CHAPTER 7

ASBESTOS MONITORING PROCEDURES

1. **GENERAL**.

a. The industrial hygienist's role in the asbestos control program can include performing personal monitoring to establish the levels of workplace personnel exposure, environmental monitoring to support asbestos engineering control, clearance sampling to protect Navy personnel in Naval activities undergoing asbestos removals and bulk sampling to identify asbestos containing material associated with occupational exposures. Guidance provided in this chapter is limited to basic requirements and protocols for bulk and air sampling, sample submission procedures, relevant exposure limits associated with asbestos monitoring, and selected definitions and references. Comprehensive program requirements and specific guidance related to other elements of the Navy's asbestos control program can be found in OPNAVINST 5100.23 Series and OPNAVINST 5100.19 Series (References 7-1 and 7-2, respectively).

Laboratory forms for asbestos fiber counting and asbestos bulk sample analysis are provided in Appendix 7-A. (The use of these forms is optional.)

b. Federal regulations for asbestos control have been established by the Occupational Safety and Health Administration (OSHA) and by the Environmental Protection Agency (EPA). The OSHA and EPA requirements are found in the following standards:

(1) 29 CFR 1910.1001 - Asbestos - (General Industry - Reference 7-3). Applies to all occupational exposures to asbestos in all industries covered by the Occupational Safety and Health Act, except those regulated under the shipyard (29 CFR 1915) or construction (29 CFR 1926) standards.

(2) 29 CFR 1915.1001 - Asbestos - (Shipyard - Reference 7-4). Regulates asbestos exposure for ship repair, ship building, ship breaking and related employments. Includes demolition or salvage of structures and vessels; installation, removal or encapsulation of materials containing asbestos; construction, alteration, repair, maintenance or renovation of vessels or structures; asbestos spills and cleanup; and transportation, disposal, storage and housekeeping involving asbestos materials. Requirements are based on class of asbestos work (Classes I through IV).

(3) 29 CFR 1926.1101 - Asbestos - (Construction Industry - Reference 7-5). Regulates construction work, including demolition or salvage of structures; installation, removal or encapsulation of asbestos; construction, alteration, repair, maintenance or renovation of structures containing asbestos; spills and/or emergency cleanup; and transportation, disposal, storage or containment of asbestos. Requirements are based on class of asbestos work (Classes I through IV).

(4) 40 CFR 61 - National Emission Standards for Hazardous Air Pollutants (NESHAP), Subpart M - National Emission Standard for Asbestos (Reference 7-6). Regulations for environmental protection from asbestos emissions, including milling; roadways; asbestos manufacturing, demolition and renovation; spraying; fabricating; insulating materials; waste disposal; and asbestos conversion operations. Regulates by friability (friable ACM, nonfriable Category I and nonfriable Category II ACM).

(5) 40 CFR 763 - Asbestos, Subpart E - Asbestos-Containing Materials in Schools and Subpart G - Asbestos Abatement Projects (Reference 7-7). Regulations promulgated under the authority of the Asbestos Hazard Emergency Response Act (AHERA). These regulations apply specifically to elementary and secondary schools, grades K-12, including schools located on military installations. This program is managed by the Department of Defense Dependents Schools Office (DODDS).

(6) 40 CFR 763 - Asbestos, Subpart E, Appendix C - Asbestos Model Accreditation Plan (MAP) (Reference 7-8). Pursuant to the authority under the Asbestos School Hazard Abatement Reauthorization Act (ASHARA), the AHERA asbestos training and accreditation requirements were extended to persons doing asbestos work in public and commercial buildings in the following disciplines: workers, supervisors, inspectors, and project designers. This includes federal employees on federal property. The Model Accreditation Plan (MAP) specified minimum training requirements for workers, contractors/supervisors, inspectors, management planners , project designers and project monitors. Although Management Planner is an AHERA (i.e., schools) discipline, it was not a discipline covered by ASHARA with respect to public and commercial buildings. The Project Monitor discipline was not included in AHERA or ASHARA but was included in the MAP since some states had established this discipline as a "state" requirement. The MAP recommended that training for Project Monitors should conform to the MAP curriculum.

2. **DEFINITIONS**.

a. Abatement action. A procedure to eliminate or reduce unsafe or unhealthful working condition(s) by coming into compliance with applicable standards. For purposes of this chapter, the abatement action involves removing, encapsulating or otherwise eliminating or reducing asbestos containing material.

b. Aggressive sampling. Air sampling done after forced-air equipment, such as a leaf blower, is used to dislodge fibers from surfaces, then fans are used to keep the fibers suspended during sample collection. Aggressive sampling is usually done in contained or regulated areas following an abatement action, after the area has been cleaned of all visible contamination.

c. Amended water. Water to which a surfactant, or wetting agent, has been added to increase the ability of the water to penetrate ACM.

d. Asbestos-containing material (ACM). Any material containing more than 1 percent asbestos, as defined by References 7-3 through 7-5. ACM can be divided into three major categories - thermal system insulation, surfacing and miscellaneous.

e. Authorized person. Any person authorized by the employer and required by work duties to be in a regulated area.

f. Background sampling. Area air sampling conducted to estimate the existing airborne fiber concentrations before initiating abatement activities. These results are compared with those taken during and/or after the abatement project to determine if the post-work environment is at least as clean as pre-abatement conditions.

g. Boundary integrity sampling. During an abatement project, area samples are collected from locations outside the containment area but inside the building (e.g., in the vicinity of the work area) to determine how well asbestos fibers are being contained in the worksite. If the containment area is the building itself, air samples should be collected both inside and outside of the building.

