ASBESTOS CONTAMINATED SOIL STATEWIDE MANAGEMENT PLAN

THE STATE OF COLORADO

Prepared for

State of Colorado Department of Transportation
Maintenance & Operations Branch
Property Management Section
Hazardous Waste Unit
15285 S. Golden Road, Building 47
Golden, CO 80401

Prepared by

HERRON® Enterprises USA, Inc.
7261 W. Hampden Ave., Lakewood, CO 80227-5305
(303) 763 9639 / Fax (303) 763 9686
Email: Lennie.Herron@comcast.net
L.P. (Lennie) Herron, Industrial Hygienist

Certificate No. 2572 (CDPHE Certified Designer/Inspector/AMS)

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Attachment A 6 CCR 1007-2, Section 5 - 24 Hour Notification of Unplanned Asbestos Discovery
Attachment B 6 CCR 1007-2, Section 5 - 10 Day Notification of Planned Asbestos Management
Attachment C 6 CCR 1007-2, Section 5 - Asbestos Waste Management Regulations
Attachment D National Institute for Occupational Safety and Health (NIOSH) Method 7400, Issue 2, 15 August 1994 *(Sampling Methods)*
Attachment E AHERA Method, Appendix A to Subpart E of Part 763 - Interim Transmission Electron Microscopy *(Analytical Methods)*

HERRON® Enterprises USA, Inc.
Hazardous Materials*Mold*Asbestos*Lead Paint
Environmental Services*Industrial Hygienists

Phone (303) 763 9639
Fax (303) 763 9686
E-Mail Lennie.Herron@comcast.net
Website www.HERRON-Enterprises.com
7261 W. Hampden Ave., Lakewood, Colorado 80227-5305

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This Asbestos Contaminated Soil Statewide Management Plan (Plan) has been developed by HERRON® Enterprises USA, Inc. (HERRON®) for the sole use of CDOT and designated contractors or consultants on construction projects statewide, and in compliance with 6 CCR 1007-2 at:

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State of Colorado Department of Transportation
Maintenance & Operations Branch
Property Management Section
Hazardous Waste Unit
15285 S. Golden Road, Building 47
Golden, CO 80401

prepared by Designer

HERRON® Enterprises USA, Inc.
7261 W. Hampden Ave., Lakewood, CO 80227-5305
(303) 763 9639 / Fax (303) 763 9686
E-Mail: Lennie.Herron@comcast.net
Mr. L.P. (Lennie) Herron, Industrial Hygienist

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HERRON® Enterprises USA, Inc.
7261 W. Hampden Ave., Lakewood, CO 80227-5305
(303) 763 9639 / Fax (303) 763 9686
Email: Lennie.Herron@comcast.net
L.P. (Lennie) Herron, Industrial Hygienist

Designer
Certificate No. 2572

1.0 PURPOSE AND OBJECTIVES

The purpose of this Asbestos Contaminated Soils Statewide Management Plan (Plan) will be referred to by the standard construction specifications, which is the most appropriate venue for ensuring immediate compliance without compromising project schedules on multiple projects. The Plan is in accordance with 6 CCR 1007-2 referred to herein as the Solid Waste Regulations, and is structured similarly. Sections of the regulation that do no apply are noted as "Not Applicable" with an explanation, if needed. This Plan has been developed and signed by an Asbestos Project Designer per Solid Waste Regulation No. 5, §5.5.6 (A)(4) who has been certified in accordance with AQCC Regulation No. 8.

The Colorado Department of Public Health and Environment's Hazardous Materials and Waste Management Division (the HMWMD) has established specific management requirements for asbestos-contaminated soil under Section 5.5 of the Regulations Pertaining to Solid Waste Disposal Sites and Facilities (6 CCR 1007-2). The applicability of these requirements is discussed in detail in Section 2 of this Plan.

This Plan is intended to provide direction to CDOT, contractors, consultants, property owners, operators, etc. who are involved in soil disturbing activities in areas with known or suspected asbestos-contaminated soil, or where asbestos-contaminated soil is discovered. The Plan is meant to assist in compliance with the Solid Waste Regulations, and where applicable, Air Quality Control Commission Regulation No. 8, Part B (5 CCR 1001-10, Part B - Asbestos) referred to herein as AQCC Regulation No. 8, Part B. However, it is important that the reader be familiar with the regulations in order to understand the context of the information provided in this Plan. This Plan is not meant to modify or replace the promulgated regulations, which may undergo periodic revisions. In the event of a conflict between this Plan and promulgated regulations, the regulations govern.

2.0 APPLICABILITY OF SOLID WASTE AND AIR REGULATIONS

2.1 Applicability

As specified in Section 5.5.1 of the Solid Waste Regulations, the following paragraphs detail when the Solid Waste Regulations apply to activities involving asbestos-contaminated soil, and when these activities are regulated under AQCC Regulation No. 8, Part B. The regulations include specific requirements that apply *only if* asbestos-contaminated soil is disturbed or will be disturbed.

- The requirements of Section 5.5 of the Solid Waste Regulations apply to the owner or operator of any property with asbestos-contaminated soil at which soil-disturbing activities are occurring or planned for any area containing asbestos-contaminated soil. Section 5.5 does not apply to asbestos waste disposal areas that have a Certificate of Designation. The requirements of Section 5.5 are triggered when the owner or operator has reason to believe or suspect the presence of asbestos-contaminated soil at a site, (such as through confirmation by analysis of observed material that is suspected of containing asbestos), or has reason to believe or suspect that visible asbestos will be encountered.

- Removal of asbestos-containing material on a facility component, that is located on or in soil that will be disturbed, shall be conducted under Section 5.5 of the Solid Waste Regulations, in accordance with work practices in AQCC Regulation No. 8, Part B, Section III.O, but is not subject to the permit requirements of AQCC Regulation No. 8, Part B, as long as the total quantity of asbestos-containing material is below the following trigger levels:

  (1) 260 linear feet on pipes,

  (2) 160 square feet on other surfaces, or

  (3) The volume equivalent of a 55-gallon drum.

  Removal of asbestos-containing material on a facility component with asbestos quantities above the trigger levels is subject to the notification, permit, and abatement requirements of AQCC Regulation No. 8, Part B, and is therefore outside the scope of Section 5.5 of the Solid Waste Regulations, as provided in Section 5.5.2(B) of the regulations.

As described in Section 8.3 of this Plan, the Solid Waste Regulations include minimum training requirements that apply to all persons performing soil-disturbing activities in areas with asbestos-contaminated soil. In addition to theses training requirements, it is suggested (and in some cases may be required by other regulations) that personnel overseeing, directing, inspecting and/or handling asbestos or asbestos-contaminated soil (including suspect asbestos) during characterization activities have the following:

- A current United States Environmental Protection Agency (EPA)/ Asbestos Hazard Emergency Response Act (AHERA) 32-hour Worker, 40-hour Contactor/Supervisor, or 24-hour Building Inspector accreditation.
- A current EPA/AHERA 8-hour refresher course certification.
- Current Colorado asbestos certification for the appropriate discipline.
- A current annual physical with medical release / respirator usage form and respirator fit test.
- All required certificates and licenses should be in accordance with the provisions set fourth in AQCC Regulation No. 8, Part B.

It is suggested that ancillary personnel not directly performing field work, such as QA/QC oversight staff, management, and owner and operator project staff, attend an asbestos awareness class prior to visiting the site.

Upon initial discovery of any suspected asbestos, field personnel should immediately notify a supervisor. The supervisor should take actions necessary to ensure that the suspect material is not disturbed while waiting for the arrival of appropriately trained personnel (as discussed in Section 8.3), including an asbestos Building Inspector to evaluate the material encountered. Trained personnel should stake, flag, or otherwise demarcate suspect materials and notify key personnel such as the project manager, prime contractor, owner, operator, or other responsible entity regarding the location of the suspect materials and the necessary precautions to be taken. Crews working in the vicinity should be warned to avoid that area until directed otherwise. All personnel working on site should be advised and directed to not disturb areas where suspected or known asbestos material is present. Personnel driving onto the site to perform inspections or oversight roll should be notified of suspect or known ACM locations and directed to not drive or otherwise disturb those areas.

2.2 Exemptions

In accordance with Section 5.5.2 of the Solid Waste Regulations, the following projects are exempt from the requirements of Section 5.5 of the Solid Waste Regulations, but may be subject to other sections of the Solid Waster Regulations or other regulatory programs:

- **NonFriable Material Removed From Soil** - In situations where the soil contains solely nonfriable material containing asbestos, that has not been rendered friable, the nonfriable material can be removed from the soil and properly disposed in accordance with Section 5.2 of the Solid Waste Regulations. The surrounding soil would **not** be considered to be asbestos-contaminated soil, and therefore **would not be subject to the requirements of Section 5.5 of the Solid Waste Regulations, or to AQCC Regulation 8, Part B**. The determination that a material is nonfriable must be made by an asbestos Building Inspector who has been certified in accordance with AQCC Regulation No. 8, Part B, and who has a minimum of six (6) months experience in asbestos-contaminated soil inspections (see Section 8.3 - Worker Training).
    - This exemption is typical of pieces of transite that is discovered during the course of the soil disturbing activity which may be relatively collected by separating from the soil.
- **Abatement of Facility Components Are Required Under AQCC Regulation No.8, Part B** - The requirements of Section 5.5 of the Solid Waste Regulations **do not** apply to asbestos abatement of facility components (including pipes, ducts and boilers) conducted in accordance with AQCC Regulation No. 8, Part B. However, disposal of asbestos must still comply with Sections 5.1 through 5.4 of the Solid Waste Regulations.
    - This exemption is a determination that the activity is not regulated by Solid Waste Regulations. Typically a cement pipe may be encountered which remains intact however, would be impacted and require removal during the soil disturbing activity. Should the trigger levels (260 linear feet 'on' pipes, 160 square feet on other surfaces, or a the volume equivalent of a 55 gallon drum) occur, a permit/notice and all requirements under AQCC Regulation No., Part B would apply.
- **Spill Response Conducted Are Required Under Regulation No.8, Part B** - The requirements of Section 5.5 of the Solid Waste Regulations **do not** apply to spill response activities that are subject to the requirements of AQCC Regulation No. 8, Part B. As above, disposal of asbestos must still comply with Sections 5.1 through 5.4 of the Solid Waste Regulations.

- This exemption is a determination that the activity is not regulated by Solid Waste Regulations. An Asbestos Spill Response means any release of asbestos fibers due to a breach of the containment barrier on an abatement project, or due to any cause other than asbestos abatement. Should an Asbestos Spill Response occur, all requirements under AQCC Regulation No., Part B would apply.

- **Ambient Occurrences of Asbestos** - Ambient occurrences of asbestos that are not due to site-specific activities. Ambient occurrences of asbestos may include, but are not limited to, naturally occurring asbestos or the distribution of asbestos from normal wear of automotive products.
- **De Minimis Projects** - Projects involving excavations with a total volume of **less than 1 cubic yard of soil** using low-emission excavation methods such as hand held tools or light equipment.
    - Although projects involving less than the de minimis quantity of less than 1 cubic yard of soil, safe work practices under this Plan should be used.
    - The disposal of asbestos containing materials will comply with Sections 5.1 through 5.4 of the Solid Waste Regulations.

The exemption for asbestos abatement projects conducted under AQCC Regulation No. 8, Part B, includes asbestos debris that may come into contact with soil during demolition of structures containing asbestos containing materials and materials containing trace amounts of asbestos (including trace soil in crawlspaces, loose fill vermiculite, etc) that can legally remain during demolition and be disposed of as normal demolition debris. **Any asbestos debris left behind after the completion of a demolition project (including site cleanup) would be subject to the requirements of Section 5.5 of the Solid Waste Regulations if disturbed in the future.**

3.0 DEFINITIONS

The following terms are defined in Section 1.2 of the Solid Waste Regulations, and their use in this Plan is intended to be consistent with their regulatory definitions. The definitions for friable and nonfriable provided below are taken from AQCC Regulation No. 8, Part B.

"Adequately wet" means sufficiently mix or penetrate with liquid to completely prevent the release of particulate material and fibers into the ambient air. If visible emissions are observed coming from asbestos-contaminated soil or asbestos-containing material, then the material has not been adequately wetted. However, the absence of visible emissions is not sufficient evidence of being adequately wet. Guidance on determining when a material is adequately wet can be found in EPA's *Asbestos NESHAP Adequately Wet Guidance*, EPA340/1-90-019 (December 1990).

"Asbestos" means the asbestiform varieties of serpentinite (chrysotile), riebeckit**e** (crocidolite), amosite (cummingtonite-grunerite), anthophyllite, and actinolite-tremolite.

"Asbestos-contaminated soil" means soil containing any amount of asbestos.

For purposes of the definition, soil which has been shown by a certified laboratory analysis to contain 'any level', including a trace (<1%) asbestos, is contaminated. Any soil area that was previously subject to this definition is not excluded, regardless of its current use or function.

Likely encounters during highway construction would include:

Utility trenches, right of ways, parcels where previous demolitions may have occurred, etc.

"Asbestos waste" means any asbestos-containing material whether it contains friable or nonfriable asbestos, that is not intended for further use. This term includes but is not limited to asbestos mill tailings, asbestos from pollution control devices, and containers that contain asbestos.

"Asbestos-containing material" means any material that contains more than one percent (1%) asbestos by weight, area or volume.

"Asbestos waste disposal area" means an area approved for the disposal of asbestos waste at a solid waste facility, including, but not limited to, a trench or monofill.

"Emergency" means an unexpected situation or sudden occurrence of a serious and urgent nature that demands immediate action and that constitutes a threat to life or health, or that may cause major damage to property.

"Facility Component" for purposes of Section 5.5, means any part of a facility including equipment. For the purpose of this definition, "facility" means (as defined in Air Quality Control Commission Regulation No. 8 (5 CCR 1001-10, Part B):

"any institutional, commercial, public, industrial, or residential structure, installation, or building (including any structure, installation, or building containing condominiums or individual dwelling units operated as a residential cooperative, but excluding: residential buildings having four or fewer dwelling units); any ship; and any active or inactive waste disposal site. For purposes of the definition, any building, structure, or installation that contains a loft used as a dwelling is not considered a residential structure, installation, or building. Any structure,

installation or building that was previously subject to this subpart is not excluded, regardless of its current use or function."

"Friable" means that the material, when dry, may be crumbled, pulverized, or reduced to powder by hand pressure, and includes previously nonfriable material after such previously nonfriable material becomes damaged to the extent that when dry it may be crumbled, pulverized, or reduced to powder by hand pressure.

"Leak tight" means that solids, liquids, or gases cannot escape or spill out. It also means dust tight.

"Management" means the handling, storage, collection, transportation and disposal of solid waste.

"Mechanical" means operated or produced by mechanism or machine. This may include, but shall not be limited to, an excavator, backhoe, grader, tiller, auger, or hand shovel.

"Nonfriable" means material which, when dry, may not be crumbled, pulverized, or reduced to powder by hand pressure.

"**Remediation"** or **"Remediate"** means a cleanup or removal to prevent or minimize the possible current or future release of hazardous substances to prevent an unacceptable threat to present or future public health, welfare or the environment.

"Site" or **"solid waste disposal site"** means the location for a facility chosen based upon geologic, hydrogeologic and operational considerations. For the purpose of Section 5.5 of the Solid Waste Regulations "site" means the area or areas where soil-disturbing activities are occurring or will occur.

