. Were either of your maternal parents ever told by a doctor that they had a chronic lung condition such as:

FATHER MOTHER

1. Yes 2. No 3. Don't Know 1. Yes 2. No 3. Don't Know

A. Chronic Bronchitis? — — — — —

B. Emphysema? — — — — —

C. Asthma? — — — — —

D. Lung cancer? — — — — —

E. Other chest conditions? — — — — —

F. Is parent currently alive?

Age if Living — — — — —  
Age at Death — — — — —  
Don't know — — — — —

G. Please Specify

Age if Living — — — — —  
Age at Death — — — — —  
Don't know — — — — —

F. For how many years have you had trouble with phlegm?

Number of years  
Does not apply

**EPISODES OF COUGH AND PHLEGM**

34A. Have you had periods of episodes of (increased) cough and phlegm lasting for 3 weeks or more each year?  
\*If 2 persons who usually have cough and/or phlegm

1. Yes — 2. No —

IF YES TO 34A

B. For how long have you had at least 3 such episodes per year?

Number of years  
Does not apply

**WHIZZING**

34A. Does your chest ever sound wheezy or whistling

- 1. When you have a cold?
- 2. Occasionally apart from colds?
- 3. Most days or nights?

1. Yes — 2. No —  
 1. Yes — 2. No —  
 1. Yes — 2. No —

IF YES TO 1, 2, or 3 in 34A

B. For how many years has this been present?

Number of years  
Does not apply  
1. Yes — 2. No —

34A. Have you ever had an attack of wheezing that has made you feel short of breath?

IF YES TO 34A

B. How old were you when you had your first such attack?

Age in years  
Does not apply

C. Have you had 2 or more such episodes?

1. Yes — 2. No —  
1. Does not apply

D. Have you ever required medicine or treatment for (b)ise) attack(s)?

1. Yes — 2. No —  
1. Does not apply

**BREATHLESSNESS**

37. If disabled from walking by any condition other than heart or lung disease, please describe and proceed to question 37A. Nature of condition(s)

38A. Are you troubled by shortness of breath when hurrying on the level or walking up a slight hill?

1. Yes — 2. No —

**IF YES TO 38A**

B. Do you have to walk slower than people of your age on the level because of breathlessness?

1. Yes — 2. No —  
1. Does not apply

C. Do you ever have to stop for breath when walking at your own pace on the level?

1. Yes — 2. No —  
1. Does not apply

D. Do you ever have to stop for breath after walking about 100 yards (or after a few minutes) on the level?

1. Yes — 2. No —  
1. Does not apply

F. Are you too breathless to leave the house or breathe on stairs or climbing one flight of stairs?

1. Yes — 2. No —  
1. Does not apply

**TOBACCO SMOKING**

39A. Have you ever smoked cigarettes? (No means less than 20 packs of cigarettes or 12 oz. of tobacco in a lifetime or less than 1 cigarette a day for 1 year.)

1. Yes — 2. No —

**IF YES TO 39A**

B. Do you now smoke cigarettes (as of one month ago)?

1. Yes — 2. No —  
1. Does not apply

C. How old were you when you first started regular cigarette smoking?

Age in years  
Does not apply

D. If you have stopped smoking cigarettes completely, how old were you when you stopped?

Age stopped  
Check if still smoking  
Does not apply

E. How many cigarettes do you smoke per day now?

Cigarettes per day  
Does not apply

F. On the average of the entire time you smoked, how many cigarettes did you smoke per day?

Cigarettes per day  
Does not apply

G. Do or did you inhale the cigarette smoke?

1. Does not apply  
2. Not at all  
3. Slightly  
4. Moderately  
5. Deeply

40A. Have you ever smoked a pipe regularly? (Yes means more than 12 oz. of tobacco in a lifetime.)

1. Yes — 2. No —

Part 2  
PERIODIC MEDICAL QUESTIONNAIRE

- IF YES TO 40A:**  
**FOR PERSONS WHO HAVE EVER SMOKED A PIPE**
- B. 1. How old were you when you started to smoke a pipe regularly?  
2. If you have stopped smoking a pipe completely, how old were you when you stopped?
- C. On the average over the entire time you smoked a pipe, how much pipe tobacco did you smoke per week?
- D. How much pipe tobacco are you smoking now?
- E. Do you or did you inhale the pipe smoke?
- 41A. Have you ever smoked cigars regularly? (Yes means more than 1 cigar a week for a year)

- IF YES TO 41A:**  
**FOR PERSONS WHO HAVE EVER SMOKED CIGARS**
- B. 1. How old were you when you started smoking cigars regularly?  
2. If you have stopped smoking cigars completely, how old were you when you stopped?
- C. On the average over the entire time you smoked cigars, how many cigars did you smoke per week?
- D. How many cigars are you smoking per week now?
- E. Do or did you inhale the cigar smoke?

1. NAME \_\_\_\_\_

2. SOCIAL SECURITY # 1-2-3-4-5-6-7-8-9-0 \_\_\_\_\_

3. CLOCK NUMBER 10-11-12-13-14-15 \_\_\_\_\_

4. PREVIOUS OCCUPATION \_\_\_\_\_

5. PLANT \_\_\_\_\_

6. ADDRESS \_\_\_\_\_

7. \_\_\_\_\_ (Zip Code)

8. TELEPHONE NUMBER \_\_\_\_\_

9. INTERVIEWER \_\_\_\_\_

10. DATE 16-17-18-19-20-21 \_\_\_\_\_

11. What is your marital status?  
1. Single \_\_\_\_\_ 6. Separated/Divorced \_\_\_\_\_  
2. Married \_\_\_\_\_  
3. Widowed \_\_\_\_\_