h. Bulk sampling. Collecting representative samples of insulating material and analyzing them using polarized light microscopy (PLM) (NIOSH Method 9002, Asbestos (bulk) by PLM) to determine if asbestos is present.

i. Category I nonfriable ACM. As defined by Reference 7-6, asbestos-containing packings, gaskets, resilient floor coverings, and asphalt roofing products containing more than one percent (1%) asbestos.

j. Category II nonfriable ACM. As defined by Reference 7-6, any material, excluding Category I nonfriable ACM, containing more than one percent (1%) asbestos that, when dry, cannot be crumbled, pulverized, or reduced to powder by hand pressure.

k. Classes of asbestos work. Divisions of asbestos work defined in 29 CFR 1915 and 29 CFR 1926 that determine the controls and work practices required during ACM or PACM activities. The four classes are:

(1) Class I asbestos work. Activities involving removal of thermal system insulation (TSI) or surfacing ACM or PACM.

(2) Class II asbestos work. Activities involving removal of non-TSI or non-surfacing materials. Examples include, but are not limited to, removal of asbestos-containing floor tile and sheeting, wallboard, some roofing and siding shingles, and construction mastics.

(3) Class III asbestos work. Repair and maintenance operations where any ACM or PACM (including TSI and surfacing ACM and PACM) is likely to be disturbed.

(4) Class IV asbestos work. Maintenance and custodial work during which employees contact but do not disturb ACM or PACM and activities to clean up waste and debris from Class I, Class II and Class III work.

l. Clearance level sampling. Sampling conducted after an abatement action to determine if the space has been adequately cleaned to release it for general occupancy. Release criteria vary depending on the air sample analytical method. Navy release criteria are established in OPNAVINST 5100.23 Series. Clearance sampling is for quality control and personnel access only. It is NOT related to employee personal exposures (i.e., permissible exposure limit or excursion limit).

m. Competent person. As defined by Reference 7-5, one capable of identifying asbestos hazards in the workplace and selecting appropriate control strategies for exposure and who has the authority to take corrective measures to eliminate such hazards. Further, for Class I and Class II asbestos work, one who has met the EPA Model Accreditation Plan (Reference 7-8) training requirements for supervisor. For Class III and Class IV asbestos work, one who meets EPA training requirements for local education agency maintenance and custodial staff. [Note: Equivalent to a "qualified person" as defined by Reference 7-4.]

n. Excursion limit (EL). A limit value established by OSHA that is intended to protect workers who have brief but intense

exposures, such as are encountered in the asbestos abatement industry. The EL for asbestos is 1.0 f/cc as averaged over a sampling period of thirty (30) minutes.

o. Friable asbestos containing material. As defined by Reference 7-6, any material containing more than 1 percent asbestos that, when dry, can be crumbled, pulverized, or reduced to powder by hand pressure.

p. Homogeneous area. An area of thermal system insulation, surfacing material, or miscellaneous material that is uniform in color, size, age, pattern, and texture.

q. Miscellaneous material. ACM not included in the TSI or surfacing material categories (e.g., floor or ceiling tiles).

r. Negative Exposure Assessment. Per References 7-4 and 7-5, for any one specific asbestos job performed by employees properly trained per the standards, employers can demonstrate that employee exposures will be at or below the PEL by producing data that meets the following criteria:

(1) Objective data that shows that the product/material containing asbestos or the work operation using the product/material cannot release airborne fibers in quantities exceeding the PEL and the EL under work conditions that would have the greatest potential for fiber release; or

(2) Sample data collected for the PEL and EL during previous asbestos jobs that are within 12 months of the present or projected job, produce sample data to show with a high degree of certainty that employee exposures will not exceed the PEL and EL. Monitoring and analysis must be in compliance with the asbestos standard that was in effect during the sampling, data must be for work conducted under conditions that closely resemble current/projected job (including processes, type of material, control methods, work practices and environmental conditions) and the employees for the sampled work must be equivalent in training and experience to employees performing the current/projected asbestos job; or

(3) Sample data collected on the current job (breathing zone samples representative of the 8-hour TWA and 30-minute EL) that show no exposure above the PELs for those employees most likely to be exposed during the entire job.

s. Nonfriable asbestos containing material. As defined by Reference 7-6, any material containing more than one percent (1%) asbestos that, when dry, canNOT be crumbled, pulverized, or reduced to powder by hand pressure.

t. Permissible exposure limits (PELs). Limit values established by OSHA that cannot be exceeded. For asbestos, the PELs are (Reference 7-9):

(1) Time-weighted average limit (TWA). The employer must ensure that no employee is exposed to airborne concentrations of asbestos in excess of 0.1 fiber per cubic centimeter (f/cc) of air as an eight (8)-hour TWA.