"Soil-disturbing activities" means excavation, grading, tilling, or any other mechanical activity used to disturb the soil.

"Structurally rigid container" means a container capable of maintaining its shape when unsupported.

"Visible emissions" means any emissions which are visually detectable without the aid of instruments, coming from material containing asbestos, asbestos waste, asbestos-contaminated soil, or from handling and disposal of asbestos waste, material containing asbestos or asbestos-contaminated soil.

"Working day" means Monday through Friday and including holidays that fall on any of the days Monday through Friday.

The following definitions are terms that either do not have specific regulatory definitions, or the regulatory definitions have been modified or clarified for use in this Plan.

"Air Monitoring Specialist" means a person who performs air monitoring referred to in this Plan and who is certified to perform air monitoring in accordance with AQCC Regulation No. 8, Part B.

"Asbestos Building Inspector" or **"Building Inspector"** means a person certified in accordance with AQCC Regulation No. 8, Part B, to perform asbestos inspection and sampling, and who has a minimum of six (6) months experience in asbestos-contaminated soil inspections.

"Asbestos Supervisor" means a person who has been certified as an asbestos Supervisor in accordance with AQCC Regulation No. 8, Part B.

"Asbestos Project Designer" or **"Project Designer"** means a person who has been certified as an asbestos Project Designer in accordance with AQCC Regulation No. 8, Part B.

4.0 HISTORICAL REVIEW TO DETERMINE THE POTENTIAL FOR ASBESTOS

4.1 Site Historical Review

Prior to disturbance of a soil area, it is recommended that an environmental professional, with experience in conducting historical property use assessments, review available historic site information to evaluate the potential to encounter asbestos. Depending on the past use of the property, it may be warranted to conduct a Phase I environmental site assessment following EPA's *Standards and Practices for All Appropriate Inquiries* and ASTM E1527-05 *Standard Practice for Environmental Site Assessments: Phase 1 Environmental Site Assessment Process*. At a minimum, information regarding the following potential conditions should be reviewed:

- **Historical** site use, including development of site buildings, structures and associated utility corridors on which there is a potential to encounter materials containing asbestos that are potentially within planned pathways of soil disturbance.
- **Past evidence** or information of historical land filling, dumping or grading of potential asbestos and asbestos waste materials.
- **The likelihood of an unexpected discovery** of building(s) and/or structure(s) with the potential of containing asbestos that may be within the pathway of planned soil disturbance.

In instances where the potential to encounter asbestos during excavation is already known, a historical review may not be necessary. Likewise, in situations involving the excavation of existing utility lines, where the presence or absence of asbestos can be readily confirmed, a historical review may not be warranted.

4.1.1 Historical Sources of Information

Historical documents and records may include, but are not limited to, the following sources and physical setting documents. Document review should be at ASTM recommended intervals (typically 5 years, 1 year at change of use or demolitions):

- Facility or site-owner records
- Site-specific foundation, water well and boring and drilling logs, and previous environmental subsurface investigation reports
- Aerial photographs
- Fire insurance maps
- City directories
- Chain of Title documents
- City inspection and land use records
- Municipal and county inspection, occupancy, construction and demolition permit records, and plan review drawings
- Fire response and emergency demolition records
- Federal, state and local agency environmental database records, including locally mapped areas of known landfill and construction waste disposal sites
- Utility corridor construction maps and plans
- USGS, State, and local geologic, and surface soils investigations and maps

Historical documents and records reviewed should cover a period of time as far back in history necessary to define the first use and development of property, and subsequent uses of the property including redevelopment of property for residential, agricultural, commercial, industrial, utility and governmental purposes. In addition to evaluating the various uses of the property, this review should include an evaluation of historic buildings or structures, and the demolition and disposal practices employed when these buildings or structures were removed. Lack of historical information available for review may necessitate an elevated awareness level for planning and protective measures.

Existing data regarding the current physical setting, including soil borings, trenching, ground penetrating radar (GPR) or other geophysical techniques, and industrial metal detectors may be reviewed by the Environmental Professional as an additional physical setting informational element to define actual soil conditions. These methodologies may assist in defining the nature of subsurface structure extent, subsurface buried material nature, and historic utility corridor and piping pathways.

In addition to historical documents, if possible, interviews should be conducted with past and present site personnel with knowledge of past site usage, construction and demolition activities, and on-site disposal and abandonment practices.

4.1.2 Historic Conditions of Concern

High potential of encountering asbestos - A high potential of encountering asbestos will exist where historical information confirms the prior existence of building(s) and or associated structures and utility corridors that potentially contained asbestos, and/or asbestos waste materials related to historic dumping, landfilling, or grading of potential asbestos waste materials. A high potential of encountering asbestos would be a "reason to believe or suspect that visible asbestos will be encountered" under Section 5.5.1 (A) of the Solid Waste Regulations, as discussed in Section 2.1 of this Plan.

Elevated potential of encountering asbestos - An elevated potential of encountering asbestos may exist but is not definitive, if there is information indicating a potential to encounter materials during subsurface activities, indications of past artificial fill use, or fill use of unknown origin. In addition, the lack of data available during the review process may result in an elevated potential to encounter asbestos. Depending on the information available, an elevated potential for encountering asbestos may be a "reason to suspect that visible asbestos will be encountered" under Section 5.5.1 (A) of the Solid Waste Regulation, and may be the basis for further inquiry or assessment.

Low potential of encountering asbestos - A low potential of encountering asbestos exists when physical setting and historic data indicate a minimal potential for past use and or development of the site, and no evidence of past dumping, filling or grading of the site. A low potential for encountering asbestos would *not* be a "reason to believe or suspect that visible asbestos will be encountered" under Section 5.5.1 (A) of the Solid Waste Regulations.

5.0 IMMEDIATE ACTIONS UPON UNANTICIPATED DISCOVERY OF SUSPECTED ASBESTOS-CONTAMINATED SOIL

To minimize potential delays, site owners and operators may proactively collaborate with the HMWMD, in advance of any soil-disturbing activities, site owners and operators will implement this Plan as needed for all future applicable soil-disturbing activities. These standard operating procedures, satisfy the requirement for a Soil Characterization and Management Plan which is intended to cover typical encounters during highway construction.

This section describes the immediate and interim actions to be implemented when unanticipated contact with asbestos-contaminated soil, subject to Section 5.5 of the Solid Waste Regulations, occurs during active construction activities (refer to Section 2.1 of this Plan for applicability of the Solid Waste Regulation). When suspect asbestos-contaminated soils or building debris are discovered during construction activities, the critical requirement is to avoid generating or being in direct contact with airborne soil, thereby limiting potential exposure to asbestos fibers. The following outlines procedures for minimizing the potential release of airborne asbestos when suspect asbestos material is discovered.

- Stop work immediately upon encountering material that is suspected of containing asbestos.
- Demarcate area suspected of containing asbestos with barrier tape, or other means, and provide site access control. Access can be prevented by means of fencing or security personnel.
- Disturb soil as little as possible to perform any initial characterization activities (as described in Section 7, "Site Characterization").
- Wet area immediately with water prior to performing any characterization activity that will disturb the material (visual inspection does not require wetting). Maintain wet conditions throughout site characterization activities. If leaving the site unattended, cover the soil piles with a layer of 6-mil polyethylene (poly), tarps, or spray with magnesium chloride solution in sufficient amounts to wet the soil to prevent drying and dust generation.
- A layer of 6-mil poly may be used to prevent cross contamination onto clean soils during initial characterization activity by placing the poly on the ground and then placing the contaminated soil directly on the poly.
- Generate no visible emissions (dust) during characterization activities.
- Contact an asbestos Building Inspector with a minimum of six (6) months experience conducting asbestos-contaminated soil inspections, and certified in accordance with AQCC Regulation No. 8, Part B, to collect samples of the suspect asbestos materials according to the procedures provided in Section 7 of this Plan. Samples must analyzed by a NVLAP accredited Laboratory using the Polarized Light Microscopy (PLM) Method (Method – EPA/600/R-93/116) to determine if any asbestos fibers are present. Alternatively, suspect material may be assumed to contain asbestos, thus eliminating the need to conduct sampling and analysis.
- Assume clothing and equipment that has come into contact with the suspect asbestos is contaminated until/unless analytical results indicate the material does not contain any asbestos. Workers and equipment should be decontaminated on site and dirt and debris should not leave the immediate work area. Heavy equipment should be left on site after decontamination until analytical results are received. The following procedures can be modified as appropriate based on project scale and the potential level of exposure:

    - Decontaminate workers by removing any visible soil and dust with damp wipes or cloths, or by the use of a HEPA filter equipped vacuum. Place wipes and cloths and in a plastic bag and label as "Investigative waste", "date", and "company name/your name". If additional clothing is available, clothes should be changed and potentially contaminated

clothes should be bagged separately from wipes and cloths (it may be possible to clean these clothes if it is determined that asbestos is present).
    - Decontaminate equipment by removal of gross soils and dust then washing the equipment. Decontamination of equipment should be conducted by a certified asbestos worker wearing proper PPE. Materials used for decontamination should be bagged and labeled as above. Decontamination rinsate water should be collected and filtered to 5 microns prior to disposal off site, or prior to use for wetting of asbestos contaminated areas (not allowed for worker decontamination water). If disposal to the sanitary sewer is anticipated, rinsate water should be filtered to 5 microns, or in accordance with local requirements if more stringent.
    - Based upon analytical results of suspect materials; if asbestos is present (or assumed to be present if sampling is not conducted), dispose of bags by double bagging and disposing of as asbestos waste in a properly permitted landfill. If analytical results indicate that no asbestos is present, bags can be disposed of as non-asbestos solid waste.

- Notify the HMWMD as soon as possible, but no later than 24 hours of discovery of visible material containing asbestos in the soils or asbestos-contaminated soil. In accordance with the Solid Waste Regulations, the notification must, at a minimum, include:

    - Property location.
    - General site description.
    - Description of activities resulting in the discovery of asbestos-contaminated soil.
    - Description of type and amount of material containing asbestos or asbestos-contaminated soil encountered.
    - Description of any access and emission controls already implemented at the site.
    - Property representative's name and phone number.
    - Contact name and phone number for the party performing soil-disturbing activities.

    Verbal notification can be provided during business hour by calling the HMWMD Customer Technical Assistance Line at (303) 692-3322, or by using the Department's 24 hour Spill Line at (877) 518-5608. Verbal notifications must be followed up by a written notification. Written notification can be submitted via facsimile to (303) 759-5355, via email to comments.hmwmd@state.co.us, or by any other means that will ensure that the notification is provided received by the HMWMD within 24 hours.

    The notification will contain all of the descriptions under this Plan for a typical highway construction project. Should the work be extensive beyond what would be considered typical, an addendum to this plan may be developed and signed by an Asbestos Project Designer per Solid Waste Regulation No. 5, §5.5.6 (A)(4) who has been certified in accordance with AQCC Regulation No. 8, and forwarded to CDPHE.

6.0 INTERIM ACTIONS TO PREVENT RELEASE OF AND/OR EXPOSURE TO ASBESTOS FIBERS

Upon confirmation of asbestos in soil, site characterization, according to Section 7.0 of this Plan, may be necessary. Prior to and during the site characterization the following interim actions should be implemented, as necessary, based on the nature and friability of material and the size and location of the project, to prevent release of and/or exposure to asbestos fibers.

- Maintain adequately wet conditions on the site until stabilized.
- Apply stabilizing agents to the soil as needed (note that some stabilizers like magnesium chloride will not work with water).
- Take measures, as necessary, to address asbestos-contaminated soil that may have been tracked to other areas by contaminated equipment. These measures could include stabilizing or covering these areas until they can be addressed under an approved Soil Characterization and Management Plan, or by conducting immediate spill response activities such as cleaning using wet methods and/or a HEPA equipped vacuum methods.
- Construct wind fences or other wind barriers, as appropriate.
- Construct barriers around activity areas.
- Cover soil with 6-mil poly, or equivalent, or spray the soil with magnesium chloride. Securely fasten poly sheeting to prevent removal by the wind.
- In addition to the 6-mil poly, an additional liner construction of reinforced polyethylene or a product similar in strength and durability, can be applied to an adjacent soil surface to prevent cross contamination by truck or heavy equipment movement.
- Reduce traffic speeds for equipment, trucks, and cars through adjacent exposed soil areas.
- Clothing and equipment that have come into contact with the asbestos-contaminated soils should be considered contaminated. Workers and equipment should be decontaminated on site, and dirt and debris should not leave the immediate work area. Decontaminate worker(s) by removing any visible soil and dust with damp wipes or cloths, or by the use of a HEPA filter equipped vacuum. Place wipes, cloths and disposable personal protective equipment (PPE) in a plastic bag and label as “Asbestos Wastes”, “date”, and “company name/your name.”
- Place equipment on a plastic barrier to collect decontamination water for filtering prior to disposal. Decontaminate equipment by removal of gross soils and dust, then wet wash equipment. Again, materials used for wiping should be bagged and labeled as stated above.
- Dispose of bagged decontamination waste materials as asbestos waste in a properly permitted landfill.
- Decontamination water should be filtered to 5 microns prior to disposal off site, or in accordance with local requirements, if more stringent, prior to disposal into a sanitary sewer.

7.0 SITE CHARACTERIZATION

Prior to commencing work in areas with known or suspected asbestos in soil, it is important to understand the nature and distribution of materials that may be encountered. This knowledge can aid in identifying areas where asbestos may be disturbed during excavation, allowing for the potential presence of asbestos to be considered in any plans for development. For instance, development can be planned in such a way that areas with asbestos are not disturbed. The plans could include pavement or open space over areas with asbestos in the subsurface, thus avoiding the need to disturb and manage asbestos-contaminated soil. Alternately, areas with asbestos can be intentionally disturbed in order to remove asbestos and reduce potential future liability. Adequate characterization and planning up-front to properly manage asbestos-contaminated soil can reduce or eliminate project delays and reduce unforeseen costs.

As part of the site characterization process, the owner or operator of a site may decide to perform surface and/or subsurface sampling to confirm or deny the presence of asbestos, and to define the extent of any asbestos-contaminated soil encountered. It should be noted that sampling of asbestos-contaminated soil is not required under Section 5.5 of the Solid Waste Regulations. However, sampling may be required at remedial projects conducted under one of the other regulatory programs discussed in Section 1 of this Plan.

7.1 General Site Description

Prior to commencing any site characterization activities, a pre-work survey should be conducted to assess existing site conditions. This survey should identify any hazards that may be present and that may affect the health and safety of those conducting characterization activities, such as working near overhead and underground utilities. All utilities should be field located prior to commencement of site activities. No drilling or excavation should begin without first notifying the Utility Notification Center of Colorado (UNCC) in accordance with applicable Colorado statutes.