12. OCCUPATIONAL HISTORY

12A. In the past year, did you work (all time (10 hours per week or more) for 6 months or more)?  
IF YES TO 12A:  
1. Yes \_\_\_\_\_ 2. No \_\_\_\_\_

12B. In the past year, did you work in a dusty job?  
IF YES TO 12B:  
1. Yes \_\_\_\_\_ 2. No \_\_\_\_\_  
3. Does Not Apply \_\_\_\_\_

12C. Was dust exposure:  
1. Mild \_\_\_\_\_ 2. Moderate \_\_\_\_\_ 3. Severe \_\_\_\_\_

12D. In the past year, were you exposed to use of chemical fumes in your work?  
1. Yes \_\_\_\_\_ 2. No \_\_\_\_\_

12E. Was exposure:  
1. Mild \_\_\_\_\_ 2. Moderate \_\_\_\_\_ 3. Severe \_\_\_\_\_

12F. In the past year, what was your:  
1. Job/occupation? \_\_\_\_\_  
2. Position/job title? \_\_\_\_\_

Age \_\_\_\_\_

Age stopped smoking pipe  
Check if still smoking pipe  
Does not apply \_\_\_\_\_

— or, per week (a standard pouch of tobacco contains 1 1/2 oz.)  
— Does not apply \_\_\_\_\_

oz. per week  
Not currently smoking a pipe \_\_\_\_\_

1. Never smoked \_\_\_\_\_  
2. Not at all \_\_\_\_\_  
3. Slightly \_\_\_\_\_  
4. Moderately \_\_\_\_\_  
5. Deeply \_\_\_\_\_

1. Yes \_\_\_\_\_ 2. No \_\_\_\_\_

Age \_\_\_\_\_

Age stopped smoking cigars  
Check if still smoking cigars  
Does not apply \_\_\_\_\_

Cigars per week  
Does not apply \_\_\_\_\_

Cigars per week  
Check if not currently smoking cigars \_\_\_\_\_

1. Never smoked \_\_\_\_\_  
2. Not at all \_\_\_\_\_  
3. Slightly \_\_\_\_\_  
4. Moderately \_\_\_\_\_  
5. Deeply \_\_\_\_\_

Signature \_\_\_\_\_ Date \_\_\_\_\_

11. RECENT MEDICAL HISTORY

11A. Do you consider yourself to be in good health? Yes \_\_\_ No \_\_\_

If NO, state reason: \_\_\_\_\_

11B. In the past year, have you developed:

- Epilepsy? Yes \_\_\_ No \_\_\_
- Rheumatic fever? Yes \_\_\_ No \_\_\_
- Kidney disease? Yes \_\_\_ No \_\_\_
- Stomach disease? Yes \_\_\_ No \_\_\_
- Diabetes? Yes \_\_\_ No \_\_\_
- Jaundice? Yes \_\_\_ No \_\_\_
- Cancer? Yes \_\_\_ No \_\_\_

14. CHEST COUGS AND CHEST ILLNESSES

14A. If you get a cold, does it usually go to your chest? (Usually means more than 1/3 the time) 1. Yes \_\_\_ 2. No \_\_\_ 3. Don't get colds \_\_\_

14B. During the past year, have you had any chest illnesses that have kept you off work, indoors at home, or in bed? 1. Yes \_\_\_ 2. No \_\_\_ 3. Does Not Apply \_\_\_

IF YES TO 14B:

14B. Did you produce phlegm with any of these chest illnesses? 1. Yes \_\_\_ 2. No \_\_\_ 3. Does Not Apply \_\_\_

14C. In the past year, how many such illnesses with (increased) phlegm did you have which lasted a week or more? Number of illnesses: \_\_\_ No such illnesses: \_\_\_

16. RESPIRATORY SYSTEM

In the past year have you had:

- 16A. Asthma Yes \_\_\_ No \_\_\_ Further Comment on Positive Answer: \_\_\_\_\_
- 16B. Bronchitis Yes \_\_\_ No \_\_\_
- 16C. Hay Fever Yes \_\_\_ No \_\_\_
- 16D. Other Allergies Yes \_\_\_ No \_\_\_

Yes or No Further Comment on Positive Answer

- Pneumonia
- Tuberculosis
- Chest Surgery
- Other Lung Problems
- Heart Disease

Do you have:

Yes or No Further Comment on Positive Answer

- Frequent colds
- Chronic cough
- Shortness of breath when walking or climbing one flight or stairs

Do you:

- Whistle
- Cough up phlegm
- Smoke cigarettes

Packs per day \_\_\_ How many years \_\_\_

Date \_\_\_\_\_

Signature \_\_\_\_\_

#### Appendix E to § 1910.1001—Interpretation and Classification of Chest Roentgenograms—Mandatory

(a) Chest roentgenograms shall be interpreted and classified in accordance with a professionally accepted classification system and recorded on a Roentgenographic Interpretation Form, \*Form CSD/NIOSH (M) 2.8.

(b) Roentgenograms shall be interpreted and classified only by a B-reader, a board eligible/certified radiologist, or an experienced physician with known expertise in pneumoconioses.

(c) All interpreters, whenever interpreting chest roentgenograms made under this section, shall have immediately available for reference a complete set of the ILO-U/C International Classification of Radiographs for Pneumoconioses, 1960.

#### Appendix F to § 1910.1001—Work Practices and Engineering Controls for Automotive Brake Repair Operations—Non-Mandatory

This appendix is intended as guidance for employers in the automotive brake and clutch repair industry who wish to reduce their employees' asbestos exposures during repair operations to levels below the new standard's action level (0.1 f/cc). OSHA believes that employers in this industry sector are likely to be able to reduce their employees' exposures to asbestos by employing the engineering and work practice controls described in Sections A and B of this appendix. Those employers who choose to use these controls and who achieve exposures below the action level will thus be able to avoid any burden that might be imposed by complying with such requirements as medical surveillance, recordkeeping, training, respiratory protection, and regulated areas, which are triggered when employee exposures exceed the action level or PEL.