(2) Excursion limit (EL). The employer must ensure that no employee is exposed to airborne concentrations of asbestos in excess of 1.0 f/cc averaged over a thirty (30) minute sampling period.

u. Presumed Asbestos-Containing Material (PACM). Thermal system insulation and surfacing material found in buildings or vessels constructed no later than 1980.

v. Qualified person. As defined by Reference 7-4, equivalent to a "competent person" as defined by Reference 7-5.

w. Regulated area. An area established by the employer to separate locations where airborne concentrations of asbestos exceed, or may reasonably be expected to exceed, the permissible exposure limits from areas where this will not occur. References 7-4 and 7-5 further define a regulated area as one established by the employer to demarcate areas where Classes I, II and III asbestos work are conducted, and any adjoining areas where waste and debris from such work accumulate. There are specific requirements for establishing, entering and marking regulated areas.

x. Regulated asbestos containing material (RACM). As defined by Reference 7-6: (1) friable asbestos containing material; (2) Category I nonfriable ACM that has become friable; (3) Category I nonfriable ACM that will be or has been subjected to sanding, grinding, cutting, or abrading; or (4) Category II nonfriable ACM that has a high probability of becoming or has become crumbled, pulverized, or reduced to powder by the forces expected to act on the material in the course of demolition or renovation operations.

y. State of the art. Work practices using the latest available technologies. The application of this term refers to the requirement for employers to use every feasible means of protecting the employee against exposure to asbestos, which may mean going above and beyond mere compliance with regulations.

z. Surfacing material. ACM that is sprayed on, troweled on or otherwise applied to surfaces (such as acoustical plaster on ceilings, fireproofing materials on structural members, or other materials on surfaces for acoustical, fireproofing and other purposes).

aa. Thermal system insulation (TSI). ACM applied to pipes, fittings, boilers, breeching, tanks, ducts, or other structural components to prevent heat energy transfer.

ab. Visual inspection. After an asbestos abatement project is complete but before any barriers are removed, the containment area must be thoroughly inspected to ensure that it has been completely abated, thoroughly cleaned and is free of visible dust and debris. Inspect per Reference 7-10. Clearance sampling is started after the containment area "passes" the visual inspection.

3. **AIR SAMPLING REQUIREMENTS**. The primary responsibility of the industrial hygienist is to evaluate employee occupational exposures, including personal monitoring of individual employees. This is the only way to accurately determine the level of an employee's exposure to a contaminant throughout the work day. Industrial hygienists may also be involved in engineering control of abatement projects. In this context, boundary integrity and clearance samples are collected.

a. Types of air samples.

(1) Personal air samples. The industrial hygienist or other trained and qualified person collects personal breathing zone air samples on employees who are or can reasonably be expected to have exposures to asbestos at or above the PEL and/or EL. If a group of employees with similar jobs is working in an area, OSHA allows monitoring on representative workers from each job classification in each work operation. These representative sampling results - for the 8-hour TWA and the 30-minute EL - are then assumed to represent the exposure of all employees in the same job/operation.

(a) Eight-hour TWA. Breathing zone air samples which are representative of the 8-hour time weighted average exposure of each employee are collected for comparison to the PEL. If a "group" monitoring strategy is used, the representative 8-hour TWA exposure must be determined on the basis of one or more samples that represent full-shift exposures for each employee on each shift in each job classification in each work area.

(b) Excursion limit. In addition to the 8-hour TWA, breathing zone air samples representative of the 30-minute short

term exposure of each employee are taken for comparison to the EL. If a "group" monitoring strategy is used, the worker(s) with the highest likely exposure on each shift in each job classification in each work area must be sampled. Samples shall be taken during the 30-minute period expected to have the highest exposure.

(2) Environmental air samples.

(a) Boundary integrity. Where negative pressure enclosures are used, background sampling is used to determine fiber concentrations before work operations begin. While work is in progress, perimeter sample results are compared to background sample results to verify the integrity of the enclosure. If the containment is inside of a building (i.e., a room or rooms), collect boundary samples inside the building but outside of the containment barriers. If the containment area is the entire building, sample both inside and outside of the building.

In some cases, background sampling may show that the level of airborne asbestos is greater than 0.01 f/cc. In these cases, boundary integrity monitoring should be conducted at the levels which would indicate a change in the ambient environment. For example, if the baseline sampling shows an ambient level of 0.05 f/cc, boundary integrity sampling should be conducted at the 0.05 f/cc level. In this way, the industrial hygienist can determine if the levels are increasing from background. Although not required, and usually expensive, use of TEM sampling and analysis can help determine if the fiber levels measured are actually due to asbestos fibers or are due to the presence of other non-asbestos fibers.

(b) Clearance samples. Clearance sampling is performed after an abatement to determine if the abated space can be released for occupancy. After completing abatement work, the contained area is cleaned, visually inspected, and then sampled to determine if it can be released for occupancy.

b. Monitoring frequency - 29 CFR 1910.1001.

(1) Initial. You must initially monitor employees who have or are expected to have exposures at or above the PEL-TWA and/or PEL-EL.

(2) Periodic. After initial monitoring is completed, representative monitoring is done at least once every six months for those employees whose exposures are reasonably expected to exceed the PEL-TWA and/or PEL-EL.

(3) Discontinuing monitoring. If initial or periodic monitoring results indicate statistically that personnel exposures are below the PEL-TWA and/or PEL-EL, monitoring of personnel covered by such results may be discontinued.

(4) Additional monitoring. Whenever there are changes in personnel, production, engineering controls, work practices or other changes that may be reasonably expected to alter exposures (either by new or additional exposures above the PEL-TWA and/or PEL-EL), the initial - periodic monitoring sequence must be reinstituted.

c. Monitoring frequency - 29 CFR 1915.1001 and 1926.1101.

(1) Initial assessment. The purpose of the initial exposure assessment is to identify workplaces or operations where employees are likely to be exposed above the PEL-TWA or PEL-EL so that controls can be implemented early enough to reduce the exposures. The initial assessment must be done by a qualified person or competent person, and consists of evaluating historical information from similar operations, reviewing plans for controls, procedures and operation conditions, employee training, exposure monitoring, etc. If the completed evaluation does not result in a negative exposure assessment, then certain controls must be implemented based on the class of work.