7.2 Type(s) and Condition of Asbestos Material

There are several common scenarios in which asbestos-contaminated soil may be encountered at a site. These include redeveloping urban or otherwise previously developed areas, disturbing former disposal or demolition areas, upgrading utility systems, and disturbing areas where contaminated soil has been disposed. The types of asbestos materials that may be encountered include, but may not be limited to:

Sample List of Suspect Asbestos - Containing Materials

Cement Pipes	Elevator Brake Shoes
Cement Wallboard	HVAC Duct Insulation
Cement Siding	Boiler Insulation
Asphalt Floor Tile	Breaching Insulation
Vinyl Floor Tile	Ductwork Flexible Fabric Connections
Vinyl Sheet Flooring	Cooling Towers
Flooring Backing	Pipe Insulation (corrugated air-cell, block, etc.)
Construction Mastics (floor tile, carpet, ceiling tile, etc.)	Heating and Electrical Ducts
Acoustical Plaster	Electrical Panel Partitions
Decorative Plaster	Electrical Cloth

Textured Paints/Coatings	Electric Wiring Insulation
Ceiling Tiles and Lay-in Panels	Chalkboards
Spray-Applied Insulation	Roofing Shingles
Blown-in Insulation	Roofing Felt
Fireproofing Materials	Base Flashing
Taping Compounds (thermal)	Thermal Paper Products
Packing Materials (for wall/floor penetrations)	Fire Doors
High Temperature Gaskets	Caulking/Putties
Laboratory Hoods/Table Tops	Adhesives
Laboratory Gloves	Wallboard
Fire Blankets	Joint Compounds
Fire Curtains	Vinyl Wall Coverings
Elevator Equipment Panels	Spackling Compounds

It is important to observe the current condition of the materials encountered to determine whether they are friable or nonfriable, and whether the friability of the material could be altered by planned site activities. Determinations regarding the type of asbestos material encountered, and its friability, must be made by an asbestos Building Inspector certified in accordance with AQCC Regulation No. 8, Part B, who has at least six (6) months experience conducting asbestos-contaminated soil inspections.

7.3 Worker Training

As described in Section 8.3 of this Plan, the Solid Waste Regulations include minimum training requirements that apply to all persons performing soil-disturbing activities in areas with asbestos-contaminated soil. In addition to theses training requirements, it is suggested (and in some cases may be required by other regulations) that personnel overseeing, directing, inspecting and/or handling asbestos or asbestos-contaminated soil (including suspect asbestos) during characterization activities have the following:

- A current United States Environmental Protection Agency (EPA)/ Asbestos Hazard Emergency Response Act (AHERA) 32-hour Worker, 40-hour Contactor/Supervisor, or 24-hour Building Inspector accreditation.
- A current EPA/AHERA 8-hour refresher course certification.
- Current Colorado asbestos certification for the appropriate discipline.
- A current annual physical with medical release / respirator usage form and respirator fit test.
- All required certificates and licenses should be in accordance with the provisions set fourth in AQCC Regulation No. 8, Part B.

It is suggested that ancillary personnel not directly performing field work, such as QA/QC oversight staff, management, and owner or operator project staff, attend an asbestos awareness class prior to visiting the site.

Upon initial discovery of any suspected asbestos, field personnel should immediately notify a supervisor. The supervisor should take actions necessary to ensure that the suspect material is not disturbed while waiting for the arrival of appropriately trained personnel (as discussed in Section 8.3), including an asbestos Building Inspector to evaluate the material encountered. Trained personnel should stake, flag, or

otherwise demarcate suspect materials and notify key personnel such as the project manager, prime contractor, owner, operator, or other responsible entity regarding the location of the suspect materials and the necessary precautions to be taken. Crews working in the vicinity should be warned to avoid that area until directed otherwise. All personnel working on site should be advised and directed to not disturb areas where suspected or known asbestos material is present. Personnel driving onto the site to perform inspections or oversight roll should be notified of suspect or known ACM locations and directed to not drive or otherwise disturb those areas.

7.4 Assessing the Presence and Extent of Asbestos

This procedure provides technical guidance and methods that can be used to identify and inspect both surface and subsurface soils when material containing asbestos is discovered during excavation projects. The purpose of this protocol is to allow the inspectors to perform investigations while avoiding any release of fugitive dust.

- Vehicles entering the area must avoid causing the release of fugitive dust. Vehicle operators should be observant and drive in a slow, cautious manner.

- Should the operators observe a suspected asbestos materials, the operator must alter course as necessary in order to avoid direct contact.

- If drilling equipment is used, the point of operation must be misted to eliminate airborne emissions, especially during auger/drill extraction. The auger should be rinsed after it is removed from a soil boring.

- Prior to vehicles exiting the area, vehicle wheels should be decontaminated. Rinsate water should be collected and filtered to 5 microns prior to disposal off site, or prior to use for wetting of asbestos-contaminated areas. If disposal into a sanitary sewer is anticipated, the water should be filtered to 5 microns, or in accordance with local requirements if more stringent.

- Personnel should take measures to minimize tracking asbestos-contaminated soil, including donning appropriate personal protective equipment, and implementing worker decontamination procedures.

The following materials may be needed during the course of discovery, inspection or remediation of soil containing asbestos:

- Appropriate field monitoring instruments (high and low flow pumps, personnel pumps, wind meters, magnifying lens or hand lens, phase contrast microscopy (PCM) microscopes (if trained personnel are onsite), etc)
- Camera
- Field log books
- Personal Protective Equipment (PPE) and cold weather gear as required.
- Tape measure and pin flags
- Garden trowel(s) and/or rakes
- Garden sprayers
- Marked 6-mil disposal bags, sample bags, generator labels, and manifests
- Suitable lab/sample reading area
- Surface soil sample field data sheets and chain-of-custody forms
- Diagrams and/or GPS equipment

7.4.1 Investigation Techniques

The following techniques can be employed during investigations to confirm or deny results of historical review. Emissions control measures should be employed during investigations where asbestos is suspected. It should be noted that sampling of asbestos-contaminated soil is not required under Section 5.5 of the Solid Waste Regulations. However, sampling may be required at remedial projects conducted under one of the other regulatory programs discussed in Section 1 of this Plan.

7.4.1.1 Surface Investigation Techniques

Visual inspections for surface occurrence of suspect asbestos material should be conducted by certified asbestos Building Inspectors, who has at least six (6) months experience conducting asbestos-contaminated soil inspections, using the procedures provided below. The number and size of grids should be determined based on the size of the area to be investigated and any information available regarding potential presence and distribution of asbestos, and the manner in which it came to be located there. For example, if the material appears to have been disposed of in one location the grid size may be scaled relative to that disposal area; however, if the material appears to be randomly distributed, the grid size may need to be altered to reflect this random distribution, in order to be truly representative of the contamination.

- Conduct a shoulder-to-shoulder visual inspection of each grid. This can be done by multiple inspectors at arms length apart inspecting the surface together or a single inspector performing transverse inspections in two directions.
- Flag or demarcate location of any suspect asbestos material discovered in the grid. This may be done by using pin flags or paint, and may be logged into a GPS unit
- If sampling is conducted, care should be taken to ensure that suspect asbestos material is adequately wetted to prevent visible emissions during the sample collection process.
- Collect a sample of suspect asbestos material following the sampling and analytical procedures in Section 7.5 below.
- If no visible suspect material is present, the inspector should note that observation on a site inspection form or field log.

7.4.1.2 Subsurface Investigation Techniques

Drilling methods can be used to assess subsurface occurrences of asbestos. If possible, drilling should be conducted using low emissions techniques such as hand augering or direct push methods. The number and location of borings should be determined based on the size of the site and any information available regarding potential presence and distribution of asbestos, and the manner in which it came to be located there. As discussed above, if the material appears to have been disposed of in one location, only a small number of borings may be needed to characterize disposal area; however, if the material appears to be randomly distributed, a larger number of borings may be needed to reflect this random distribution, in order to adequately characterize potential area(s) of the contamination. The following procedure can be used to assess subsurface asbestos:

- Auger holes should be drilled to a depth that will penetrate native (undisturbed) soil by at least six (6) inches, or to the anticipated depth of a planned excavation. Native soil can be identified based on geotechnical information (i.e., whether soil is consolidated or unconsolidated) and best professional judgment. However, because the identification of native soil is often difficult, this identification should be made by a person who is experience in performing lithologic evaluation and is familiar with local lithology.

- Care should be taken to ensure that suspect asbestos material is adequately wetted to prevent visible emissions during the inspection and sampling process.
- All soil cores should be visually inspected to identify the presence of visible suspect asbestos material. The presence or absence of suspect asbestos should be noted on the soil sampling field log. Any suspect asbestos material present should be sampled and analyzed in accordance with the procedures in Section 7.5 below.
- The presence of asbestos in soil can be assessed by collecting composite soil samples from each soil boring. Composite samples should be made up of five (5) to ten (10) aliquots per soil boring. Soil samples should be collected and analyzed in accordance with the procedures in Section 7.5 below.
- Soil cuttings containing asbestos-contaminated soil should be containerized and disposed of in accordance with the disposal requirements discussed in Section 8.9.4 of this Plan.

Potholing or trenching can be used to visually assess the presence of suspect asbestos material, and to facilitate sample collection. Care should be taken to ensure that soil and any suspect asbestos material are adequately wetted to prevent visible emissions during investigation and sampling activities. Sample collection should be conducted as discussed in Section 7.5.1.2 of this Plan. The following process can be used when conducting potholing or trenching.

- Establish a grid pattern for investigational pits ("potholes") or trenches to assess the area of future soil-disturbing activities or remediation. Conduct a subsurface visual investigation for suspect debris, by digging potholes or trenches at each investigation location. Dig potholes or trenches to a depth of future excavation, or to a depth where there is a high degree of confidence that "native" or "undisturbed" soil is encountered. Flag, photograph and sample any material suspected of containing asbestos or assume material contains asbestos.
- Continue potholing or trenching incrementally in an outward direction from the last piece of debris found, until no suspect debris is noted in any of the pits. Once the outer boundary of the debris field is established, additional potholes or trenches may be required to further define the extent of debris.
- If soil piles derived from trenching or potholes are stored on site, they should be covered with 6 mil plastic or sprayed with as stabilizer such as magnesium chloride.

Ground Penetrating Radar (GPR), Electromagnetic (EM) or other geophysical techniques or studies may be useful tools to detect different soil conductivities or the presence of buried objects, which may suggest previous earthmoving activities, and disposal and abnormal fill area.

7.5 Sampling and Analysis

The sampling and analytical procedures presented in this section are based on techniques that have been used to characterize asbestos in soil at various sites throughout Colorado. As additional projects emerge, and experience at sites with asbestos-contaminated soil increases, these sampling and analytical techniques may be refined or modified. In general, sampling and analysis methods should meet data quality objectives and address the heterogeneous nature of contamination

7.5.1 Sampling Procedures

7.5.1.1 Sampling Suspect Asbestos Material

The following procedures should be used for the collection of samples of suspect asbestos material identified during surface or subsurface sampling:

- Samples of suspect asbestos material shall be placed in appropriate sample containers such as sample bags or jars.
- Care should be taken to ensure that suspect asbestos material is adequately wetted to prevent visible emissions during the sampling process.
- A field sampling form or log book entry should be maintained for each sample. The form or log book entry should contain the location, date and time of each sample, a description of the type of and friability of any suspect material encountered, and any observations made during sample collection.
- Proper chain-of-custody protocols should be followed for all samples collected.

7.5.1.2 Surface Soil Sampling

The following procedures can be used for the collection of surface soil samples:

- Using the grids established for visual inspections (discussed above), collect five (5) to ten (10) random aliquots of surface soil per grid. The actual number of aliquots may vary depending on the size of the area and other site conditions. Depending on the source and distribution of asbestos, and the results of the visual inspections, sampling of all grids may not be warranted.
- Sample aliquots should be collected using a scooping device (stainless steel spoon or equivalent), and transferred to a composite sample container.
- When all aliquots have been collected, the composite sample container should be sealed and labeled with a sample number unique to the grid from which the sample was collected. The sample should be homogenized by the laboratory prior to analysis.
- A field sampling form or log book entry should be maintained for each sample. The form or log book entry should contain the location, date and time of each sample, a description of the type of and friability of any suspect material encountered, and any observations made during sample collection.
- Proper chain-of-custody protocols should be followed for all samples collected.

7.5.1.3 Subsurface Soil Sampling – Drilling/Soil Borings

The following procedures can be used for the collection of subsurface soil samples from soil borings:

- A composite sample should be collected from each soil boring. The sample should be made up of five (5) to ten (10) aliquots representative of the soil boring. The actual number of aliquots may vary depending on the depth of sampling and the conditions observed.
- The first aliquot should be collected from 0-1 inches below ground surface (or depth that is representative of surface conditions), or at the depth at which asbestos is anticipated to be encountered (as in the case of buried utilities).
- Care should be taken to ensure that suspect asbestos material is adequately wetted to prevent visible emissions during the sampling process.
- Sample aliquots should be collected using a scooping device (stainless steel spoon or equivalent), and transferred to a composite sample container.
- When all aliquots have been collected, the composite sample container should be sealed and labeled with a sample number unique to the boring from which the sample was collected. The sample should be homogenized by the laboratory prior to analysis.
- A field sampling form or log book entry should be maintained for each sample. The form or log book entry should contain the location, date and time of each sample, a description of the type of and friability of any suspect material encountered, and any observations made during sample collection.
- Proper chain-of-custody protocols should be followed for all samples collected.

7.5.1.4 Subsurface Soil Sampling – Potholes and Trenches

The following procedures can be used for the collection of subsurface soil samples from potholes or trenches:

- Collect a composite sample made up of five (5) to ten (10) aliquots representative of the soil encountered in the trench or pothole. The actual number of aliquots may vary depending on the depth of sampling and the conditions observed. In addition, it may be warranted to collect separate samples from various strata, with aliquots collected from an individual strata, to better characterize observed conditions.
- Care should be taken to ensure that suspect asbestos material is adequately wetted to prevent visible emissions during the sampling process.
- Sample aliquots should be collected using a scooping device (stainless steel spoon or equivalent), and transferred to a composite sample container.
- When all aliquots have been collected, the composite sample container should be sealed and labeled with a sample number unique to the location from which the sample was collected. The sample should be homogenized by the laboratory prior to analysis.
- A field sampling form or log book entry should be maintained for each sample. The form or log book entry should contain the location, date and time of each sample, a description of the type of and friability of any suspect material encountered, and any observations made during sample collection.
- Proper chain-of-custody protocols should be followed for all samples collected.

7.5.2 Analytical Procedures

Suspect Material - Samples of suspect asbestos-containing material will be analyzed by a NVLAP-accredited Laboratory by PLM methodology using method-EPA/600/R-93/116", to determine if any asbestos fibers are present. Alternatively, samples of suspect asbestos material may be qualitatively analyzed by a NVLAP-accredited Laboratory by TEM methodology, or an equivalent method, to determine if any asbestos fibers are present.

Soil Samples - Soil samples should be analyzed by PLM for bulk asbestos samples (Method – EPA/600/R-93/116). The samples should be homogenized by the laboratory prior to sample analysis. Samples found to have no detectable asbestos fibers by PLM should be qualitatively analyzed by Transmission Electron Microscopy (TEM) to confirm the absence of asbestos.

7.6 Determining Ambient Concentrations of Asbestos

In certain situations, it may be helpful to determine the ambient, or background, concentration of asbestos in soil that is not the result of site-specific activities. It is recommended that all sampling plans, to determine the presence and concentration of background asbestos, be presented to and approved by the HMWMD prior to their implementation.

8.0 MANAGEMENT OF ASBESTOS-CONTAMINATED SOILS

This Section 8 is intended to guide the actions of owners, operators, contractors and consultants when asbestos-contaminated soils are being disturbed. Asbestos-contaminated soil "management" projects are those where soil may be handled, stored, collected, transported and/or disposed of as asbestos-contaminated soil as part of a larger project. Refer to the regulatory definitions of management and remediation, provided in Section 3, for further guidance.