Asbestos exposure in the automotive brake and clutch repair industry occurs primarily during the replacement of clutch plates and brake pads, shoes, and linings. Asbestos fibers may become airborne when an automotive mechanic removes the asbestos-containing residue that has been deposited as brakes and clutches wear. Employee exposures to asbestos occur during the cleaning of the brake drum or clutch housing.

Based on evidence in the rulemaking record (Exs. 84-74, 84-263, 90-148), OSHA believes that employers engaged in brake repair operations who implement any of the work practices and engineering controls described in Sections A and B of this appendix may be able to reduce their employees' exposures to levels below the action level (0.1 fiber/cc). These control methods and the relevant record evidence on these and other methods are described in the following sections.

#### A. Enclosed Cylinder/HEPA Vacuum System Method

The enclosed cylinder-vacuum system used in one of the facilities visited by representatives of the National Institute for Occupational Safety and Health (NIOSH) during a health hazard evaluation of brake repair facilities (Ex. 84-263) consists of three components:

- (1) A wheel-shaped cylinder designed to cover and enclose the wheel assembly;
- (2) A compressed-air hose and nozzle that fits into a port in the cylinder; and
- (3) A HEPA-filtered vacuum used to evacuate airborne dust generated within the cylinder by the compressed air.

To operate the system, the brake assembly is enclosed in a cylinder that has viewing ports to provide visibility and cotton sleeves through which the mechanic can handle the brake assembly parts. The cylinder effectively isolates asbestos dust in the drum from the mechanic's breathing zone. The brake assembly isolation cylinder is available from the Nilflak Company<sup>1</sup> and comes in two sizes to fit brake drums in the 7-to-12-inch size range common to automobiles and light trucks and the 12-to-19-inch size range common to large commercial vehicles. The cylinder is equipped with built-in compressed-air guns and a connection for a vacuum cleaner equipped with a High Efficiency Particulate Air (HEPA) filter. This type of filter is capable of removing all particles greater than 0.3 microns from the air. When the vacuum cleaner's filter is full, it must be replaced according to the manufacturer's instruction, and appropriate HEPA-filtered dual cartridge respirators should be worn during the process. The filter of the vacuum cleaner is assumed to be contaminated with asbestos fibers and should be handled carefully, wetted with a fine mist of water, placed immediately in a labelled plastic bag, and disposed of properly. When the cylinder is in place around the brake assembly and the HEPA vacuum is connected, compressed air is blown into the cylinder to loosen the residue from the brake assembly parts. The vacuum then evacuates the loosened material from within the cylinder, capturing the airborne material on the HEPA filter.

The HEPA vacuum system can be disconnected from the brake assembly isolation cylinder when the cylinder is not being used. The HEPA vacuum can then be used for clutch facing work, grinding, or other routine cleaning.

#### B. Compressed Air/Solvent System Method

A compressed-air hose fitted at the end with a bottle of solvent can be used to loosen the asbestos-containing residue and to capture the resulting airborne particles in the solvent mist. The mechanic should begin spraying the asbestos-contaminated parts with the solvent at a sufficient distance to ensure that the asbestos particles are not dislodged by the velocity of the solvent spray. After the asbestos particles are thoroughly wetted, the spray may be brought closer to the parts and the parts may be sprayed as necessary to remove grease and other material. The automotive parts sprayed with the mist are then wiped with a rag, which must then be disposed of appropriately. Rags should be placed in a labelled plastic bag or other container while they are still wet. This ensures that the asbestos fibers will not become airborne

<sup>1</sup> Mention of trademarks or commercial products does not constitute endorsement or recommendation for use.

after the brake and clutch parts have been cleaned. (If cleanup rags are laundered rather than disposed of, they must be washed using methods appropriate for the laundering of asbestos-contaminated materials.)

OSHA believes that a variant of this compressed-air/solvent mist process offers advantages over the compressed-air/solvent mist technique discussed above, both in terms of costs and employee protection. The variant involves the use of spray cans filled with any of several solvent cleaners commercially available from auto supply stores. Spray cans of solvent are inexpensive, readily available, and easy to use. These cans will also save time, because no solvent delivery system has to be assembled, i.e., no compressed-air hose/mister ensemble. OSHA believes that a spray can will deliver solvent to the parts to be cleaned with considerably less force than the alternative compressed-air delivery system described above, and will thus generate fewer airborne asbestos fibers than the compressed-air method. The Agency therefore believes that the exposure levels of automotive repair mechanics using the spray can/solvent mist process will be even lower than the exposures reported by NIOSH (Ex. 84-263) for the compressed-air/solvent mist system (0.08 f/cc).

#### C. Information on the Effectiveness of Various Control Measures

The amount of airborne asbestos generated during brake and clutch repair operations depends on the work practices and engineering controls used during the repair or removal activity. Data in the rulemaking record document the 8-hour time-weighted average (TWA<sub>8</sub>) asbestos exposure levels associated with various methods of brake and clutch repair and removal.

NIOSH submitted a report to the record entitled "Health Hazard Evaluation for Automotive Brake Repair" (Ex. 84-263). In addition, Exhibits 84-74 and 90-148 provided exposure data for comparing the airborne concentrations of asbestos generated by the use of various work practices during brake repair operations. These reports present exposure data for brake repair operations involving a variety of controls and work practices, including:

- Use of compressed air to blow out the brake drums;
- Use of a brush, without a wetting agent, to remove the asbestos-containing residue;
- Use of a brush dipped in water or a solvent to remove the asbestos-containing residue;
- Use of an enclosed vacuum cleaning system to capture the asbestos-containing residue; and
- Use of a solvent mixture applied with compressed air to remove the residue.