NOTE: All Class I work is presumed to expose employees in excess of the PEL-TWA and PEL-EL unless there is a negative exposure assessment or air sample results confirm no exposures above the PEL-TWA or PEL-EL.

(2) General monitoring. Employee monitoring must be representative 8-hour TWA and 30-minute EL samples, completed in time to comply with all requirements triggered by exposure data or by the lack of a negative exposure assessment.

(3) Periodic. Employees in Class I and II operations require daily representative exposure monitoring unless a negative exposure assessment has been documented or all such employees wear supplied air respirators in the pressure demand mode or other positive pressure respirators.

Daily monitoring is also required for employees in Class I operations that do not have controls as specified in the standard, regardless of the respiratory protection provided.

Employees at other operations expected to exceed the PELs are monitored with sufficient frequency to document exposure validity ("periodically").

(4) Discontinuing monitoring. If initial or periodic monitoring results indicate statistically that personnel exposures are below the PEL-TWA and/or PEL-EL, monitoring of personnel covered by such results may be discontinued.

(5) Additional monitoring. Whenever there are changes in process, personnel, production, engineering controls, work practices or other changes that may be reasonably expected to alter exposures, (either by new or additional exposures above the PEL and/or EL), periodic monitoring must be reinstituted, even if the operation was originally classified with a negative exposure assessment.

4. **PERSONAL AIR SAMPLE COLLECTION AND ANALYSIS**. Use the latest revision of the OSHA Reference Method (ORM) ID-160 or the NIOSH method 7400 (Asbestos and Other Fibers by PCM) to collect and analyze asbestos air samples. BUMED industrial hygienists should be thoroughly familiar with the complete methods. Major elements of the sampling and analytical procedures are provided below.

a. The sampling media for airborne asbestos fibers is 25 mm diameter mixed cellulose ester filters (MCEF), 0.8 micron pore size. The filter membranes must be designated by the manufacturer as "suitable for asbestos counting."

b. The collection device is a 25 mm diameter, three-piece cassette with a backup pad and a 50 mm electrically conductive extension cowl. The black carbon-filled conductive cowl reduces the electrostatic attraction between the asbestos fibers and the collection device. To prevent the accumulation of contamination in the joint between the cowl and cassette, wrap the joint with tape or a shrink band (which also provides a convenient writing surface). If this is not done, contamination in the joint can fall onto the filter when the cassette is opened and affect the sample results. A shrink band is preferred since tape leaves a sticky residue on the cassette. Samples are collected with the cassette open-faced.

c. Personal sampling pumps must be capable of calibration at flow rates between 0.5 and 2.5 liters per minute (L/min) for the OSHA Reference Method. Calibrate each sampling pump before and after use with a representative filter cassette installed between the pump and the calibration device.

d. Where possible, a sufficient air volume for each air sample is collected to yield between 100 and 1,300 fibers per square millimeter (f/mm^2) on the membrane filter. This range of fiber loading is optimal for fiber counting analysis accuracy. To determine what the sufficient air volume should be, estimate the airborne asbestos concentration ahead of time. With

experience, IHs become fairly proficient at estimating expected fiber concentrations based on factors such as general area cleanliness, type of work or process and prior sampling results from similar processes.

The general quantification guidelines in the NIOSH method 7400 for sampling are: (1) 1-4 L/min for 8 hours at the 0.1 f/cc level in non-dusty atmospheres; (2) short, consecutive samples, each with <400 L sample volume for dusty atmospheres; (3) 7-16 L/min over short sampling times to capture episodic exposures; and (4) total sample volumes of 3,000-10,000 L in "clean" areas where concentrations are expected to be much less than 0.1 f/cc.

(1) A sample calculation for determining volume is shown in equation 7-1. Using the minimum fiber loading of 100 f/mm² and an expected fiber level of 0.1 f/cc, you would need to collect a total air volume of 385 liters.

$$V = \frac{A_c \times E}{L \times 1000}$$

Equation 7-1

Where:

V = minimum sample volume (in liters)
A_C = effective collection area (in square millimeters)
(A_C = 385 mm^2 for a 25 mm diameter filter)
E = fiber density (in fibers per square millimeter)
(E optimal = 100 to 1300 f/mm^2)
L = targeted fiber concentration (in fibers per cubic centimeter)
1000 = conversion factor (1000 cm^3 in 1 liter)

(2) Using Equation 7-2, determine the collection time required for the total air volume just calculated. Remember that air flow should be between 0.5 and 2.5 L/min for the OSHA Reference Method. Using the 385 liter volume calculated in equation 7-1 and a target flow rate of 2 L/min, the minimum sample time is 193 minutes.

$$t = \frac{V}{Q}$$

Equation 7-2

Where:

t = sampling time (in minutes)
V = minimum sample volume required (in liters)
Q = sampling flow rate (in L/min)

(3) In dusty atmospheres where fiber levels are likely to exceed 0.1 f/cc or where non-asbestos dust levels are high enough that filters may become overloaded, smaller volumes of air (i.e., less than 400 liters) should be collected in order to obtain countable samples. In such cases, take short consecutive samples and calculate the time-wieghted average results over the total collection time using Equation 7-3.

$$TWA = \frac{C_1 T_1 + C_2 T_2 + \ldots + C_n T_n}{T_1 + T_2 + \ldots + T_n}$$

Equation 7-3

Where:

TWA = Time-weighted average concentration over all sampled periods (in f/cc)
C = fiber concentration (in f/cc)
T = sample time (in minutes)

e. Personal samples are taken in the employee's breathing zone. Attach the collection device to or near the collar or lapel near the worker's face. Remove the top cover from the conductive cowl extension and orient the open face downward.

f. Samples must be accompanied by field blanks to determine if media was contaminated during the sampling procedure. Each set of samples requires two (2) field blanks or 10% of the total samples, whichever is greater. Field blanks are handled the same as samples except that no air is drawn through them.

g. At the end of sampling, replace the cassette top cover and end plugs. Tape in place.

h. Ship samples and blanks, with the conductive cowls attached, in a rigid container. Pack the samples to prevent jostling or damage. Do not use packing materials such as vermiculite or polystyrene peanuts, as they can cause electrostatic charges.

5. **ENVIRONMENTAL AIR SAMPLE COLLECTION AND ANALYSIS.** Sampling media and collection procedures for environmental assessments are basically the same as those used for personal sampling. Field blanks (2 per sample set or 10% of the total samples, whichever is greater, with a maximum of 10) are required and are used the same way as in personal sampling. The major differences are in the required sampling volumes/times and in the number of samples required to characterize environmental results. Remember that these samples are for abatement quality control - NOT personnel exposures.

a. Theoretical volume requirements:

(1) Using Equation 7-1 and assuming an environmental targeted fiber concentration of 0.01 f/cc and a filter loading of 100 f/mm^2, the total air volume needed for optimal accuracy is 3,850 liters. This sample volume can be substantially reduced by implementing an agressive asbestos quality assurance (QA) program, consisting of intracounter/intralaboratory checks (blind recounts and comparisons between fiber counters in a single laboratory) and interlaboratory checks (exchanging mounted slides that are representative of the fiber counting workload with other laboratories (at least two) to compare fiber counts performed in different laboratories). If the laboratory can significantly increase the precision of the analysis, the minimum sample volume can be decreased because the confidence limit converstion factor in Equations 7-4 and 7-5 below will be smaller. It is important that the intralaboratory and interlaboratory relative standard deviations be reported on the analytical report if sample volumes smaller than those calculated using the standard confidence limit converstion factor of 4 are used.

(2) With the increased air volume, it follows that we need higher air flow rates. For example, if we keep the 2 L/min flow rate used in equation 7-2, sampling time is now 1,925 minutes - over 32 hours! To reduce sampling time to something reasonable, use high volume pumps that can sample at 10-16 L/min. As with personal air sampling, pumps must be calibrated before and after use with a representative filter cassette in-line between the pump and the calibration device. Calibrated precision rotameters are useful for this purpose.

b. Practical volume requirements:

(1) Environmental sampling is qualitative - it serves as a pass/fail quality control to determine if an abated space is sufficiently clean to release for occupancy or if containment controls are preventing fiber release outside of the containment. NIOSH 7400 was not designed to be a qualitative analysis procedure, yet we use it routinely for doing environmental sample

analysis. The theoretical calculations above - which require 3,850 liters of air - are based on analytical parameters and assumptions used for quantifying worker exposure. To sample for qualitative environment conditions, volume requirements may be adjusted.

(2) The limit of detection (LOD) for NIOSH 7400 is 7 f/mm² (or about 5.5 fibers per 100 fields counted). Rearranging equation 7-4 yields equation 7-5, which shows the volume needed to be at or above the method's limit of detection (i.e., 95% confident that any single sample complies with the clearance criteria of 0.01 f/cc) is 1,078 liters:

$$\frac{D \times A}{V} = \frac{L}{4}$$

Equation 7-4

$$V = \frac{D \times A \times 4}{L \times 1000}$$

Equation 7-5

Where:

V = minimum sample volume (liters)
D = limit of detection (in fibers per area of 100 fields [5.5 fibers per 0.785 mm^2])
A_C = effective filter collection area (385 mm^2 for a 25 mm diameter filter)
L = targeted limit value fiber concentration (in fibers per cubic centimeter [0.01 f/cc])
1000 = conversion factor (1000 cm^3 in 1 liter)
4 = confidence limit conversion factor assuming an analytical relative standard deviation of 0.45 [See EXPLANATORY NOTE below.]

EXPLANATORY NOTE: According to NIOSH 7400, there is no independent means available to assess overall accuracy of the method. One way to judge is to estimate how well any single count agrees with the mean count from a large number of analysts. Refer to the NIOSH method for a complete discussion, including the statistical parameters.

For purposes of Equation 7-5, Figure 1 of the 7400 method (*Interlaboratory Precision of Fiber Counts*)

shows that at the LOD of 5.5 f/100 fields, 90% of the time the count will fall within 300% above and 63% below that value in relative terms - that is, the range is 2 to 22 f/100 fields. Because the upper confidence limit is 4 times the detection limit, the result reported should have a value that is 1/4 of the target fiber concentration. That is, you have 95% confidence that the sample results are BELOW the target level.

TO RETAIN 95% CONFIDENCE THAT THE RESULT IS ACTUALLY LESS THAN 0.01 f/cc, THIS VOLUME IS VALID **ONLY** IF THE ACTUAL FIBER COUNT IS LESS THAN OR EQUAL TO 5.5 FIBERS PER 100 FIELDS. IF THE FIBER COUNT IS GREATER, YOU WOULD REQUIRE A LARGER VOLUME TO RETAIN CONFIDENCE THAT THE VALUE IS BELOW THE TARGET FIBER CONCENTRATION (i.e., 0.01 f/cc).