The Owner and Operator under a typical highway construction project should be distinguished. Any asbestos contaminated soils is the property of the Owner, regardless of the soil disturbing activity. As CDOT is required to share right of way by Colorado State Statute, it is the intent of CDOT to comply with the regulations when abandoned utility lines are encountered during construction.

The regions of CDOT will be responsible for determining the existence of utility lines, to the extent there is available information that allows this to be ascertained during the planning stages of various projects. Negotiations and agreement with respective utility companies and local jurisdictions will be the responsibility of each region. This Plan is only for purposes of compliance with the regulations when there are unexpected discoveries and/or compliance by CDOT is required in order to avoid construction delays.

Enforcement of the regulations, as it relates to utility companies or local jurisdictions ("operator"), and any utility lines or risk management issues that may remain after construction, is strictly between CDPHE and the operator.

8.1 General Site Description

In addition to site characterization activities conducted pursuant to Section 7 of this Plan, and prior to commencement of any site operations, a pre-work survey should be conducted to assess existing site conditions. This survey should identify any hazards that may be present and that may affect the health and safety of persons at the site. For example, the survey should:

- determine safe access and movement within work areas, walkways and passageways;
- identify archeological interests, if any;
- identify and assess the risks of working near overhead and/or underground high voltage or telephone lines, if any;
- establish sufficient overhead clearance for power and/or telephone lines, if any;
- assess the risks of working near other overhead and underground utilities; and
- determine the location of sanitary facilities and drinking water sources for project personnel.

All utilities should be field-located prior to commencement of site activities. No excavation should begin without first notifying the Utility Notification Center of Colorado (UNCC) in accordance with applicable Colorado statutes.

The owner, operator, or asbestos contractor may have other work plans applicable to the site which the contractor and consultant should be aware of. Ancillary plans could include, for example, stormwater plans, communication plans, transportation plans, and site health and safety plans. The asbestos contractor and consultant should be familiar with ancillary site plans and should comply with them where applicable.

Special consideration should be given to evaluate other challenges presented by site conditions. For example, wetlands and areas of historical, archaeological and cultural resources should be identified, as may be required by local, State, or federal regulations, prior to commencement of site activities and protected throughout the project. Adverse impacts may be avoided by the use of stormwater control devices or other specific protection measures. Site visitors and workers should be prevented from trespassing on, removing or otherwise disturbing, areas of special consideration.

8.2 Nature and Extent of Asbestos Material(s)

Management of asbestos-contaminated soil does not require a complete delineation of the type or extent of contamination, either in an area where soil disturbance is planned, or on a property in general. However, prior to commencement of soil disturbing activities, it may be beneficial to have an asbestos Building Inspector, who has at least six (6) months experience conducting asbestos-contaminated soil inspections, identify the nature and extent of asbestos material present in the area of planned disturbance so that it may be handled in accordance with a HMWMD approved plan.

Additionally, the asbestos Building Inspector should identify areas of potential or known asbestos contaminated soil in areas surrounding or near the planned work area in order to prevent unintended disturbance. Visible surface contamination should be managed in all cases so as to eliminate the pathway of exposure to uncontrolled asbestos-contaminated soil. Areas of suspect or known contamination should be clearly marked with indicators such as paint and/or flags.

Once the areas of potential or known contamination have been identified, the asbestos Building Inspector should ascertain the friability of asbestos contamination present. A mixture of both friable and nonfriable asbestos in soil shall be managed in the manner prescribed for friable asbestos. Sampling for purposes of waste characterization, if necessary, should be conducted in accordance with sampling procedures presented in Section 7.

8.3 Worker Training

Personnel overseeing, directing, inspecting and/or handling asbestos and asbestos contaminated soil (including suspect asbestos) should have, at a minimum and as appropriate to the activity, the following training and experience as set forth in the Solid Waste Regulations:

- Individuals performing soil-disturbing activities, at sites where asbestos-contaminated soil may be encountered, are required to complete an on-the-job asbestos-contaminated soil awareness training. The training must provide information necessary to perform their duties in a way that ensures compliance with the requirements of Section 5.5 of the Solid Waste Regulations. The training must be conducted by an Asbestos Supervisor, Building Inspector or Project Designer, certified in accordance with AQCC Regulation No. 8, Part B, and who has a minimum of six (6) months experience in asbestos-contaminated soil management.

- Individuals performing soil-disturbing activities, in an area with asbestos waste or asbestos-contaminated soil, are required to complete an asbestos awareness training in accordance with the 2005 OSHA standards set forth at 29 CFR 1926.1101(k)(9)(vii). In addition, the individual is required to complete asbestos-contaminated soil training that provides information necessary to perform their duties in a way that ensures compliance with the requirements of Section 5.5 of the Solid Waste Regulations. The training must be conducted by an Asbestos Supervisor, Building Inspector or Project Designer, certified in accordance with AQCC Regulation No. 8, Part B, and who has a minimum of six (6) months experience in asbestos-contaminated soil management. This training requirement applies to equipment operators but is not required for

drivers of trucks carrying contaminated material for disposal to approved landfills. However, it is recommended that drivers complete an on-the-job asbestos-contaminated soil awareness training.

- Individuals performing inspection and identification of asbestos in soil must have a current asbestos Building Inspector certification in accordance with AQCC Regulation No. 8, Part B, and must have a minimum of six (6) months experience conducting asbestos-contaminated soil inspections.

- Individuals preparing and signing Soil Characterization and Management Plans must have a current Asbestos Project Designer certification in accordance with AQCC Regulation No. 8, Part B.

- Individuals performing air monitoring must have a current Air Monitoring Specialist certification in accordance with AQCC Regulation No. 8, Part B.

In addition, individuals with the potential for exposure to asbestos fibers should be trained in the proper usage of personnel protective equipment and have a current annual physical with a medical release/respirator usage form.

It should be noted that the requirements for six (6) months of asbestos-contaminated soil experience for trainers and inspectors can be satisfied by documenting total time worked on projects involving asbestos in soil, including asbestos projects in crawl spaces and utility trenches.

8.4 Mobilization

8.4.1 Site-Specific Training

As part of the mobilization, all personnel, including superintendents, should receive site-specific training. The training should cover the provisions of the Plan and the HMWMD approved standard operating procedures. This training should also include, at a minimum, the following:

- background of asbestos; including health effects,
- recognition of debris in soil that may contain asbestos,
- controls and notifications to be followed when debris that may contain asbestos is identified,
- the nature of operations that could result in exposure to asbestos,
- spill prevention and contamination reduction techniques,
- proper use, handling and disposal of personal protection equipment (PPE),
- best management practices for the establishment of work zones and stormwater control,
- engineering controls and other measures to prevent contact with contaminants,
- personnel decontamination,
- emergency procedures, and
- equipment decontamination.

8.4.2 Site Preparation

Consistent with Section 8.1, the contractor and consultant should review and maintain utility locations and markers; develop and delineate work zones, haul routes, excavation areas; and identify direct loading

areas so as to minimize the physical impact on the site. Haul routes should be reviewed for conformance with any existing transportation plan and should be compared to site conditions.

8.4.3 Safety Meetings

Daily safety meetings should be conducted prior to the start of each work day. These meetings should focus primarily on the safe completion of the work plan for the day, as well as safe work practices and contingencies associated with the scheduled tasks. Other topics may be discussed as deemed appropriate by site health and safety personnel. New work or different site conditions should be discussed in individual crew or specific crew meetings. At a minimum, daily safety meetings should include and confirm the following:

- delineation of the removal grid system and depth,
- establishment of work zones,
- utility identification,
- haul routes and site access,
- equipment mobilization,
- dust and particulate emissions control,
- water source and weather proofing, and
- fencing and wind break barriers as required.

8.4.4 Spill Response Plan

A spill response plan should be developed to provide a systematic and controlled response to an asbestos-contaminated soil spill that could adversely impact human health or the environment. The spill response plan should be implemented in addition to the other protective measures described in this Section 8. Refer to Section 6 for additional information concerning "Interim Actions to Prevent Release of and/or Exposure to Asbestos Fibers."

8.5 Planned Soil-Disturbing Activities

8.5.1 Horizontal and Vertical Extent of Excavation

During an asbestos-contaminated soil management project, only that soil which will be disturbed during the course of the project, must be removed and properly disposed in accordance with 6 CCR 1007-2, Section 5.5. There is no requirement that the complete extent of asbestos contamination be identified, nor removed.

Accordingly, some asbestos-contaminated soil management projects will result in asbestos-contaminated soil being left in place. Leaving undisturbed asbestos-contaminated soil in place is acceptable as long as there is no demonstrated exposure pathway. For example, if asbestos is visible in the in the sidewall of an excavation, but the lateral extent of the excavation is complete, it is acceptable to cover the asbestos with a 6-mil poly tarp during site work. However, where known or suspected asbestos-contaminated soil is being left in place, it is recommended that a written record, with a surveyed or GPS diagram, be made which identifies the areas of known or potential contamination. An environmental covenant, as discussed in 10.0 of this Plan, is one tool that may be used to document the presence of asbestos-contaminated soil.

Following the removal of asbestos-contaminated soil, appropriate controls should be implemented consistent with this Section 8 to prevent the disturbance of asbestos-contaminated soil remaining in the excavation area but not identified for removal. These areas should be covered with tarp, as described

above, or continuously wetted in order to protect on-site personnel and prevent disturbance and emissions. When appropriate and as determined by the consultant, personnel entering the excavation area should wear appropriate PPE, air monitoring should be conducted in accordance with Section 8.7 and all efforts should be made to prevent the disturbance of remaining asbestos-contaminated soil.

8.5.2 Soil Removal Techniques

Soil removal activities should be conducted in a manner that minimizes soil handling in order to minimize emissions. Emissions are most likely to occur at the point of excavation, and when pushing or moving soils around and at the dumping point (where a large surface area of soil is exposed), with the latter two activities presenting the greatest chance for emissions. Therefore, the staging of soil should be avoided whenever practicable (e.g., excavate the soil and load it directly into the truck), and dumping of soil should be done in a careful and controlled manner, with misting is to control emissions.

It should be noted that misting is not designed or meant to "adequately wet" the soil, but provide a "water curtain" around the soil to contain possible emissions. Adequate wetting of soil should have already occurred before commencing soil disturbance. The key to wetting is to conduct good pre-excavation injection wetting and letting the water soak into the soil. Evenly moist soil throughout will provide the most efficient use of water and the greatest emissions control, with minimal hassle and cross-contamination potential. In contrast, drenching the dirt with a fire hose, may result in using large amounts of water with very little emission control benefit.

Project specific soil removal techniques should be detailed in the Soil Characterization and Management Plan. Though each site will present somewhat unique circumstances, in most cases, the removal of asbestos-contaminated soil should be generally consistent with the protocols described below.

Twenty-four hours in advance of soil disturbing activities, the work area should be adequately wetted to prevent any visible dust emissions that may be generated during mobilization and site setup. In order to prepare the work area, amended water may be applied using a root watering wand or other mechanism to allow sufficient penetration of water into the soil. Injection wetting is preferred over surface wetting to ensure the most even distribution of water. Surface wetting, if not carefully conducted, has the potential to create areas of ponding and mud pits, resulting in work difficult working conditions increased potential for cross-contamination If surface wetting is conducted, it should be done in such a manner as to prevent generation of dust, run-off or splattering. During actual soil disturbing activities, water should be applied to the site of the disturbance as appropriate to suppress any visible emissions.

The contractor and consultant should institute adequate dust control protocols throughout the course of the removal project. Removal of asbestos-contaminated soil should be done with heavy equipment to minimize dust emissions at the point of removal.

Utilizing equipment appropriate to the site conditions (i.e. excavator, mini excavator, backhoe, etc.), soil excavation should proceed within the designated work area. Excavation equipment should be fitted with a spray bar or equivalent system to provide an emissions barrier during the removal process. Additional hand wetting may be accomplished as long as no dust, run-off or splattering results. It is recommended that a dedicated misting station be used at the dump point, that encloses the entire bucket and surface area of soil being dumped. Use of garden hoses may not be adequate to cover the entire area. The dump point is probably the most critical emissions point; therefore, misting at this point is very important.

Excavation of asbestos-contaminated soil must not overreach the bounds of wetting. Excavation should be conducted in lifts small enough to ensure that disturbed soil remains adequately wet. Overreaching is

one of the biggest problems encountered during soil removal, and can be avoided by adequately pre-wetting the site before digging commences.

Generally, removal of asbestos-contaminated soil should begin at one edge of the work area and proceed across to the opposite edge of the planned excavation. Removal should be conducted in a direction to prevent the spread of contamination. Uncontaminated soil in the swing radius of heavy equipment should be covered with poly to prevent contamination during removal activities. The bucket should only be filled to 2/3 their capacity to eliminate the chance of spillage.

At all times, an asbestos Building Inspector, certified in accordance with AQCC Regulation No. 8, Part B, should monitor the work area under active removal. Should any area under active removal prove too large for adequate stabilization of asbestos-contaminated soil, the work area should be reduced. All asbestos-contaminated soil which is not under active removal should be adequately stabilized in order to prevent the spread of contamination.

If at any time visible emissions are observed, all removal activities should immediately cease until such time as the work practices are altered so as to prevent further visible emissions. Occurrences of visible emissions should be recorded in the site record.

Each excavation should be monitored and visually inspected by the contractor and an asbestos Building Inspector during removal activities. If subsurface anomalies are encountered (such as unexpected debris or materials), the contractor and consultant should stop all work and notify the owner/client, and operator. Work should then proceed only when directed by the site safety officer and the consultant.

Air monitoring should be conducted in accordance with Section 8.7 during asbestos-contaminated soil removal activities. Air samples should be collected to ensure personnel protection as well as measure the adequacy of engineering and environmental controls employed in the work areas.

8.5.2.1 Excavation Equipment and Placement of the Excavator

Equipment to be used for removal of asbestos contaminated soil will vary depending on the site-specific conditions. Equipment appropriate to topography, soil type and other field conditions should be used. All excavation equipment should be decontaminated in accordance with Section 8.8.7.

The contractor and asbestos consultant should establish site access controls for each individual and primary work area in accordance with the procedures described in this Section 8. These controls should allow for the incorporation of a contamination reduction zone to be utilized for the dry decontamination of heavy equipment (buckets, tires and tracks) between work areas if needed.

Every attempt should be made to keep the excavation equipment on clean or non-contaminated soil. In the event the excavator must be placed onto asbestos-contaminated soil, the following or similar engineering controls should be implemented to avoid contamination:

- place a suitable impermeable lining (e.g., plastic) over contaminated soils,
- import rocks, recycled asphalt road material, or clean soil, etc., and place on the liner over the impacted area,
- use an alternate (rubber tired) excavator,
- utilize barriers (plywood, plastic, railroad ties) on impacted soils taking care to decontaminate such barriers before reuse in other areas.

At the completion of the project, all contaminated lining and fill materials must be decontaminated or disposed of as asbestos waste material. Equipment should be decontaminated as described in 8.8.7 of this Plan.

8.5.2.2 Direction to Prevent Spread of Contamination

The excavation protocols should include control for any asbestos-contaminated soil which might fall from excavation equipment. Asbestos-contaminated soil falling within the work area should fall only on the contaminated portion of the work area or else should be removed by the equipment operator prior to completion of the remaining work area. Asbestos-contaminated soil falling onto the plastic-lined load station should be cleaned and added to the truckload prior to the truck moving off the plastic, or cleaned after the truck leaves the plastic and added to the next truckload. The excavator and load station should be moved as required to complete multiple work areas.