#### Prohibited Methods

The use of compressed air to blow the asbestos-containing residue off the surface of the brake drum removes the residue effectively but simultaneously produces an airborne cloud of asbestos fibers. According to NIOSH (Ex. 84-263), the peak exposures of mechanics using this technique were as high as 15 fibers/cc, and 8-hour TWA exposures ranged from 0.03 to 0.19 f/cc.

Dr. William J. Nicholson of the Mount Sinai School of Medicine (Ex. 84-74) cited data from Knight and Hickish (1970) that indicated that the concentration of asbestos ranged from 0.84 to 5.35 f/cc over a 60-minute sampling period when compressed air was being used to blow out the asbestos-containing residue from the brake drum. In the same study, a peak concentration of 87 f/cc was measured for a few seconds during brake cleaning performed with compressed air. Rohl et al. (1976) (Ex. 90-148) measured area concentrations (of unspecified duration) within 3-5 feet of operations involving the cleaning of brakes with compressed air and obtained readings ranging from 6.6 to 28.8 f/cc. Because of the high exposure levels that result from cleaning brake and clutch parts using compressed air, OSHA has prohibited this practice in the revised standard.

#### Ineffective Methods

When dry brushing was used to remove the asbestos-containing residue from the brake drums and wheel assemblies, peak exposures measured by NIOSH ranged from 0.61 to 0.61 f/cc, while 8-hour TWA levels were at the new standard's permissible exposure limit (PEL) of 0.2 f/cc (Ex. 84-263). Rohl and his colleagues (Ex. 90-148) collected area samples 1-3 feet from a brake cleaning operation being performed with a dry brush, and measured concentrations ranging from 1.3 to 3.6 f/cc; however, sampling times and TWA concentrations were not presented in the Rohl et al. study.

When a brush wetted with water, gasoline, or Stoddart solvent was used to clean the asbestos-containing residue from the affected parts, exposure levels (8-hour TWAs) measured by NIOSH also exceeded the new 0.2 f/cc PEL, and peak exposures ranged as high as 2.62 f/cc (Ex. 84-263).

#### Preferred Methods

Use of an engineering control system involving a cylinder that completely encloses the brake shoe assembly and a High Efficiency Particulate Air (HEPA) filter-equipped vacuum produced 8-hour TWA employee exposures of 0.01 f/cc and peak exposures ranging from nondetectable to 0.07 f/cc (Ex. 84-263). (Because this system achieved exposure levels below the standard's action level, it is described in detail below.) Data collected by the Mount Sinai Medical Center (Ex. 90-148) for Nilfisk of America, Inc., the manufacturer of the brake assembly enclosure system, showed that for two of three operations sampled, the exposure of mechanics to airborne asbestos fibers was nondetectable. For the third operator sampled by Mt. Sinai researchers, the exposure was 0.5 f/cc, which the authors attributed to asbestos that had contaminated the operator's clothing in the course of previous brake repair operations performed without the enclosed cylinder/vacuum system.

Some automotive repair facilities use a compressed-air hose to apply a solvent mist to remove the asbestos-containing residue from the brake drums before repair. The NIOSH data (Ex. 84-263) indicated that mechanics employing this method experienced exposures (8-hour TWAs) of 0.8

f/cc, with peaks of 0.25 to 0.66 f/cc. This technique, and a variant of it that OSHA believes is both less costly and more effective in reducing employee exposures, is described in greater detail above in Sections A and B.

#### D. Summary

In conclusion, OSHA believes that it is likely that employers in the brake and clutch repair industry will be able to avail themselves of the action level trigger built into the revised standard if they conscientiously employ one of the three control methods described above: the enclosed cylinder/HEPA vacuum system, the compressed air/solvent method, or the spray can/solvent mist system.

#### Appendix G to § 1910.1001—Substance Technical Information for Asbestos—Non-Mandatory

##### I. Substance Identification

A. Substance: "Asbestos" is the name of a class of magnesium-silicate minerals that occur in fibrous form. Minerals that are included in this group are chrysotile, crocidolite, amosite, tremolite asbestos, anthophyllite asbestos, and actinolite asbestos.

B. Asbestos, tremolite, anthophyllite, and actinolite are used in the manufacture of heat-resistant clothing, automotive brake and clutch linings, and a variety of building materials including floor tiles, roofing felts, ceiling tiles, asbestos-cement pipe and sheet, and fire-resistant drywall. Asbestos is also present in pipe and boiler insulation materials, and in sprayed-on materials located on beams, in crawlspaces, and between walls.

C. The potential for a product containing asbestos, tremolite, anthophyllite, and actinolite to release breathable fibers depends on its degree of friability. Friable means that the material can be crumbled with hand pressure and is therefore likely to emit fibers. The fibrous or fluffy sprayed-on materials used for fireproofing, insulation, or sound proofing are considered to be friable, and they readily release airborne fibers if disturbed. Materials such as vinyl-asbestos floor tile or roofing felts are considered nonfriable and generally do not emit airborne fibers unless subjected to sanding or sawing operations. Asbestos-cement pipe or sheet can emit airborne fibers if the materials are cut or sawed, or if they are broken during demolition operations.

D. Permissible exposure: Exposure to airborne asbestos, tremolite, anthophyllite, and actinolite fibers may not exceed 0.2 fibers per cubic centimeter of air (0.2 f/cc) averaged over the 8-hour workday.

##### II. Health Hazard Data

A. Asbestos, tremolite, anthophyllite, and actinolite can cause disabling respiratory disease and various types of cancers if the fibers are inhaled. Inhaling or ingesting fibers from contaminated clothing or skin can also result in these diseases. The symptoms of these diseases generally do not appear for 20 or more years after initial exposure.