(c) If using transmission electron microscopy (TEM) for analysis using NIOSH 7402, the required sample volume is 1,200 liters (See Reference 7-7, Subpart E, Appendix A, *Interim Transmission Electron Microscopy Analytical Methods - Mandatory and Nonmandatory - and Mandatory Section to Determine Completion of Response Actions*).

(d) Filter overloading may be a concern with high collection volumes. If ambient non-asbestos dust levels are high and filters are overloaded, the laboratory will void the sample as uncountable. This shouldn't be a problem in relatively clean environments such as schools and office buildings. In "dirty" environments such as shipyards or manufacturing facilities, filter overloading may be an issue. Check the filter periodically. If it is visibly loading, remove the cassette and replace it with a clean one. For example, if you will analyze the samples with the NIOSH 7400 method (i.e., requires 1,078 liters minimum volume), collect four 270 liter samples, then average the results over the total collection time using Equation 7-3.

c. Environmental Sampling Strategy.

(1) Background air samples serve as the reference baseline for "normal" ambient fiber concentrations. They are compared with sample results taken during an abatement to determine if containment boundaries are preventing contamination of surrounding areas or with samples taken after an abatement to assess adequate cleanup. If background results show that the ambient asbestos level is significantly above 0.01 f/cc, it would make little sense to conduct boundary integrity sampling at the 0.01 f/cc level. By first determining the actual background

airborne asbestos concentration, you can decide the correct strategy for monitoring during the abatement.

(2) Always locate sampling pumps away from turbulent air areas, such as near furniture, in room corners, at barrier entries, close to outside obstructions, etc. If the work area is a single room, place inside sampling pumps in a somewhat uniform pattern throughout the room. If many rooms are involved, select rooms to sample at random. Collect boundary integrity samples for a negative pressure containment outside of the containment but inside the building. If negative pressure containment is not used, collect outside samples outdoors and about 2 meters above the ground.

(3) Clearance sampling is conducted after the site has passed the visual inspection. Before sampling, remove all plastic coverings on floors, walls and other surfaces. Leave the perimeter boundary (between the abatement site and the rest of the building) and door, vent and window sheeting intact until the area passes the clearance criteria. Remember that clearance sampling is an engineering/quality control procedure and is not related to the PEL-TWA or PEL-EL.

(4) Include descriptive comments about the operation on the sample sheet. Listing the type of sample (i.e., background, clearance, etc.) is also helpful to the analyst.

d. Aggressive Clearance Sampling Procedure. Currently, there is no standard protocol for aggressive sampling, but the EPA recommends its use when collecting certain post-abatement clearance samples and requires its use when collecting post-abatement clearance samples in schools. The logic is to suspend any fibers that are present and keep them circulating during sample collection, thus increasing the likelihood of capturing fibers if they are present.

(1) Conduct aggressive sampling only after the containment area has passed a thorough visual inspection per ASTM E-1386.

(2) Appendix M of Reference 7-11 gives the following procedures for sampling aggressively. Note that containment area requirements are maintained and negative pressure units continue to operate during the aggressive sampling.

(a) Before starting the sampling pumps, direct the exhaust from forced air equipment (such as a 1-horsepower leaf blower) against all walls, ceilings, floors, ledges, and other surfaces in the room. This should take at least 5 minutes per 1,000 square feet of floor.

NOTE: Leaf blowers usually generate noise levels in excess of 84 dBA. Persons doing this procedure may require hearing protection.

(b) To keep air circulating throughout the room while sampling, use one 20-inch fan (minimum size) per 10,000 cubic feet of room space. Fans should be about 2 meters off the floor, placed in the center of the room on slow speed and pointed toward the ceiling.

(c) Start the sampling pump(s) and sample for the required time.

(d) When sampling is complete, turn off the pump(s) before turning off the fan(s).

(3) The negative pressure containment (i.e., the remaining barriers, sheeting, etc.) MUST remain intact until after samples are analyzed, results are deemed acceptable and the area is released.

e. Number of Environmental Samples.

(1) For clearance sampling, Reference 7-11 recommends collecting a minimum of five samples per homogeneous work site or one per room, whichever is greater. The space is cleared for reoccupancy if none of the samples are above 0.01 f/cc, given that the sample volume is sufficient for reliable quantification (using phase contrast microscopy (PCM) per the NIOSH 7400 method, minimum sample volume is 1,078 liters).

Using appropriate sampling techniques, collect samples from each homogeneous work site. In some circumstances, a clearance level of 0.01 f/cc cannot be achieved since the outdoor (i.e., ambient) air which is used for replacement air during abatement has a fiber concentration greater than 0.01 f/cc. In that case, collect samples outdoors and outside the abatement area (a number equal to the number of samples collected inside) that are representative of the replacement air. Then perform a statistical analysis to demonstrate that inside the work site sample results show no statistically significant difference from the outdoor concentration.

(2) If analysis is by transmission electron microscopy (TEM), collect a minimum of 5 samples inside each homogeneous work area and 5 samples outside of the work area (either outside of the containment or outdoors). Include three (3) blanks (i.e., two (2) field blanks and one (1) unopened media blank)). The area can be reoccupied if the average concentration of all five

samples is ≤70 structures/square millimeter (S/mm^2) and the minimum sampling volume of 1,199 Liters of air per 25 mm diameter filter is met. Alternatively, the area can be released if the average fiber levels inside are not statistically different from the average fiber level outside the containment, assuming the minimum sample volume requirement is met and the field blanks are both ≤70 S/mm^2.

f. Air Sample Analysis.