Stormwater will be managed in accordance with the Water Quality Control Commission's stormwater regulations (5 CCR 1002-61), that includes specific stormwater permitting and management requirements for construction sites. The Department's Water Quality Control Division should be contacted to determine the specific requirements for each project.

When feasible, the contractor should direct load excavated asbestos-contaminated soil into the beds of properly lined trucks that will haul the soil for disposal. Refer to Section 8.9 for further information on accepted waste handling and disposal practices. A plastic-lined load-out station should be created close to the edge of each work area. Trucks that will transport asbestos-contaminated soil to an approved disposal facility should be directed onto the load-out station.

8.6 Site Access Control

Every attempt should be made to prevent unauthorized site access. One means of preventing access is the installation of portable fence panels to enclose work areas and posting appropriate warning signs in visible locations. Both the contractor and asbestos consultant should be responsible for limiting access to the work site and only authorized personnel should be allowed on site in accordance with the project health and safety plan. All personnel should sign in and out as they enter and leave designated work areas.

8.7 Air Monitoring

During the removal of asbestos-contaminated soil, the Air Monitoring Specialist should collect air samples to assist in determining the adequacy of engineering and environmental controls employed at the site. In addition, personal air monitoring should be performed in accordance with OSHA requirements.

Air samples should be collected inside each work area. It is suggested that samplers be placed on personnel in the work area. The goal is to collect information regarding worst-case emissions by collecting samples as close to the area of soil disturbance as possible. In all cases the sample points must be located to capture the worst-case emissions during that particular activity. The sample locations should not be fixed, and should be changed as necessary to keep pace with the point of excavation and loading.

It is recommended that all samples be collected on 25mm cassettes and submitted for TEM analysis to a NIST NVLAP accredited laboratory. Although analysis using Phase Contrast Microscopy (PCM) is commonly done during asbestos abatement projects, TEM analysis is preferred for asbestos-contaminated

soil projects since decisions regarding the adequacy of work practices and engineering controls are ultimately made based on the results of TEM analysis. If samples are submitted for PCM analysis, at least two samples (one sample for the highest PCM result and one randomly selected among the remaining samples) should be analyzed by TEM each day that active asbestos-contaminated soil removal activities are being conducted. The results of TEM sampling will be used to assess the adequacy of work practices and engineering controls to determine if adjustments are necessary. If the controls are deemed adequate by the asbestos consultant and the HMWMD, the number of daily TEM samples may be reduced; however, the frequency of TEM samples should be increased, if at any time, subsequent PCM air samples indicate an increase in emissions.

All samples collected should be delivered to the laboratory at the end of the workday using appropriate chain-of-custody procedures. PCM verbal results should be made available to the consultant and the contractor before work begins the following day. TEM verbal results should be made available to the consultant and the contractor within 24 hours of receipt of samples by the laboratory. Hard copy results should be on site within 24 hours of verbal communication, or as soon as practicable.

Notification of Positive TEM Results - After TEM analysis of personal and work area samples, if an air sample contains any concentration of airborne asbestos fibers, the HMWMD should be notified immediately, via one of the methods provided in Section 5 of this Plan. Work practices and engineering controls should be modified to reduce emissions. If subsequent air monitoring results indicate that work practices and engineering controls are still not adequate, soil removal activities should cease and a control plan be developed and submitted to the HMWMD. Soil removal should not continue until the HMWMD provides written authorization to proceed.

8.8 Dust Control/Emissions Control Measures

Dust generated during removal activities presents a potential impact to air quality. Soils contaminated with asbestos present an even greater threat and pose a risk to human health and the environment. Accordingly, dust suppression and emissions controls are critical elements of asbestos-contaminated soil removal activities.

Whenever potentially contaminated soils and debris are being disturbed, the contractor and asbestos Building Inspector should be on site at all times that asbestos contaminated soil is removed to ensure that no visible emissions are generated at any time during soil-disturbing activities. An asbestos Building Inspector should be on site at all times to monitor the moisture of the asbestos-contaminated soil being removed and to ensure that it is adequately wet. If visible emissions are observed during the removal process, work practices should be reviewed and modified by the contractor and asbestos Building Inspector.

At no time should vehicle traffic be allowed on surfaces where the surface samples have shown positive test results. In addition to restricted access for vehicles, all other vehicle access should only be allowed to occur on a reinforced, tear-resistant polyethylene sheeting or equivalent liner. This excludes equipment that is to remain off road throughout the project. The off-road equipment may travel on soils that have been excluded for surface contamination and have been saturated for the control of visible emissions.

The prevent the possible cross contamination of clean surfaces, a 6-mil polyethylene sheeting should be placed over clean surfaces in the vicinity of the work area. In addition, reinforced, tear-resistant polyethylene sheeting or equivalent liners should be applied to surfaces where truck traffic will be moving from the work area onto non-surface contaminated soils.

Potential dust emissions from stockpiled soils should be mitigated by the application of water or stabilizing agents (such as magnesium chloride), and/or by covering with tarps or other appropriate cover material.

8.8.1 Soil Wetting or Stabilizing

A continuous water supply (i.e., water truck, water tanks, fire hydrant and fire hose, etc.) should be available at all times during removal activities. The water truck or water hose should be capable of applying water or a water mist directly to the ground surface to minimize dust and prevent emissions.

A misting system localized to the work area should be installed prior to removal activities. The water misting system should be constructed out of PVC piping or equivalent materials that will generate a low energized mist of water droplets large enough to minimize drift but fine enough to control any fiber emissions generated from the work area without over-saturation of the soil. There are two types of misting systems that can be utilized; one type is mounted around the immediate excavation area and one type is mounted on the equipment. Ground mounted misting systems are very effective on small excavations. Equipment mounted misting systems are typically not as effective as ground mounted systems; however, they are generally used on large excavation projects because the use of ground mounted misters is usually not practical for work in large areas. In addition, if improperly designed, ground mounted misters can cause a buildup of water; however, if fine misters are used with a wind fence, ground mounted misters work much better than equipment mounted misters.

Prior to commencing any removal activities, a root watering system should be used to saturate soils beneath the surface and the surface soil should be sprayed with amended water to suppress any dust migration or visible emissions within the work area. Sufficient time should be allowed for the amended water to penetrate the surface prior to the commencement of work. The root watering system should be utilized initially at least 24 hours in advance of the commencement of work and repeated as necessary to ensure adequate saturation of soil prior to removal activities.

During the removal process, all areas of impact should be kept adequately wet. Wetting may be accomplished with amended water (water to which surfactant chemicals have been added), such as a 50:50 mixture of polyoxyethylene ester and polyoxyethylene ether, or the equivalent, in a 0.16 percent solution (1 ounce to 5 gallons) of water. The amended water should be applied at low pressure so as not to generate dust or splattering.

Soil should have water or amended water applied at the point of contact. The excavator or other removal equipment should handle the material wet and direct load the soil into a tractor trailer or other appropriate waste container. The trailer or other waste container should contain a leak tight container constructed out of 6-mil polyethylene sheeting. In addition to the point of impact wetting, additional wetting should occur within the trailer or waste container itself to provide additional emissions control at the point of loading.

8.8.2 Wind Break Barriers

Wind break barriers should be constructed prior to commencement of removal activities. Wind break barriers should be constructed out of materials appropriate to site conditions. For example, temporary chain link fencing at a level of approximately 6 feet in height with fence screen installed and fitted to each panel may be used to assist in controlling any potential migration of dust and debris throughout the removal process. All wind speed measurements should be taken inside any wind break barriers and in locations in close proximity to, and representative of, the work area in which the soil is being handled.

8.8.3 High Wind Work Stoppage

Shutdown conditions – Soil removal/disturbance operations should immediately and temporarily cease when one or more of the following 4 conditions have been met:

- any wind gust reaches or exceeds 20 miles per hour as determined by hand-held instruments;
- sustained wind speeds reach or exceed 12 miles per hour averaged over a period of 10 minutes;
- winds produce visible emissions or create movement of dust or debris in or near the removal/disturbance areas or the loading areas; or
- winds impact the ability of engineering controls to work as designed.

During wind-related work shutdowns, other work activities not involving soil removal or disturbance (e.g. lining dumpsters) may continue.

Startup conditions – Soil removal/disturbance operations may resume after all of the following 4 conditions have been met:

- all wind gust readings, for a period of 20 minutes, drop below 20 miles per hour as determined by hand-held instruments;
- sustained wind speeds are below 12 miles per hour averaged over a period of 20 minutes;
- winds are no longer producing visible emissions or creating movement of dust or debris in or near the removal/disturbance area; and
- winds are not impacting the ability of engineering controls to work as designed.

8.8.4 Covers

Exposed clean surfaces within the work area should be protected with 6-mil polyethylene sheeting or an equivalent cover to eliminate the potential for contamination during removal of soil within the work area.

Exposed asbestos-contaminated soil should be covered or otherwise stabilized during high wind work stoppages.

8.8.5 Containment Structures

In some cases, construction of containment structures will be appropriate in order to eliminate the potential release of asbestos dust emissions to adjacent facilities/locations, and in order to protect human health and the environment.

When greatly diffuse contamination is encountered, or relatively high concentrations of asbestos are present in the soil (e.g., soil with greater than 1% asbestos content and no visible asbestos debris), or when the soil matrix is loose (i.e., the soil does not bind well to the asbestos and, therefore, does not help control emissions), it may be necessary to construct a containment system over the work area. Containment systems can range from pre-engineered tent structures that are relatively large and easy to erect, to basic site built tents made with reinforced polyethylene sheeting mounted on site fabricated structures. Containment barriers must be placed under negative pressure with HEPA filtered fan units to further prevent emissions. Containment systems provide the greatest emission control and facilitate faster excavation through minimizing interruption in production from high wind events, poor weather conditions, unfavorable soil absorption rates (e.g., wetting becomes less critical because of the other engineering), etc. The most difficult problem with a containment system is the decontamination of the waste trucks. This problem is not technically insurmountable, but if not designed properly can

substantially lower the cost-benefit on the containment system. Even if not necessarily required by law, it is recommended that exterior containment systems be designed and installed by licensed asbestos abatement contractors (as they have expertise in designing and maintaining exterior containment systems).

In addition, containment structures may be necessary under Regulation No. 8, Part B, if the work involves buried pipes that are covered in asbestos-containing materials with quantities in excess of the trigger levels; which are 260 linear feet on pipes, 160 square feet on other surfaces, or a volume equivalent of a 55-gallon drum. In such circumstances, it may be preferable to establish a containment structure prior to excavation of buried pipes since it is very common to find that pipes have been disturbed in the past, resulting in loose asbestos and asbestos-contaminated soil.

8.8.6 External Critical Barriers for Nearby Structures

In some cases, construction of external critical barriers may be necessary for the protection of structures or people located near the work area.

When the abatement area is close to other structures, and within the potential airshed of those structures (such as occupied structures within 50' of the work area), the owners of the structures should be advised of the potential hazards and the abatement contractor should offer to seal openings to the adjacent structure(s) to prevent fiber migration into the structure(s). The "airshed" can be thought of as an area in which air mixes freely; that is, pollution generated at any point within an airshed will be more or less equally distributed throughout. Practical determination of the airshed could be made through using smoke generators to determine characteristic airflow patterns. Any windows, doors, vents or other openings that are within the airshed are considered "critical openings." The so-called "critical barriers" that seal these openings usually consist of 6-mil polyethylene sheeting, sometimes reinforced sheeting, which is secured with spray glue, tape and sometimes staples or furring strips.

Vents that cannot be sealed, such as furnace combustion vents in homes, should be ducted out of the air shed using flex ducting. Vents with "tight-sealing" flappers, such as certain types of household dryer vents, need not be covered.

8.8.7 Equipment Decontamination

All excavation equipment should be thoroughly cleaned before being mobilized to the work area. Cleaning procedures should be conducted in such a manner as to ensure that all residual soil and contaminants are removed and other hazards are not present. Equipment should also be inspected for leaking fluids in order to prevent introducing other contaminants to the site. Leaking equipment should not be allowed on site.

Once the removal process has been determined complete, decontamination of the equipment should occur within a waste container when possible. The equipment that was in contact with the contaminated material should be thoroughly cleaned using water (or amended water) and rags. The water and rags should be containerized, and the container then sealed for transportation and disposal. The final decontamination of equipment should occur within a catch basin, constructed out of 10 mil polyethylene sheeting and at least 12 inches deep for the purposes of collection and filtration of the water generated during the decontamination process. Decontamination water should be filtered to 5 microns prior to collection for offsite disposal or being discharged into a contaminated soil loaded truck. Alternatively, the filtered decontamination water can be used for wetting of asbestos-contaminated areas. Disposal into the sanitary sewer may be allowed after filtration to 5 microns, or to local requirements if more stringent.

All vehicles that were used in the intrusive removal activities should receive a thorough and invasive cleaning, as described above, prior to being removed from the site. Each vehicle should receive a documented inspection, by an asbestos Building Inspector, prior to its demobilization.

8.8.8 Worker Decontamination

A fully functioning decontamination unit or trailer should be utilized at each site. The decontamination unit should be located within 100 feet of the property and as near the removal area as practical. The decontamination unit should consist of 3 chambers, should have fully operational hot and cold running water, adjustable at the shower tap, and a functioning water filtration unit that will filter the waste water down to 5 microns prior to being drummed for offsite disposal, or discharged into contaminated soil loaded truck. If disposal into the sanitary sewer is anticipated, water should be filtered to 5 microns, or local requirements if more stringent.

Workers should wear a clean outer protective suit as they exit from the work area to the decontamination area. Workers should either double suits and remove the exterior suit or don a second, clean suit over the single suit within the work area prior to moving into the decontamination unit. The decontamination unit should be utilized by the workers each time they exit the work area. Workers may not wear street clothes under suits.

8.9 Waste Handling

8.9.1 Loading

Removal of asbestos-contaminated soil should be conducted utilizing a direct load system when possible. Asbestos-contaminated soil should be removed wet and transported directly from the contaminated work area to a waste container that contains a minimum 6-mil polyethylene sheeting, leak tight disposal bag. Soil that contains visible friable asbestos must be loaded into a waste container that contains at least two 6-mil polyethylene sheeting, leak tight disposal bags, in accordance with the disposal requirements for friable asbestos waste (Section 5.3.5(A) of the Solid Waste Regulations). Once each dump has been executed within the disposal container, the excavator should return the bucket to a closed position prior to returning to the specific area undergoing removal activities.

While the excavation equipment operator is loading the disposal container, the walls of the container should act as the wind break barrier until the load is wrapped and ready for disposal. During the process of loading the container, the excavation equipment operator should lower the bucket as close as possible to the interior of the container before dumping, and dump the load slowly to allow adequate misting. The loading site should be equipped with a dedicated misting station on the opposite side of the disposal container (opposite the loading point). This misting station must be provided with enough water pressure and personnel to ensure that the entire surface area of the dump is shrouded in the mist. The most effective misting system is a prefabricated misting bar that can be quickly hooked on the edge of the disposal container and water turned on with a single valve (the bar is almost as long as the container so that mist/spray covers the entire container). If personnel are used to mist the loads manually, they should be positioned on a scaffold system that runs the length of the disposal container. The number of personnel and hoses is dictated by the ability to mist the entire surface area of the dump.

Throughout the entire loading process, water or amended water should be applied to suppress any visible emissions that might occur. The swing radius of the excavator should have a 6-mil polyethylene liner over the clean surface to control cross contamination as material is transferred. In addition, the excavation bucket should not be filled to more than 2/3 its normal capacity so as to minimize spillage.