B. Exposure to asbestos, tremolite, anthophyllite, and actinolite has been shown

to cause lung cancer, mesothelioma, and cancer of the stomach and colon. Mesothelioma is a rare cancer of the thin membrane lining of the chest and abdomen. Symptoms of mesothelioma include shortness of breath, pain in the walls of the chest, and/or abdominal pain.

##### III. Respirators and Protective Clothing

A. Respirators: You are required to wear a respirator when performing tasks that result in asbestos, tremolite, anthophyllite, and actinolite exposure that exceeds the permissible exposure limit (PEL) of 0.2 f/cc. These conditions can occur while your employer is in the process of installing engineering controls to reduce asbestos, tremolite, anthophyllite, and actinolite exposure, or where engineering controls are not feasible to reduce asbestos, tremolite, anthophyllite, and actinolite exposure. Air-purifying respirators equipped with a high-efficiency particulate air (HEPA) filter can be used where airborne asbestos, tremolite, anthophyllite, and actinolite fiber concentrations do not exceed 2 f/cc; otherwise, air-supplied, positive-pressure, full facepiece respirators must be used. Disposable respirators or dust masks are not permitted to be used for asbestos, tremolite, anthophyllite, and actinolite work. For effective protection, respirators must fit your face and head snugly. Your employer is required to conduct fit tests when you are first assigned a respirator and every 6 months thereafter. Respirators should not be loosened or removed in work situations where their use is required.

B. Protective Clothing: You are required to wear protective clothing in work areas where asbestos, tremolite, anthophyllite, and actinolite fiber concentrations exceed the permissible exposure limit (PEL) of 0.2 f/cc to prevent contamination of the skin. Where protective clothing is required, your employer must provide you with clean garments. Unless you are working on a large asbestos, tremolite, anthophyllite, and actinolite removal or demolition project, your employer must also provide a change room and separate lockers for your street clothes and contaminated work clothes. If you are working on a large asbestos, tremolite, anthophyllite, and actinolite removal or demolition project, and where it is feasible to do so, your employer must provide a clean room, shower, and decontamination room contiguous to the work area. When leaving the work area, you must remove contaminated clothing before proceeding to the shower. If the shower is not adjacent to the work area, you must vacuum your clothing before proceeding to the change room and shower. To prevent inhaling fibers in contaminated change rooms and showers, leave your respirator on until you leave the shower and enter the clean change room.

##### IV. Disposal Procedures and Cleanup

A. Wastes that are generated by processes where asbestos, tremolite, anthophyllite, and actinolite is present include:

1. Empty asbestos, tremolite, anthophyllite, and actinolite shipping containers.
2. Process wastes such as cuttings, trimmings, or reject material.

3. Housekeeping waste from sweeping or vacuuming.

4. Asbestos, tremolite, anthophyllite, and actinolite fireproofing or insulating material that is removed from buildings.

5. Building products that contain asbestos, tremolite, anthophyllite, and actinolite removed during building renovation or demolition.

6. Contaminated disposable protective clothing.

B. Empty shipping bags can be flattened under exhaust hoods and packed into airtight containers for disposal. Empty shipping drums are difficult to clean and should be sealed.

C. Vacuum logs or disposable paper filters should not be cleaned, but should be sprayed with a fine water mist and placed into a labeled waste container.

D. Process waste and housekeeping waste should be wetted with water or a mixture of water and surfactant prior to packaging in disposable containers.

E. Material containing asbestos, tremolite, anthophyllite, and actinolite that is removed from buildings must be disposed of in leak-tight 6-mil thick plastic bags, plastic-lined cardboard containers, or plastic-lined metal containers. These wastes, which are removed while wet, should be sealed in containers before they dry out to minimize the release of asbestos, tremolite, anthophyllite, and actinolite fibers during handling.

#### V. Access to Information

A. Each year, your employer is required to inform you of the information contained in this standard and appendices for asbestos, tremolite, anthophyllite, and actinolite. In addition, your employer must instruct you in the proper work practices for handling materials containing asbestos, tremolite, anthophyllite, and actinolite, and the correct use of protective equipment.

B. Your employer is required to determine whether you are being exposed to asbestos, tremolite, anthophyllite, and actinolite. You or your representative has the right to observe employee measurements and to record the results obtained. Your employer is required to inform you of your exposure, and, if you are exposed above the permissible limit, he or she is required to inform you of the actions that are being taken to reduce your exposure to within the permissible limit.

C. Your employer is required to keep records of your exposures and medical examinations. These exposure records must be kept for at least thirty (30) years. Medical records must be kept for the period of your employment plus thirty (30) years.

D. Your employer is required to release your exposure and medical records to your physician or designated representative upon your written request.

#### Appendix H to § 1910.1001—Medical Surveillance Guidelines for Asbestos Tremolite, Anthophyllite, and Actinolite Non-Mandatory

##### I. Route of Entry Inhalation, Ingestion

##### II. Toxicology

Clinical evidence of the adverse effects associated with exposure to asbestos, tremolite, anthophyllite, and actinolite, is

present in the form of several well-conducted epidemiological studies of occupationally exposed workers, family contacts of workers, and persons living near asbestos, tremolite, anthophyllite, and actinolite mines. These studies have shown a definite association between exposure to asbestos, tremolite, anthophyllite, and actinolite and an increased incidence of lung cancer, pleural and peritoneal mesothelioma, gastrointestinal cancer, and asbestosis. The latter is a disabling fibrotic lung disease that is caused only by exposure to asbestos. Exposure to asbestos, tremolite, anthophyllite, and actinolite has also been associated with an increased incidence of esophageal, kidney, laryngeal, pharyngeal, and buccal cavity cancers. As with other known chronic occupational diseases, disease associated with asbestos, tremolite, anthophyllite, and actinolite generally appears about 20 years following the first occurrence of exposure. There are no known acute effects associated with exposure to asbestos, tremolite, anthophyllite, and actinolite.