(1) Samples collected for airborne fiber concentration can be analyzed locally or sent to a Consolidated Industrial Hygiene Laboratory. Regardless, fiber counting analyses can be done only by individuals who have successfully completed the NIOSH 582 (Sampling and Evaluation of Airborne Asbestos Dust) or equivalent training course AND who maintain a proficient rating in the Proficiency Analytical Testing (PAT) program.

(2) All laboratories offering fiber counting must maintain a proficient rating in the PAT program and must establish internal quality control (QC) programs. As a minimum, the QC program must include intracounter checks (blind recounts and comparisons between the laboratory's individual microscopists) and interlaboratory analyses (exchanging slides that are representative of the usual work with at least two other laboratories for comparisons of fiber counts).

(3) Some analytical laboratories include a qualifying statement on the analysis report for samples that do not meet the volume requirements for reliable quantification under NIOSH 7400. Note that the inclusion of such a qualifier does not negate the use of results, but the industrial hygienist must consider the limitations of interpreting and using the results.

6. **BULK SAMPLE COLLECTION AND ANALYSIS**.

a. Per References 7-4, 7-5 and 7-8, persons collecting bulk asbestos samples for shipyard or construction work must successfully complete an accredited asbestos inspector course (minimum 3 days) and attend annual refresher training (1/2 day). Training courses must comply with Reference 7-8 requirements, including accreditation by a state.

b. When collecting bulk samples, assume that the sampling procedure itself may generate airborne asbestos fibers, especially if the bulk material is already damaged. As a minimum, the person collecting the sample should wear respiratory protection, disposable gloves and coveralls.

c. NIOSH Method 9002. The collection information in this procedure is very general and allows for the collection of a wide variety of material types. This method is especially amenable to sampling formed products.

(1) Place 1 to 10 grams of the material to be analyzed in a sample container. The method specifies sample containers as 10-50 ml screw-top plastic vials, but polyethylene interlocking seal bags are acceptable substitute containers. If polyethylene bags are used, samples should be double bagged and labeled appropriately.

(2) For large samples that are fairly homogeneous (e.g., whole ceiling tiles), submit a small piece representative of the whole. Adjust sample size as needed to ensure that it is representative of the parent material, but is small enough not to cause a disposal burden to the analytical laboratory.

(3) Tape sample vial lids and recheck lock-seals on sample bags to ensure they will not open in transit.

(4) If shipping is necessary, ship the sample vials/bags in a rigid container with sufficient packing material to prevent damage or sample loss. As a precaution against possible contamination should bulk sample containers open, ship bulk samples separately from air samples.

d. EPA Bulk Methods. References 7-7 (interim bulk analysis method, Appendix E to Subpart E) and 7-12 (proposed replacement procedure) contain the following collection elements:

(1) If the insulation is in good condition, leave it undisturbed. If there is reason to suspect that the material may be ACM, assume it is ACM and do not sample.

(2) The sample should be collected in a manner to ensure that all the layers of the material are collected, so that a truly representative sample is attained.

(3) The analytical procedure is prefaced with a note that states ALL SAMPLE AND SLIDE PREPARATIONS SHOULD BE CARRIED OUT IN A NEGATIVE PRESSURE VENTILATED HOOD OR GLOVE BOX WITH CONTINUOUS AIR FLOW. This is standard procedure. Additionally, the ventilation exhaust should be routed through a high-efficiency particulate air (HEPA) filter to remove asbestos fibers prior to discharge to the environment. **DO NOT** handle bulk samples without such controls, regardless of which procedure you use.

e. OSHA ID-191 Bulk Asbestos Procedure. References 7-3 through 7-5 have non-mandatory appendices for bulk asbestos sampling.

(1) Using a tube or cork borer, collect 1-2 grams of each type of material and place in separate 20 ml scintillation vials.

Note that the procedure states: "Do not use envelopes, plastic or paper bags of any kind to collect samples." The rationale is that the bellows effect created when bags are opened can liberate the free fibers inside and contaminate the analyst and the lab area with asbestos fibers. While this is true as a general statement, samples should only be opened under a negative pressure ventilated hood or glove box, thus containing and properly controlling any fiber release.

(2) Sample in an inconspicuous place. Seal the sampling site with an encapsulant.

(3) Seal and label samples. If mailing, package to prevent breaking during shipment, and include appropriate paperwork.

(4) Collect the bulk sample from all layers and phases of the material. If possible, take separate samples from each layer (phase) of the bulk material.

(5) Thoroughly clean the cork borer between samples.

f. General bulk sampling protocol. When collecting bulk samples, BUMED IHs should use the guidance below (adapted from Reference 7-13, Appendix G).

(1) If a restricted area is established, wear at least a NIOSH-approved half-mask air-purifying respirator with high-efficiency particulate air (HEPA) filters.

(2) Determine whether it is necessary to secure the supply and exhaust ventilation to prevent airborne fiber distribution during sample collection.

(3) To control asbestos dust while collecting bulk insulation samples, the cut area should be lightly moistened with amended water. Water is most easily applied if in a water sprayer or a plastic water spray bottle adjusted to deliver a mist.

(4) While cutting into the lagging, hold a disposable plastic bag under the area for collection of debris generated during this procedure.

(5) Carefully cut through all the layers of insulation to obtain a representative sample. If using a core sampler (i.e., cork borer or single use core sampler), use a slow twisting motion and be sure the boring device penetrates down to the substrate.