Once the trailer or container has been loaded to a safe level for transportation, it should be sealed within the 6-mil polyethylene sheeting container and transported for disposal. Each vehicle will receive a documented inspection, by an asbestos Building Inspector, prior to it leaving the site. This will include an inspection of the tailgate to ensure that is securely latched and chained to prevent it from opening during transportation.

8.9.2 Packaging

Containers or trucks should be lined with a minimum of one 6-mil thick pre-formed polyethylene liner (do not use roll poly). In accordance with the disposal requirements for friable asbestos waste (Section 5.3.5(A) of the Solid Waste Regulations), at least two 6-mil polyethylene liners must be used for soil that contains visible friable asbestos. Polyethylene liners should be designed and sized for the container to be used and should be folded over sides of trailers or containers to protect against contamination during loading and to facilitate decontamination. After loading, both liners should be sealed separately. The liners must be sealed in a manner that ensures that they remain then leak-tight during transportation and disposal operations.

Containers of friable asbestos waste, or asbestos-contaminated soil with visible friable asbestos, must be labeled, in accordance with the requirements of Section 5.3.5 of the Solid Waste Regulations, using one of the following legends in type at least 5 inches tall:

(1)	CAUTION CONTAINS ASBESTOS AVOID OPENING OR BREAKING CONTAINER BREATHING ASBESTOS IS HAZARDOUS TO YOUR HEALTH
(2)	DANGER CONTAINS ASBESTOS FIBERS AVOID CREATING DUST CANCER AND LUNG DISEASE HAZARD

In addition, Department of Transportation (DOT) asbestos placards should be placed on all four vertical sides of the container or vehicle being used.

Containers of nonfriable asbestos waste, asbestos-contaminated soil with visible nonfriable asbestos, and asbestos-contaminated soil with no visible asbestos, should be labeled noting “asbestos, danger” and the generator, and placed on top of sealed liner. DOT asbestos placards should be placed on all four vertical sides of the container or vehicle being used.

8.9.3 Transportation

The asbestos contractor should direct the schedule of transportation of asbestos-contaminated soil. When loaded, each truck should be assigned a manifest to serve as the shipping document for that particular load. Asbestos-contaminated soil must be transported and disposed in a leak tight container in accordance with the disposal requirements discussed in the following section. Documentation stating that the soil originating from the site shall not be used a daily cover or sold as clean fill must accompany each load of asbestos-contaminated soil removed from the site.

8.9.4 Disposal

Disposal of asbestos-contaminated soil must be conducted in accordance with the following requirements, in accordance with Section 5.5.7 of the Solid Waste Regulations:

- Asbestos-contaminated soils containing visible friable asbestos shall be disposed in a leak tight container as friable asbestos waste in accordance with the requirements of Section 5.3 of the Solid Waste Regulations.
- Asbestos-contaminated soil containing only visible nonfriable asbestos, that has not been rendered friable, shall be disposed of as nonfriable asbestos in accordance with Section 5.2 of the Solid Waste Regulations.
- Asbestos-contaminated soils containing no visible asbestos shall be disposed in a manner similar to nonfriable asbestos waste, as described in Section 5.2 of the Solid Waste Regulations.
- Soils that are not asbestos-contaminated, based on analysis showing no detectable amounts of asbestos, may be replaced into the disturbed area as needed, used as fill, or disposed of as solid waste.

Section 5.7 of the Solid Waste Regulation also requires that documentation stating that the soil originating from the site shall not be used as daily cover or sold as clean fill accompany each load of asbestos-contaminated soil removed from the site.

8.10 Clearance

Asbestos-contaminated soil management projects do not require final clearance sampling, unlike asbestos-contaminated soil remediation projects. However, the asbestos consultant should conduct a final visual inspection of the area of asbestos-contaminated soil removal to determine what, if any, controls must be instituted to allow future activity in the excavation area. For example, if asbestos remains in the sidewalls of an excavation, a determination should be made by an asbestos Building Inspector or the asbestos contactor as to whether personnel entering the excavation must wear PPE, air monitoring must be conducted or temporary or permanent liners should be installed over asbestos-contaminated-soil left in place. Due to the wet nature of the removal process, adequate drying time should be allowed before a final visual inspection is conducted. In some cases, it may be beneficial to conduct a pre-final visual inspection while the area is moist, as it may be easier to see some forms of asbestos when they are still wet (this is not true with some types of asbestos-containing materials, such as aircell or Transite). However, final visual inspections may only be conducted when soil is dry.

8.10.1 Backfilling Excavation

The excavation should be backfilled only after final visual inspection by the consultant to allow for the implementation of appropriate controls. Backfilled soil should be protected with adequate covers if additional removal activities are to occur in other areas of the site.

8.10.2 Designation of Cleared Work Areas

New flagging or other means of visual communication should be utilized to show that a particular work area has been excavated and work is complete. Completed work areas may be utilized as haul routes or for other site access provided appropriate controls are instituted to prevent contamination of these areas.

8.11 Demobilization

After the project has been determined complete, the contractor should remove the misting system, break down the wind break barriers and other fencing and de-mobilize the decontamination trailer/unit.

Waste containers should be removed from the site and taken to an approved landfill for disposal immediately upon completion. Any remaining protective barriers should then be removed from the site.

8.12 Close-out Report

The contractor and consultant should maintain complete documentation of the project. A project close-out report should be prepared and should, at a minimum, include the following:

- property description and description of area(s) with asbestos-contaminated soil;
- description of soil disturbing activities;
- description of all field operations or daily logs;
- containment logs (where appropriate);
- air monitoring logs and analytical results;
- description/results of all asbestos sampling events, including sample locations;
- analytical results;
- disposal summaries and manifests;
- maps showing excavation profiles;
- maps showing the location of any asbestos left in place (where appropriate);
- description of any engineering or institutional controls for any asbestos left in place
- photographs showing pre- and post-removal conditions; and
- worker certifications.

Project close-out reports for asbestos-contaminated soil management projects are not required to be submitted to the HMWMD. In addition, submittal of project close-out reports is not required for remediation projects conducted under Section 5.5.5 of the Solid Waste Regulations.

9.0 REMEDIATION OF ASBESTOS-CONTAMINATED SOIL

This Section 9 is intended to guide the actions of owners, operators, contractors and consultants when asbestos-contaminated soil is being totally or partially remediated pursuant to a HMWMD approved plan under Section 5.5.5 of the Solid Waste Regulations, or other remedial program as discussed in Section 1 of this Plan. Asbestos-contaminated soil "remediation" projects are those where the owner, operator, contractor and consultant intend to remediate asbestos-contaminated soil to a specific concentration, or based on specific risk criteria (referred to herein as "remediation objectives") as defined in the remediation plan. Refer to the regulatory definitions of "management" and "remediation" provided in Section 3, for further guidance.

Unless indicated otherwise below, all provisions of Section 8 "Management of Asbestos Contaminated Soils" should be considered and incorporated where appropriate in any Soil Characterization and Management Plan submitted to the HMWMD pursuant to Section 5.5.5 of the Solid Waste Regulations.

9.1 Risk Assessment and Site Characterization

The property owner may wish to conduct a site-specific risk assessment to evaluate potential risks of exposure to asbestos-contaminated soil left in place. The risk assessment should consider future uses of the property and whether any engineering or institutional controls are needed to manage future risk of exposure.

Local jurisdictions and utility companies are responsible for site-specific risk assessments and evaluating potential risks of exposure to asbestos-contaminated soil left in place, and regulatory compliance, beyond construction. CDPHE is responsible for enforcement of the regulations and any risk assessment or management plan that may be required beyond construction and outside the perimeters of the construction project.

9.2 Clearance Sampling and Inspection

After asbestos-contaminated soil has been excavated to the appropriate depth as established by the consultant, the work area should be confirmed clean through post-excavation sampling and visual inspection. If sampling does demonstrates the site has not been remediated to remediation objectives, additional excavation should be performed. Final visual inspections and final clearance sampling should be conducted after remediated areas have been allowed to dry.

Only a certified asbestos Building Inspector with a minimum of 6 months experience in asbestos-contaminated soil abatement may clear an asbestos-contaminated soil remediation project. In order to avoid potential conflicts of interest, it is recommended that the certified asbestos Building Inspector be an employee of the independent asbestos consultant hired to oversee the remediation project and not an employee of the contractor performing the remediation.

9.2.1 Visual Inspection

As removal activities progress, visual inspections should be performed to ensure that all visible asbestos-contaminated soil has been removed from the work area. Inspections by the asbestos Building Inspector should be performed for each work area remediated on a daily basis; typically at the end of the each work day, but may be conducted more frequently. If visible contamination will be allowed to remain over-night, the area should be stabilized with an appropriate cover so as to prevent disturbance of the material and visible emissions.

Final visual inspection should be conducted when the contractor calls for inspection upon completion of remediation activities. Due to the wet nature of the remediation process, adequate drying time should be allowed before a final visual inspection is conducted (see section 9.2 immediately above).

The final visual inspection should consist of at least 2 passes over the entire area with one pass in one direction (e.g., East-West) and the subsequent pass going perpendicular to the first pass (e.g., North-South). The inspector should use invasive inspection techniques, such as periodically raking or digging through the surface and closely inspecting the disturbed area. Detailed close examination and sifting of the soil in multiple, 10' x 10' test grids scattered throughout the area is also recommended in addition to the passes described above. Final visual inspections must be conducted with adequate lighting; early morning or late afternoon inspections should generally be avoided because of shading. It is important to note that a final visual inspection of soil, while a valuable and important tool for determining project completion, is not very reliable even when conscientiously performed; hence, there is no substitute for a good soil characterization and project design for over excavating contaminated soils (i.e., knowing where the native soil horizon is and excavating well past this horizon to ensure complete removal), employing good soil abatement practices and instituting positive controls against cross-contamination.

The presence of any visible asbestos-contaminated soil will not pass final visual inspection. If visible asbestos-contaminated soil is observed, the area should be adequately wetted and additional excavation should be conducted. A subsequent visual inspection should be conducted after each additional excavation event until the area passes. Generally, because of the inherent limitations associated with visual inspections, if one piece of debris is found it is likely that more debris is present, but hidden from view.

In the event that not all asbestos-contaminated soil will be remediated, the contractor, under direction from the asbestos Building Inspector, should proceed in accordance with a HMWMD approved plan for clearance of the work area.

9.2.2 Soil Sampling

Once a certified asbestos Building Inspector has determined that the remediation has passed visual inspection, the following protocol can be followed, in addition to sampling procedures presented in Section 7.0 of this Plan, for collection of clearance bulk samples from the excavation.

a. After the desired depth is attained in each work area, collect one composite, made up of five (5) to ten (10) aliquots, from exposed excavation floor and each exposed sidewall. The actual number of aliquots may vary based on the size of the area and other observed conditions.
b. Submit composite samples to a NVLAP-accredited laboratory for asbestos PLM analysis.
c. Review results to determine whether depth and extent of excavation are adequate or if over-excavation is required.
d. If depth of excavation is not adequate (based on analytical results of floor screening samples), then excavate an additional 6 inches and collect another composite floor sample as directed in (a).
e. If extent of excavation is not adequate (based on analytical results of sidewall screening samples), then remove an additional 6 inches from appropriate sidewall(s) and collect additional sidewall sample(s) as directed in (a).
f. Repeat removal and sampling cycle until results are below remediation objectives.

The excavation should be backfilled only after final visual inspection and final clearance sampling demonstrate that asbestos-contaminated soil has been remediated in accordance with the HMWMD

approved remediation plan and Soil Characterization and Management Plan. Backfilled soil should be protected with adequate covers if additional removal activities are to occur on the site.

In certain situations, sampling may not be necessary to verify completion of remedial activities. Examples may include excavation of a disposal or fill area where the boundaries of waste or fill are known or can be identified based on the presence of native (undisturbed) material or other change in condition indicative of non-impacted soil.

9.3 Close-out Report

The contractor and consultant should maintain complete documentation of the project. A project close-out report should be prepared, as described in Section 8.12 of this Plan. The submittal of project close-out reports is not required for remediation projects conducted under Section 5.5.5 of the Solid Waste Regulations. However, submittal of project close-out reports for asbestos-contaminated soil remediation projects may be required for projects conducted under a CDPHE corrective action mechanism.

ATTACHMENT A

24 HOUR NOTIFICATION OF UNPLANNED ASBESTOS DISCOVERY

ATTACHMENT B

10 DAY NOTIFICATION OF PLANNED ASBESTOS MANAGEMENT

ATTACHMENT C

6 CCR 1007-2, SECTION 5 - ASBESTOS WASTE MANAGEMENT REGULATIONS

ATTACHMENT D

NATIONAL INSTITUTE FOR OCCUPATIONAL SAFETY AND HEALTH (NIOSH) METHOD 7400, ISSUE 2, 15 AUGUST 1994 *(SAMPLING METHODS)*

ATTACHMENT E

AHERA METHOD, APPENDIX A TO SUBPART E OF PART 763 - INTERIM TRANSMISSION ELECTRON MICROSCOPY *(ANALYTICAL METHODS)*

ATTACHMENT E
AHERA Method, Appendix A to Subpart E of Part 763 - Interim Transmission Electron Microscopy *(Analytical Methods)*

As extracted from the Electronic Code of Federal Regulations:

http://ecfr.gpoaccess.gov/cgi/t/text/text-idx?c=ecfr&sid=1ddcedc56483dad548cb7fee1c166b29&rgn=div5&view=text&node=40:30.0.1.1.18&idno=40#40:30.0.1.1.18.2.1.17.2

1.1.1.1.1 Appendix A to Subpart E of Part 763—Interim Transmission Electron Microscopy Analytical Methods—Mandatory and Nonmandatory—and Mandatory Section To Determine Completion of Response Actions

top

I. Introduction

The following appendix contains three units. The first unit is the mandatory transmission electron microscopy (TEM) method which all laboratories must follow; it is the minimum requirement for analysis of air samples for asbestos by TEM. The mandatory method contains the essential elements of the TEM method. The second unit contains the complete non-mandatory method. The non-mandatory method supplements the mandatory method by including additional steps to improve the analysis. EPA recommends that the non-mandatory method be employed for analyzing air filters; however, the laboratory may choose to employ the mandatory method. The non-mandatory method contains the same minimum requirements as are outlined in the mandatory method. Hence, laboratories may choose either of the two methods for analyzing air samples by TEM.

The final unit of this Appendix A to subpart E defines the steps which must be taken to determine completion of response actions. This unit is mandatory.

II. Mandatory Transmission Electron Microscopy Method

A. Definitions of Terms

1. *Analytical sensitivity*—Airborne asbestos concentration represented by each fiber counted under the electron microscope. It is determined by the air volume collected and the proportion of the filter examined. This method requires that the analytical sensitivity be no greater than 0.005 structures/cm ^{3} .

2. *Asbestiform*—A specific type of mineral fibrosity in which the fibers and fibrils possess high tensile strength and flexibility.

3. *Aspect ratio*—A ratio of the length to the width of a particle. Minimum aspect ratio as defined by this method is equal to or greater than 5:1.

4. *Bundle*—A structure composed of three or more fibers in a parallel arrangement with each fiber closer than one fiber diameter.