Epidemiological studies indicate that the risk of lung cancer among exposed workers who smoke cigarettes is greatly increased over the risk of lung cancer among non-exposed smokers or exposed nonsmokers. These studies suggest that cessation of smoking will reduce the risk of lung cancer for a person exposed to asbestos, tremolite, anthophyllite, and actinolite but will not reduce it to the same level of risk as that existing for an exposed worker who has never smoked.

##### III. Signs and Symptoms of Exposure-Related Disease

The signs and symptoms of lung cancer or gastrointestinal cancer induced by exposure to asbestos, tremolite, anthophyllite, and actinolite are not unique, except that a chest X-ray of an exposed patient with lung cancer may show pleural plaques, pleural calcification, or pleural fibrosis. Symptoms characteristic of mesothelioma include shortness of breath, pain in the walls of the chest, or abdominal pain. Mesothelioma has a much longer latency period compared with lung cancer (40 years versus 15-20 years), and mesothelioma is therefore more likely to be found among workers who were first exposed to asbestos at an early age. Mesothelioma is always fatal.

Asbestosis is pulmonary fibrosis caused by the accumulation of asbestos fibers in the lungs. Symptoms include shortness of breath, coughing, fatigue, and vague feelings of sickness. When the fibrosis worsens, shortness of breath occurs even at rest. The diagnosis of asbestosis is based on a history of exposure to asbestos, the presence of characteristic radiologic changes, end-inspiratory crackles (rales), and other clinical features of fibrosing lung disease. Pleural plaques and thickening are observed on X-rays taken during the early stages of the disease. Asbestosis is often a progressive disease even in the absence of continued exposure, although this appears to be a highly individualized characteristic. In severe cases, death may be caused by respiratory or cardiac failure.

##### IV. Surveillance and Preventive Considerations

As noted above, exposure to asbestos, tremolite, anthophyllite, and actinolite has been linked to an increased risk of lung cancer, mesothelioma, gastrointestinal cancer, and asbestosis among occupationally exposed workers. Adequate screening tests to determine an employee's potential for developing serious chronic diseases, such as cancer, from exposure to asbestos, tremolite, anthophyllite, and actinolite do not presently exist. However, some tests, particularly chest X-rays and pulmonary function tests, may indicate that an employee has been overexposed to asbestos, tremolite, anthophyllite, and actinolite, increasing his or her risk of developing exposure-related chronic diseases. It is important for the physician to become familiar with the operating conditions in which occupational exposure to asbestos, tremolite, anthophyllite, and actinolite is likely to occur. This is particularly important in evaluating medical and work histories and in conducting physical examinations. When an active employee has been identified as having been overexposed to asbestos, tremolite, anthophyllite, and actinolite, measures taken by the employer to eliminate or mitigate further exposure should also lower the risk of serious long-term consequences.

The employer is required to institute a medical surveillance program for all employees who are or will be exposed to asbestos, tremolite, anthophyllite, and actinolite at or above the action level (0.1 fiber per cubic centimeter of air) for 30 or more days per year and for all employees who are assigned to wear a negative-pressure respirator. All examinations and procedures must be performed by or under the supervision of a licensed physician, at a reasonable time and place, and at no cost to the employee.

Although broad latitude is given to the physician in prescribing specific tests to be included in the medical surveillance program, OSHA requires inclusion of the following elements in the routine examination:

(i) Medical and work histories with special emphasis directed to symptoms of the respiratory system, cardiovascular system, and digestive tract.

(ii) Completion of the respiratory disease questionnaire contained in Appendix D.

(iii) A physical examination including a chest roentgenogram and pulmonary function test that includes measurement of the employee's forced vital capacity (FVC) and forced expiratory volume at one second (FEV<sub>1</sub>).

(iv) Any laboratory or other test that the examining physician deems by sound medical practice to be necessary.

The employer is required to make the prescribed tests available at least annually to those employees covered, more often than specified if recommended by the examining physician; and upon termination of employment.

The employer is required to provide the physician with the following information: A copy of this standard and appendices; a description of the employee's duties as they

relate to asbestos exposure; the employee's representative level of exposure to asbestos, tremolite, anthophyllite, and actinolite; a description of any personal protective and respiratory equipment used; and information from previous medical examinations of the affected employee that is not otherwise available to the physician. Making this information available to the physician will aid in the evaluation of the employee's health in relation to assigned duties and fitness to wear personal protective equipment, if required.

The employer is required to obtain a written opinion from the examining physician containing the results of the medical examination; the physician's opinion as to whether the employee has any detected medical conditions that would place the employee at an increased risk of exposure-related disease; any recommended limitations on the employee or on the use of personal protective equipment; and a statement that the employee has been informed by the physician of the results of the medical examination and of any medical conditions related to asbestos, tremolite, anthophyllite, and actinolite exposure that require further explanation or treatment. This written opinion must not reveal specific findings or diagnoses unrelated to exposure to asbestos, tremolite, anthophyllite, and actinolite, and a copy of the opinion must be provided to the affected employee.

#### PART 1926—(AMENDED)

5. An authority citation is added to Subpart D of Part 1926, to read as follows:

Authority: Secs. 4, 6, 8 Occupational Safety and Health Act of 1970, 29 U.S.C. 653, 655, 657; Sec. 107, Contract Work Hours and Safety Standards Act (Construction Safety Act), 40 U.S.C. 333, and Secretary of Labor's Orders 12-71 (36 FR 8754), 8-76 (41 FR 25059), or 9-63 (48 FR 33736), as applicable. Sections 1926.55(c) and 1926.58 also issued under 29 CFR Part 1911.