(a) When collecting samples of soft insulation material, a knife may be the appropriate tool. For hard, pre-formed insulation, a chisel or sharpened screwdriver may be better, since the increased force needed to penetrate the insulation makes accidental hand contact with the knife blade a real possibility.

(b) Sampling tools equipped with cutting edges are commercially available. Some Navy shipyards have locally fabricated stainless steel borers modeled after cork borers, but substantially stronger. Tools are also available that are equipped with local exhaust mechanisms fitted with HEPA filters.

(c) Whatever device is used for sampling, it must be cleaned after each sample collection to prevent cross-contamination of samples. For boring tools, clean the wet bore with a wire bore-brush and follow with a water wash. Single use samplers should be wet wiped before capping.

(6) Using forceps, a spatula (or similar grasping equipment) or a gloved hand, place the insulation and associated lagging cloth in a 4" x 4" polyethylene interlocking seal bag or screw top vial. Cap the vial or seal the bag; wet wipe the exterior. Label the bag or vial with "DANGER - CONTAINS ASBESTOS FIBERS." Also label with sample location, command, collection date and sample number. If using a seal bag, fold and place the labeled bag inside another 4" x 4" polyethylene interlocking seal bag.

(7) Cover exposed insulation at the collection site with plastic, duct tape and/or a sealant. Place the respirator in a plastic bag for decontamination. Wash hands, tools and sprayer.

g. Bulk Sample Analysis. Asbestos bulk samples will be analyzed at the activity level by individuals specifically trained in polarized light microscopy (PLM)/dispersion staining, in a formal classroom course. Analysts and laboratories must maintain proficiency in the NAVENVIRHLTHCEN-approved Research Triangle Institute (RTI) asbestos identification program.

Most field activities are capable of analyzing samples for the presence or absence of asbestos using PLM with visual estimation of the % asbestos. If PLM analysis includes the percent (%)

determination of asbestos by visual estimation and the content is less than 10% but not "none detected", Reference 7-6, under the definition of ACM says that the sample should be analyzed by PLM using the "point counting" technique. In practical terms, the building owner has the following options:

(1) Assume that the sample contains more than 1% asbestos and treat the material as ACM or

(2) Have the laboratory use the point counting method specified in Reference 7-7 to reanalyze the sample to provide a more definitive asbestos content result. The point counting result shall be used for all decision making when point counting is performed.

NOTE 1: Most owners select the first option. In practice, it is rare that "point counting" results in less than 1% asbestos (i.e., not ACM) analytical result.

NOTE 2: A valid "none detected" visual estimation (i.e., not point counting) PLM result requires that a minimum of three slide mounts be prepared and completely analyzed.

7. **REFERENCES**.

7-1 OPNAVINST 5100.23 Series, Chapter 17, *Asbestos Control*.

7-2 OPNAVINST 5100.19 Series, Chapter B1, *Asbestos Control Program*.

7-3 Code of Federal Regulations, Title 29, Part 1910.1001. *Asbestos* (General Industry).

7-4 Code of Federal Regulations, Title 29, Part 1915.1001. *Asbestos* (Shipyards).

7-5 Code of Federal Regulations, Title 29, Part 1926.1101. *Asbestos* (Construction Industry).

7-6 Code of Federal Regulations, Title 40, Part 61. *National Emission Standards for Hazardous Air Pollutants (NESHAP)*. Subpart M, National Emission Standard for Asbestos.

7-7 Code of Federal Regulations, Title 40, Part 763. *Asbestos* (AHERA). Subpart E, Asbestos-Containing Materials in Schools. Subpart G, Asbestos Abatement Projects.

7-8 Code of Federal Regulations, Title 40, Part 763. *Asbestos*. Appendix C to Subpart E, Asbestos Model Accreditation Plan.

7-9 Federal Register, Vol. 59, No. 153, 10 Aug 94, pp. 40963-41162. *Occupational Exposure to Asbestos; Final Rule.* 29 CFR Parts 1910, 1915, 1926.

7-10 ASTM. *Standard Practice for Visual Inspection of Asbestos Abatement Projects*. ASTM E 1368-90. Philadelphia, PA: American Society for Testing and Materials. 1990.

7-11 Environmental Protection Agency. *Measuring Airborne Asbestos Following an Abatement Action.* EPA 600/4-85-049. Washington, DC: U.S. EPA. 1985.

7-12 Environmental Protection Agency. *Test Method. Method for the Determination of Asbestos in Bulk Building Materials*. EPA/600/R-93/116. Research Triangle Park, NC: U.S. EPA. 1993.

7-13 Environmental Protection Agency. *Guidance for Controlling Asbestos-Containing Materials in Buildings*. EPA 560/5-85-024. Washington, DC: U.S. EPA. 1985.

APPENDIX 7-A

LABORATORY ASBESTOS FIBER COUNTING AND ASBESTOS BULK SAMPLE ANALYSIS FORMS

1. **FORMS**. Provided below are optional forms which can be used by laboratories performing asbestos fiber counting or bulk sample analysis for asbestos. These forms are in Microsoft Word format and require Microsoft Word to be installed on your computer in order to open them. To open each form, click on the hyperlink.

a. Asbestos Fiber Counting Form. This form can be used for documenting laboratory asbestos fiber counting - CIHL Form 005 1/02.

b. Asbestos Bulk Sample Analysis Form. This form can be used for documenting laboratory asbestos bulk sample analysis - CIHL Form 006 01/02 .