5. *Clean area*—A controlled environment which is maintained and monitored to assure a low probability of asbestos contamination to materials in that space. Clean areas used in this method have HEPA filtered air under positive pressure and are capable of sustained operation with an open laboratory blank which on subsequent analysis has an average of less than 18 structures/mm ^{2} in an area of 0.057 mm ^{2} (nominally 10 200-mesh grid openings) and a maximum of 53 structures/mm ^{2} for any single preparation for that same area.

6. *Cluster*—A structure with fibers in a random arrangement such that all fibers are intermixed and no single fiber is isolated from the group. Groupings must have more than two intersections.

7. *ED*—Electron diffraction.

8. *EDXA*—Energy dispersive X-ray analysis.

9. *Fiber*—A structure greater than or equal to 0.5 µm in length with an aspect ratio (length to width) of 5:1 or greater and having substantially parallel sides.

10. *Grid*—An open structure for mounting on the sample to aid in its examination in the TEM. The term is used here to denote a 200-mesh copper lattice approximately 3 mm in diameter.

11. *Intersection*—Nonparallel touching or crossing of fibers, with the projection having an aspect ratio of 5:1 or greater.

12. *Laboratory sample coordinator*—That person responsible for the conduct of sample handling and the certification of the testing procedures.

13. *Filter background level*—The concentration of structures per square millimeter of filter that is considered indistinguishable from the concentration measured on a blank (filters through which no air has been drawn). For this method the filter background level is defined as 70 structures/mm ^{2} .

14. *Matrix*—Fiber or fibers with one end free and the other end embedded in or hidden by a particulate. The exposed fiber must meet the fiber definition.

15. *NSD*—No structure detected.

16. *Operator*—A person responsible for the TEM instrumental analysis of the sample.

17. *PCM*—Phase contrast microscopy.

18. *SAED*—Selected area electron diffraction.

19. *SEM*—Scanning electron microscope.

20. *STEM*—Scanning transmission electron microscope.

21. *Structure*—a microscopic bundle, cluster, fiber, or matrix which may contain asbestos.

22. *S/cm 3*—Structures per cubic centimeter.

23. *S/mm 2*—Structures per square millimeter.

24. *TEM*—Transmission electron microscope.

B. Sampling

1. The sampling agency must have written quality control procedures and documents which verify compliance.

2. Sampling operations must be performed by qualified individuals completely independent of the abatement contractor to avoid possible conflict of interest (References 1, 2, 3, and 5 of Unit II.J.).

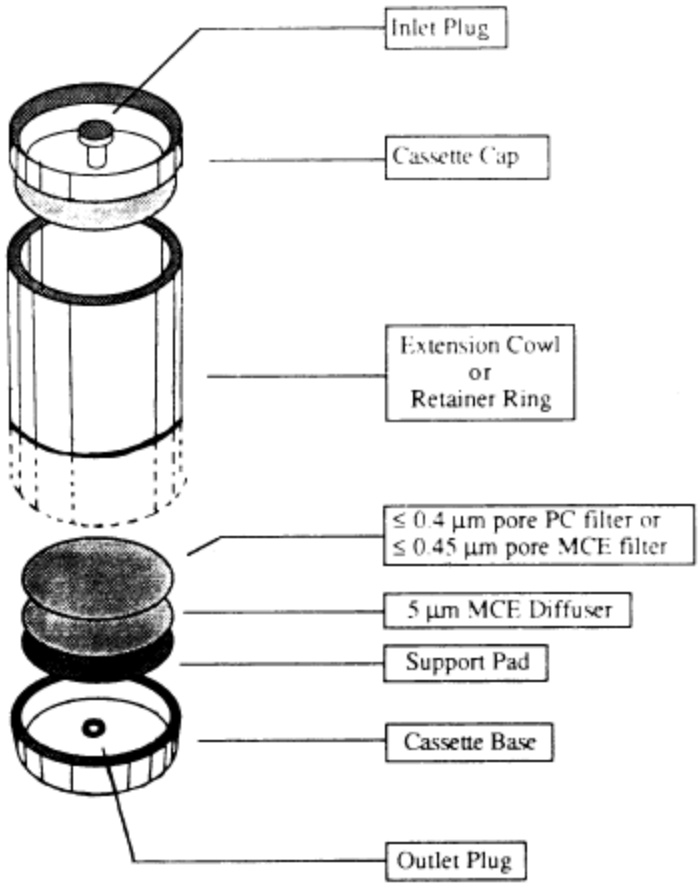
3. Sampling for airborne asbestos following an abatement action must use commercially available cassettes.

4. Prescreen the loaded cassette collection filters to assure that they do not contain concentrations of asbestos which may interfere with the analysis of the sample. A filter blank average of less than 18 s/mm ^{2} in an area of 0.057 mm ^{2} (nominally 10 200-mesh grid openings) and a single preparation with a maximum of 53 s/mm ^{2} for that same area is acceptable for this method.

5. Use sample collection filters which are either polycarbonate having a pore size less than or equal to 0.4 µm or mixed cellulose ester having a pore size less than or equal to 0.45 µm.

6. Place these filters in series with a 5.0 µm backup filter (to serve as a diffuser) and a support pad. See the following Figure 1:

FIGURE I--SAMPLING CASSETTE CONFIGURATION



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7. Reloading of used cassettes is not permitted.

8. Orient the cassette downward at approximately 45 degrees from the horizontal.

9. Maintain a log of all pertinent sampling information.

10. Calibrate sampling pumps and their flow indicators over the range of their intended use with a recognized standard. Assemble the sampling system with a representative filter (not the filter which will be used in sampling) before and after the sampling operation.

11. Record all calibration information.

12. Ensure that the mechanical vibrations from the pump will be minimized to prevent transferral of vibration to the cassette.

13. Ensure that a continuous smooth flow of negative pressure is delivered by the pump by damping out any pump action fluctuations if necessary.

14. The final plastic barrier around the abatement area remains in place for the sampling period.

15. After the area has passed a thorough visual inspection, use aggressive sampling conditions to dislodge any remaining dust. (See suggested protocol in Unit III.B.7.d.)

16. Select an appropriate flow rate equal to or greater than 1 liter per minute (L/min) or less than 10 L/min for 25 mm cassettes. Larger filters may be operated at proportionally higher flow rates.

17. A minimum of 13 samples are to be collected for each testing site consisting of the following:

a. A minimum of five samples per abatement area.

b. A minimum of five samples per ambient area positioned at locations representative of the air entering the abatement site.

c. Two field blanks are to be taken by removing the cap for not more than 30 seconds and replacing it at the time of sampling before sampling is initiated at the following places:

i. Near the entrance to each abatement area.

ii. At one of the ambient sites. (DO NOT leave the field blanks open during the sampling period.)

d. A sealed blank is to be carried with each sample set. This representative cassette is not to be opened in the field.

18. Perform a leak check of the sampling system at each indoor and outdoor sampling site by activating the pump with the closed sampling cassette in line. Any flow indicates a leak which must be eliminated before initiating the sampling operation.

19. The following Table I specifies volume ranges to be used:

TABLE 1--NUMBER OF 200 MESH EM GRID OPENINGS ($0.0057\ MM^2$) THAT NEED TO BE ANALYZED TO MAINTAIN SENSITIVITY OF 0.005 STRUCTURES/CC BASED ON VOLUME AND EFFECTIVE FILTER AREA

Effective Filter Area 385 sq mm		Effective Filter Area 855 sq mm	
Volume (liters)	# of grid openings	Volume (liters)	# of grid openings
560	*24*	*1,250*	*24*
600	23	1,300	23
700	19	1,400	21
800	17	1,600	19
900	15	1,800	17
1,000	14	2,000	15
1,100	12	2,200	14
1,200	**11**	2,400	13
1,300	**10**	2,600	12
1,400	**10**	**2,800**	**11**
1,500	**9**	**3,000**	**10**
1,600	**8**	**3,200**	**9**
1,700	**8**	**3,400**	**9**
1,800	**8**	**3,600**	**8**
1,900	7	**3,800**	**8**
2,000	7	**4,000**	**8**
2,100	6	4,200	7
2,200	6	4,400	7
2,300	6	4,600	7
2,400	6	4,800	6
2,500	5	5,000	6
2,600	5	5,200	6
2,700	5	5,400	6
2,800	5	5,600	5
2,900	5	5,800	5
3,000	5	6,000	5
3,100	4	6,200	5
3,200	4	6,400	5
3,300	4	6,600	5
3,400	4	6,800	4
3,500	4	7,000	4
3,600	4	7,200	4
3,700	4	7,400	4
3,800	4	7,600	4

Recommended Volume Range

Recommended Volume Range

Note minimum volumes required:
25 mm : 560 liters
37 mm : 1250 liters

Filter diameter of 25 mm = effective area of 385 sq mm
Filter diameter of 37 mm = effective area of 855 sq mm

20. Ensure that the sampler is turned upright before interrupting the pump flow.

21. Check that all samples are clearly labeled and that all pertinent information has been enclosed before transfer of the samples to the laboratory.

22. Ensure that the samples are stored in a secure and representative location.

23. Do not change containers if portions of these filters are taken for other purposes.

24. A summary of Sample Data Quality Objectives is shown in the following Table II:

TABLE II--SUMMARY OF SAMPLING AGENCY DATA QUALITY OBJECTIVES

This table summarizes the data quality objectives from the performance of this method in terms of precision, accuracy, completeness, representativeness, and comparability. These objectives are assured by the periodic control checks and reference checks listed here and described in the text of the method.

Unit Operation	QC Check	Frequency	Conformance Expectation
Sampling materials	Sealed blank	1 per I/O site	95%
Sample procedures	Field blanks	2 per I/O site	95%
	Pump calibration	Before and after each field series	90%
Sample custody	Review of chain-of-custody record	Each sample	95% complete
Sample shipment	Review of sending report	Each sample	95% complete

C. Sample Shipment

Ship bulk samples to the analytical laboratory in a separate container from air samples.

D. Sample Receiving

1. Designate one individual as sample coordinator at the laboratory. While that individual will normally be available to receive samples, the coordinator may train and supervise others in receiving procedures for those times when he/she is not available.

2. Bulk samples and air samples delivered to the analytical laboratory in the same container shall be rejected.

E. Sample Preparation

1. All sample preparation and analysis shall be performed by a laboratory independent of the abatement contractor.

2. Wet-wipe the exterior of the cassettes to minimize contamination possibilities before taking them into the clean room facility.

3. Perform sample preparation in a well-equipped clean facility.

Note: The clean area is required to have the following minimum characteristics. The area or hood must be capable of maintaining a positive pressure with make-up air being HEPA-filtered. The cumulative analytical blank concentration must average less than 18 s/mm ^{2} in an area of 0.057 mm ^{2} (nominally 10 200-mesh grid openings) and a single preparation with a maximum of 53 s/mm ^{2} for that same area.

4. Preparation areas for air samples must not only be separated from preparation areas for bulk samples, but they must be prepared in separate rooms.

5. Direct preparation techniques are required. The object is to produce an intact film containing the particulates of the filter surface which is sufficiently clear for TEM analysis.

a. TEM Grid Opening Area measurement must be done as follows:

i. The filter portion being used for sample preparation must have the surface collapsed using an acetone vapor technique.

ii. Measure 20 grid openings on each of 20 random 200-mesh copper grids by placing a grid on a glass and examining it under the PCM. Use a calibrated graticule to measure the average field diameters. From the data, calculate the field area for an average grid opening.

iii. Measurements can also be made on the TEM at a properly calibrated low magnification or on an optical microscope at a magnification of approximately 400X by using an eyepiece fitted with a scale that has been calibrated against a stage micrometer. Optical microscopy utilizing manual or automated procedures may be used providing instrument calibration can be verified.

b. TEM specimen preparation from polycarbonate (PC) filters. Procedures as described in Unit III.G. or other equivalent methods may be used.

c. TEM specimen preparation from mixed cellulose ester (MCE) filters.

i. Filter portion being used for sample preparation must have the surface collapsed using an acetone vapor technique or the Burdette procedure (Ref. 7 of Unit II.J.)

ii. Plasma etching of the collapsed filter is required. The microscope slide to which the collapsed filter pieces are attached is placed in a plasma asher. Because plasma ashers vary greatly in their performance, both from unit to unit and between different positions in the asher chamber, it is difficult to specify the conditions that should be used. Insufficient etching will result in a failure to expose embedded filters, and too much etching may result in loss of particulate from the surface. As an interim measure, it is recommended that the time for ashing of a known weight of a collapsed filter be established and that the etching rate be calculated in terms of micrometers per second. The actual etching time used for the particulate asher and operating conditions will then be set such that a 1–2 μm (10 percent) layer of collapsed surface will be removed.

iii. Procedures as described in Unit III. or other equivalent methods may be used to prepare samples.

F. TEM Method

1. An 80–120 kV TEM capable of performing electron diffraction with a fluorescent screen inscribed with calibrated gradations is required. If the TEM is equipped with EDXA it must either have a STEM attachment or be capable of producing a spot less than 250 nm in diameter at crossover. The microscope shall be calibrated routinely for magnification and camera constant.

2. *Determination of Camera Constant and ED Pattern Analysis.* The camera length of the TEM in ED operating mode must be calibrated before ED patterns on unknown samples are observed. This can be achieved by using a carbon-coated grid on which a thin film of gold has been sputtered or evaporated. A thin film of gold is evaporated on the specimen TEM grid to obtain zone-axis ED patterns superimposed with a ring pattern from the polycrystalline gold film. In practice, it is desirable to optimize the thickness of the gold film so that only one or two sharp rings are obtained on the superimposed ED pattern. Thicker gold film would normally give multiple gold rings, but it will tend to mask weaker diffraction spots from the unknown fibrous particulate. Since the unknown d-spacings of most interest in asbestos analysis are those which lie closest to the transmitted beam, multiple gold rings are unnecessary on zone-axis ED patterns. An average camera constant using multiple gold rings can be determined. The camera constant is one-half the diameter of the rings times the interplanar spacing of the ring being measured.

3. *Magnification Calibration.* The magnification calibration must be done at the fluorescent screen. The TEM must be calibrated at the grid opening magnification (if used) and also at the magnification used for fiber counting. This is performed with a cross grating replica (e.g., one containing 2,160 lines/mm). Define a field of view on the fluorescent screen either by markings or physical boundaries. The field of view must be measurable or previously inscribed with a scale or concentric circles (all scales should be metric). A logbook must be maintained, and the dates of calibration and the values obtained must be recorded. The frequency of calibration depends on the past history of the particular microscope. After any maintenance of the microscope that involved adjustment of the power supplied to the lenses or the high-voltage system or the mechanical disassembly of the electron optical column apart from filament exchange, the magnification must be recalibrated. Before the TEM calibration is performed, the analyst must ensure that the cross grating replica is placed at the same distance from the objective lens as the specimens are. For instruments that incorporate a eucentric tilting specimen stage, all specimens and the cross grating replica must be placed at the eucentric position.

4. While not required on every microscope in the laboratory, the laboratory must have either one microscope equipped with energy dispersive X-ray analysis or access to an equivalent system on a TEM in another laboratory.

5. Microscope settings: 80–120 kV, grid assessment 250–1,000X, then 15,000–20,000X screen magnification for analysis.

6. Approximately one-half (0.5) of the predetermined sample area to be analyzed shall be performed on one sample grid preparation and the remaining half on a second sample grid preparation.

7. Individual grid openings with greater than 5 percent openings (holes) or covered with greater than 25 percent particulate matter or obviously having nonuniform loading must not be analyzed.