6. Paragraph (c) of § 1926.55 is hereby revised to read as follows:

§ 1926.55 Gases, vapors, fumes, dusts, and mists.

(c) Paragraphs (a) and (b) of this section do not apply to the exposure of employees to airborne asbestos, tremolite, anthophyllite, or actinolite dust. Whenever any employee is exposed to airborne asbestos, tremolite, anthophyllite, or actinolite dust, the requirements of § 1926.56 of this title shall apply.

7. A new § 1926.58 is added to Subpart D to read as follows:

§ 1926.58 Asbestos, tremolite, anthophyllite, and actinolite.

(a) *Scope and application.* This section applies to all construction work as defined in 29 CFR 1910.12(b), including but not limited to the following:

(1) Demolition or salvage of structures where asbestos, tremolite, anthophyllite, or actinolite is present;

(2) Removal or encapsulation of materials containing asbestos, tremolite, anthophyllite, or actinolite;

(3) Construction, alteration, repair, maintenance, or renovation of structures, substrates, or portions thereof, that contain asbestos, tremolite, anthophyllite, or actinolite;

(4) Installation of products containing asbestos, tremolite, anthophyllite, or actinolite;

(5) Asbestos, tremolite, anthophyllite, and actinolite spill/emergency cleanup; and

(6) Transportation, disposal, storage, or containment of asbestos, tremolite, anthophyllite, or actinolite or products containing asbestos, tremolite, anthophyllite, or actinolite on the site or location at which construction activities are performed.

(b) *Definitions.* "Action level" means an airborne concentration of asbestos, tremolite, anthophyllite, actinolite, or a combination of these minerals of 0.1 fiber per cubic centimeter (f/cc) of air calculated as an eight (8)-hour time-weighted average.

"Asbestos" includes chrysotile, amosite, eriodolite, tremolite asbestos, anthophyllite asbestos, actinolite asbestos, and any of these minerals that has been chemically treated and/or altered.

"Assistant Secretary" means the Assistant Secretary of Labor for Occupational Safety and Health, U.S. Department of Labor, or designee.

"Authorized person" means any person authorized by the employer and required by work duties to be present in regulated areas.

"Clean room" means an uncontaminated room having facilities for the storage of employees' street clothing and uncontaminated materials and equipment.

"Competent person" means one who is capable of identifying existing asbestos, tremolite, anthophyllite, or actinolite hazards in the workplace and who has the authority to take prompt corrective measures to eliminate them, as specified in 29 CFR 1926.32(f). The duties of the competent person include at least the following: establishing the negative-pressure enclosure, ensuring its integrity, and controlling entry to and exit from the enclosure; supervising any employee exposure monitoring required by the standard; ensuring that all employees working within such an enclosure wear the appropriate personal protective equipment, are trained in the use of appropriate methods of exposure control, and use the hygiene facilities

and decontamination procedures specified in the standard; and ensuring that engineering controls in use are in proper operating condition and are functioning properly.

"Decontamination area" means an enclosed area adjacent and connected to the regulated area and consisting of an equipment room, shower area, and clean room, which is used for the decontamination of workers, materials, and equipment contaminated with asbestos, tremolite, anthophyllite, or actinolite.

"Demolition" means the wrecking or taking out of any load-supporting structural member and any related razing, removing, or stripping of asbestos, tremolite, anthophyllite, or actinolite products.

"Director" means the Director, National Institute for Occupational Safety and Health, U.S. Department of Health and Human Services, or designee.

"Employee exposure" means that exposure to airborne asbestos, tremolite, anthophyllite, actinolite, or a combination of these minerals, that would occur if the employee were not using respiratory protective equipment.

"Equipment room (change room)" means a contaminated room located within the decontamination area that is supplied with impermeable bags or containers for the disposal of contaminated protective clothing and equipment.

"Fiber" means a particulate form of asbestos, tremolite, anthophyllite, or actinolite, 5 micrometers or longer, with a length-to-diameter ratio of at least 3 to 1.

"High-efficiency particulate air (HEPA) filter" means a filter capable of trapping and retaining at least 99.97 percent of all monodispersed particles of 0.3 micrometers in diameter or larger.

"Regulated area" means an area established by the employer to demarcate areas where airborne concentrations of asbestos, tremolite, anthophyllite, actinolite, or a combination of these minerals exceed or can reasonably be expected to exceed the permissible exposure limit. The regulated area may take the form of (1) a temporary enclosure, as required by paragraph (e)(6) of this section, or (2) an area demarcated in any manner that minimizes the number of employees exposed to asbestos, tremolite, anthophyllite, or actinolite.

"Removal" means the taking out or stripping of asbestos, tremolite, anthophyllite, or actinolite or materials containing asbestos, tremolite, anthophyllite, or actinolite.

APPENDIX B

OSHA Mortality Estimates  
From Exposure to Varying  
Concentrations of Asbestos  
For Different Time Periods

Table 6

Estimated Asbestos Related Cancer Mortality per 100,000  
By Number of Years Exposed and Exposure Level<sup>1</sup>

Asbestos fiber concentration (f/ml)	Cancer mortality /100,000 exposed			Total
	Lung	Mesothelioma	Gastrointestinal <sup>2</sup>	
<u>1 year exposure</u>				
0.1	7.2	6.9	0.7	14.8
0.2	14.4	13.8	1.4	29.6
0.5	36.1	34.6	3.6	74.3
2.0	144	138	14.4	296.4
4.0	288	275	28.8	591.8
5.0	360	344	36.0	740.0
10.0	715	684	71.5	1470.5
<u>20 year exposure</u>				
0.1	139	73	13.9	225.9
0.2	278	146	27.8	451.8
0.5	692	362	69.2	1123.2
2.0	2713	1408	271.3	4392.3
4.0	5278	2706	527.8	8511.8
5.0	6509	3317	650.9	10476.9
10.0	12177	6024	1217.7	13996.7
<u>45 years exposure</u>				
0.1	231	82	23.1	336.1
0.2	460	164	46.0	670.0
0.5	1143	407	114.3	1664.3
2.0	4416	1554	441.6	6411.6
4.0	8441	2924	844.1	12209.1
5.0	10318	3547	1031.8	14896.8
10.0	18515	6141	1851.5	26507.5

<sup>1</sup> Assumes exposure begins at age 25. Risks are calculated using U.S. male lung cancer background rates for 1977.

<sup>2</sup> Estimated as 10% of lung cancer risk rather than calculated using dose-response information.

Several comments should be made regarding the results in Table 6. Though excess relative risk is linear in dose, the excess mortality rates given in Table 6 are not strictly linear in dose. Therefore, for example, the risk at 2 f/cc is not exactly 4 times the risk at 0.5 f/cc, though there is a close approximation. It should also be noted that the risks for longer periods of exposures do not appear to be a straight forward multiplication of the risks of shorter duration. In the longer exposure categories, where exposures will affect older workers, some adjustments have been made for competing risks which are likely to affect the death rate from lung cancer. In addition, when looking at total cancer risks, it must be remembered that these include the risk

of mesothelioma, which is related to time in an exponential fashion.

As can be seen from Table 6, the predicted risk from mesothelioma is approximately equal to the lung cancer risk for one year of exposure and to about half of the risk value for lung cancer in the 20-year exposure group. The excess risk of mesothelioma after a lifetime exposure (45 years) to asbestos is approximately one-third the lifetime excess lung cancer risk. These predictions comport with observations in several populations, where mortality from mesothelioma is observed to comprise approximately 50% of the excess mortality from lung cancer.

Using the equations given earlier, and based on the calculations in Table 6, OSHA predicts a lifetime excess risk of total cancer for a lifetime exposure (45

years) to 2 f/cc as 6411 excess deaths per 100,000 workers, or approximately 64 per 1000. Since risk from a 20 year exposure to asbestos may also be of interest, the models predict an excess cancer mortality of 4392 deaths per 100,000 workers exposed at 2 f/cc for 20 years.

Reducing the PEL from 2 f/cc to 0.2 f/cc reduces the risk from lifetime exposure from 64 per 1000 to 6.7 per 1000. Similarly, for a 20 year exposure, the risk is reduced from 44 per 1000 to 4.5 per 1000, representing a 90% reduction in risk. The lifetime risk from one year of exposure follows a similar course. The risk reduces from 296 per 100,000 at 2 f/cc to 30 per 100,000 at 0.2 f/cc.

Lastly, Table 6 contains risks for levels higher than 2 f/cc because OSHA believes some industrial areas (such as construction) may still be at these higher level. This population of workers would consequently experience a much greater reduction in risk by reducing exposures to 0.2 f/cc or less. Moreover, to the extent that the controls that are installed to meet the new PEL result in exposures below 0.2 f/cc, cancer risks will be reduced to a greater extent than indicated in the table.

#### V. Quantifying the Excess Risk From Asbestosis

The November proposal included a quantification of the excess risk of asbestosis. Asbestosis is a type of pulmonary fibrosis diagnosed on the basis of a history of exposure to asbestos; it is characterized by radiologic changes to the lung, breathlessness, impaired lung function, and other clinical features of fibrosing lung disease. Asbestosis can be manifested in a range of degrees of severity and can result in disability and death.

An early response by the lung to asbestos exposure is formation of plaques, which are opaque patches visible on chest X-rays. The presence of plaques may indicate an increased risk of future development of asbestosis, but this is not certain. Although the significance of pleural plaques in terms of disease is not clear, the presence of plaques is not normal.

Asbestosis has been known to progress or worsen after cessation of exposure to asbestos, probably due to irreversible injury and/or the retention of asbestos fibers in the lung. In addition to lung function impairment, asbestosis contributes to increased asbestos-related mortality. Increased resistance created by the lung obstruction can lead to heart failure.

## APPENDIX C

### FIBER SIZE DISTRIBUTION - TRANSMISSION ELECTRON MICROSCOPY

The standard methods for measuring asbestos include counting the fibers by phase contrast microscopy (PCM) at 450x magnification. Since there are limits to the size of the fiber that can be seen by PCM, the standard requires that in order to be counted, it must be at least three times as long as it is wide, and be at least 5 microns ( $\mu\text{m}$ ) in length. Thus, many of the fibers that are small are not counted. By conducting transmission electron microscopy (TEM) analysis on a few of the samples, we can obtain an estimate of the number of fibers present that are smaller than 5  $\mu\text{m}$  in length or too thin to be visualized by PCM. The significance of these fibers to cancer induction is not fully understood. It is suspected that the very thin ( $<0.25\mu\text{m}$  in width) and long ( $>8\mu\text{m}$  in length) fibers may be the most potent carcinogenic agents (Walton WH. The nature, hazards and assessment of occupational exposure to airborne asbestos dust: A review. *Ann Occup Hy* 1982. 25:117-247). The very thin fibers would not normally be counted by PCM.

In order to address the fiber dimensions of the asbestos present at Friction Division, four samples were analyzed by transmission electron microscopy (TEM). Results of these samples are given below in Table I.

TABLE I  
ASBESTOS FIBER RESULTS BY  
TRANSMISSION ELECTRON MICROSCOPIC ANALYSIS

SOURCE	TYPE	PCM f $>$ 5 $\mu$	TOTAL f/cc	% $>$ 5 microns
Mixer	Personal	0.85	2.54	33
Table (drum)	Personal	0.51	2.70	19
Preform	Area	0.66	2.58	26
Preform	Area (cowl)	0.51	1.39	37

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