8. Reject the grid if:

a. Less than 50 percent of the grid openings covered by the replica are intact.

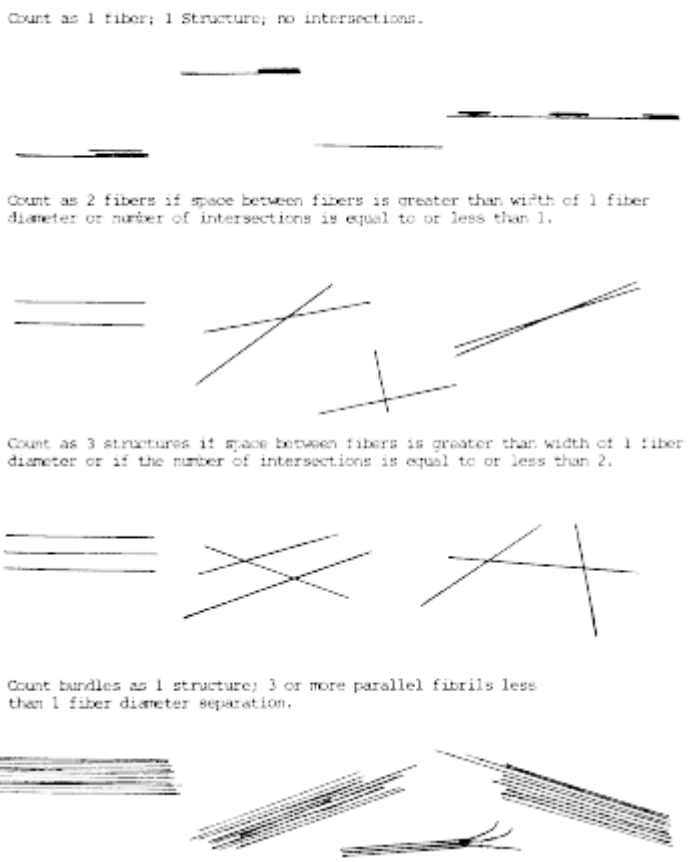
b. The replica is doubled or folded.

c. The replica is too dark because of incomplete dissolution of the filter.

9. *Recording Rules*.

a. Any continuous grouping of particles in which an asbestos fiber with an aspect ratio greater than or equal to 5:1 and a length greater than or equal to 0.5 µm is detected shall be recorded on the count sheet. These will be designated asbestos structures and will be classified as fibers, bundles, clusters, or matrices. Record as individual fibers any contiguous grouping having 0, 1, or 2 definable intersections. Groupings having more than 2 intersections are to be described as cluster or matrix. An intersection is a nonparallel touching or crossing of fibers, with the projection having an aspect ratio of 5:1 or greater. See the following Figure 2:

FIGURE 2--COUNTING GUIDELINES USED IN DETERMINING ASBESTOS STRUCTURES



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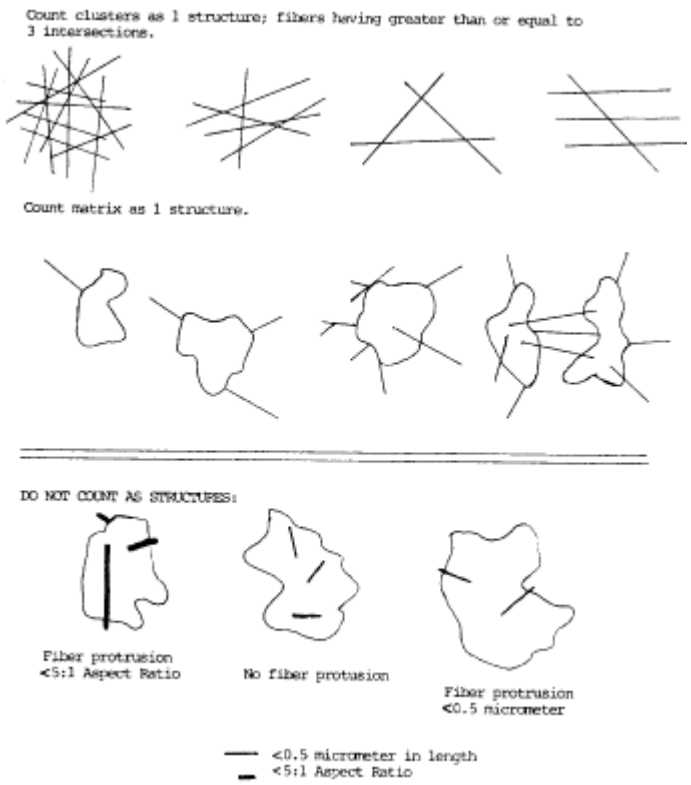

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i. *Fiber.* A structure having a minimum length greater than or equal to 0.5 µm and an aspect ratio (length to width) of 5:1 or greater and substantially parallel sides. Note the appearance of the end of the fiber, i.e., whether it is flat, rounded or dovetailed.

ii. *Bundle.* A structure composed of three or more fibers in a parallel arrangement with each fiber closer than one fiber diameter.

iii. *Cluster.* A structure with fibers in a random arrangement such that all fibers are intermixed and no single fiber is isolated from the group. Groupings must have more than two intersections.

iv. *Matrix.* Fiber or fibers with one end free and the other end embedded in or hidden by a particulate. The exposed fiber must meet the fiber definition.

b. Separate categories will be maintained for fibers less than 5 µm and for fibers equal to or greater than 5 µm in length.

c. Record NSD when no structures are detected in the field.

d. Visual identification of electron diffraction (ED) patterns is required for each asbestos structure counted which would cause the analysis to exceed the 70 s/mm ^{2} concentration. (Generally this means the first four fibers identified as asbestos must exhibit an identifiable diffraction pattern for chrysotile or amphibole.)

e. The micrograph number of the recorded diffraction patterns must be reported to the client and maintained in the laboratory's quality assurance records. In the event that examination of the pattern by a qualified individual indicates that the pattern has been misidentified visually, the client shall be contacted.

f. Energy Dispersive X-ray Analysis (EDXA) is required of all amphiboles which would cause the analysis results to exceed the 70 s/mm ^{2} concentration. (Generally speaking, the first 4 amphiboles would require EDXA.)

g. If the number of fibers in the nonasbestos class would cause the analysis to exceed the 70 s/mm ^{2} concentration, the fact that they are not asbestos must be confirmed by EDXA or measurement of a zone axis diffraction pattern.

h. Fibers classified as chrysotile must be identified by diffraction or X-ray analysis and recorded on a count sheet. X-ray analysis alone can be used only after 70 s/mm ^{2} have been exceeded for a particular sample.

i. Fibers classified as amphiboles must be identified by X-ray analysis and electron diffraction and recorded on the count sheet. (X-ray analysis alone can be used only after 70 s/mm ^{2} have been exceeded for a particular sample.)

j. If a diffraction pattern was recorded on film, record the micrograph number on the count sheet.

k. If an electron diffraction was attempted but no pattern was observed, record N on the count sheet.

l. If an EDXA spectrum was attempted but not observed, record N on the count sheet.

m. If an X-ray analysis spectrum is stored, record the file and disk number on the count sheet.

10. Classification Rules.

a. *Fiber.* A structure having a minimum length greater than or equal to 0.5 µm and an aspect ratio (length to width) of 5:1 or greater and substantially parallel sides. Note the appearance of the end of the fiber, i.e., whether it is flat, rounded or dovetailed.

b. *Bundle.* A structure composed of three or more fibers in a parallel arrangement with each fiber closer than one fiber diameter.

c. *Cluster.* A structure with fibers in a random arrangement such that all fibers are intermixed and no single fiber is isolated from the group. Groupings must have more than two intersections.

d. *Matrix.* Fiber or fibers with one end free and the other end embedded in or hidden by a particulate. The exposed fiber must meet the fiber definition.

11. After finishing with a grid, remove it from the microscope, and replace it in the appropriate grid holder. Sample grids must be stored for a minimum of 1 year from the date of the analysis; the sample cassette must be retained for a minimum of 30 days by the laboratory or returned at the client's request.

G. Sample Analytical Sequence

1. Under the present sampling requirements a minimum of 13 samples is to be collected for the clearance testing of an abatement site. These include five abatement area samples, five ambient samples, two field blanks, and one sealed blank.

2. Carry out visual inspection of work site prior to air monitoring.

3. Collect a minimum of 5 air samples inside the work site and 5 samples outside the work site. The indoor and outdoor samples shall be taken during the same time period.

4. Remaining steps in the analytical sequence are contained in Unit IV of this Appendix.

H. Reporting

1. The following information must be reported to the client for each sample analyzed:

a. Concentration in structures per square millimeter and structures per cubic centimeter.

b. Analytical sensitivity used for the analysis.

c. Number of asbestos structures.

d. Area analyzed.

e. Volume of air sampled (which must be initially supplied to lab by client).

f. Copy of the count sheet must be included with the report.

g. Signature of laboratory official to indicate that the laboratory met specifications of the method.

h. Report form must contain official laboratory identification (e.g., letterhead).

i. Type of asbestos.

I. Quality Control/Quality Assurance Procedures (Data Quality Indicators)

Monitoring the environment for airborne asbestos requires the use of sensitive sampling and analysis procedures. Because the test is sensitive, it may be influenced by a variety of factors. These include the supplies used in the sampling operation, the performance of the sampling, the preparation of the grid from the filter and the actual examination of this grid in the microscope. Each of these unit operations must produce a product of defined quality if the analytical result is to be a reliable and meaningful test result. Accordingly, a series of control checks and reference standards are to be performed along with the sample analysis as indicators that the materials used are adequate and the operations are within acceptable limits. In this way, the quality of the data is defined and the results are of known value. These checks and tests also provide timely and specific warning of any problems which might develop within the sampling and analysis operations. A description of these quality control/quality assurance procedures is summarized in the following Table III:

TABLE III--SUMMARY OF LABORATORY DATA QUALITY OBJECTIVES

Unit Operation	QC Check	Frequency	Conformance Expectation
Sample receiving	Review of receiving report	Each sample	95% complete
Sample custody	Review of chain-of-custody record	Each sample	95% complete
Sample preparation	Supplies and reagents	On receipt	Meet specs. or reject
	Grid opening size	20 openings/20 grids/lot of 1000 or 1 opening/sample	100%
	Special clean area monitoring	After cleaning or service	Meet specs or reclean
	Laboratory blank	1 per prep series or 10%	Meet specs. or reanalyze series
	Plasma etch blank	1 per 20 samples	75%
	Multiple preps (3 per sample)	Each sample	One with cover of 15 complete grid sqs.
Sample analysis	System check	Each day	Each day
	Alignment check	Each day	Each day
	Magnification calibration with low and high standards	Each month or after service	95%
	ED calibration by gold standard	Weekly	95%
	EDS calibration by copper line	Daily	95%
Performance check	Laboratory blank (measure of cleanliness)	Prep 1 per series or 10% read 1 per 25 samples	Meet specs or reanalyze series
	Replicate counting (measure of precision)	1 per 100 samples	1.5 x Poisson Std. Dev.
	Duplicate analysis (measure of reproducibility)	1 per 100 samples	2 x Poisson Std. Dev.
	Known samples of typical materials (working standards)	Training and for comparison with unknowns	100%
	Analysis of NBS SRM 1876 and/or RM 8410 (measure of accuracy and comparability)	1 per analyst per year	1.5 x Poisson Std. Dev.
	Data entry review (data validation and measure of completeness)	Each sample	95%
	Record and verify ID electron diffraction pattern of structure	1 per 5 samples	80% accuracy
Calculations and data reduction	Hand calculation of automated data reduction procedure or independent recalculation of hand-calculated data	1 per 100 samples	85%

1. When the samples arrive at the laboratory, check the samples and documentation for completeness and requirements before initiating the analysis.

2. Check all laboratory reagents and supplies for acceptable asbestos background levels.

3. Conduct all sample preparation in a clean room environment monitored by laboratory blanks. Testing with blanks must also be done after cleaning or servicing the room.

4. Prepare multiple grids of each sample.

5. Provide laboratory blanks with each sample batch. Maintain a cumulative average of these results. If there are more than 53 fibers/mm ^{2} per 10 200-mesh grid openings, the system must be checked for possible sources of contamination.

6. Perform a system check on the transmission electron microscope daily.

7. Make periodic performance checks of magnification, electron diffraction and energy dispersive X-ray systems as set forth in Table III under Unit II.I.

8. Ensure qualified operator performance by evaluation of replicate analysis and standard sample comparisons as set forth in Table III under Unit II.I.

9. Validate all data entries.

10. Recalculate a percentage of all computations and automatic data reduction steps as specified in Table III under Unit II.I.

11. Record an electron diffraction pattern of one asbestos structure from every five samples that contain asbestos. Verify the identification of the pattern by measurement or comparison of the pattern with patterns collected from standards under the same conditions. The records must also demonstrate that the identification of the pattern has been verified by a qualified individual and that the operator who made the identification is maintaining at least an 80 percent correct visual identification based on his measured patterns.

12. Appropriate logs or records must be maintained by the analytical laboratory verifying that it is in compliance with the mandatory quality assurance procedures.

Colorado Department of Public Health and Environment
Hazardous Materials and Waste Management Division
Asbestos Contaminated Soil Notification Form

24 HOUR NOTIFICATION OF UNPLANNED ASBESTOS DISCOVERY

For 24-hour notification of the unplanned discovery of asbestos-contaminated soil, a completed a copy of this form should be faxed to 303-759-5355 Attn: Solid Waste Unit Leader, or emailed to comments.hmwmd@state.co.us . If the Hazardous Materials and Waste Management Division has not pre-approved standard operating procedures that will be implemented, you must then submit a **Soil Characterization and Management Plan** to the Division for approval. If the Division has pre-approved standard operating procedures that will be implemented, you only need to submit a completed copy of this form.

The Soil Characterization and Management Plan should be mailed to: Colorado Department of Public Health and Environment, HMWMD-B2 Attn: Solid Waste Unit Leader, 4300 Cherry Creek Drive South, Denver CO 80246-1530
or emailed to: comments.hmwmd@state.co.us .

Date and time reported:			
Contact person for entity performing soil-disturbing activity:		**Phone:**	**Ext:**
Organization, company or agency:			
Address:			
City:	**State:**	**Zip:**	
Name of property owner/operator or property representative:			
Owner/operator contact (if different):		**Phone:**	**Ext:**
Address:		**Fax:**	
City:	**State:**	**Zip:**	
Discovery date:	**Discovery time (include AM or PM):**		
Location of property: (Street address or other location description – e.g. highway mile marker)	**Street Address:**		
	County:	**City:**	**Zip:**
General Site Description:			
Activity resulting in discovery:			
Description of material encountered:			
Description of access or emissions controls implemented:			

Has the Division pre-approved standard procedures that will be implemented? ☐ **yes** ☐ **no**

If "no," implement interim actions and submit a Soil Characterization and Management Plan for Division review and approval.

ATTACHMENT B

10 DAY NOTIFICATION OF PLANNED ASBESTOS MANAGEMENT

Colorado Department of Public Health and Environment
Hazardous Materials and Waste Management Division
Asbestos Contaminated Soil Notification Form

10 DAY NOTIFICATION OF PLANNED ASBESTOS MANAGEMENT

For notification of planned management of asbestos-contaminated soil, a completed copy of this form should be submitted to the Hazardous Materials and Waste Management Division at least 10 working days prior to any planned soil-disturbing activity. If the Division has not pre-approved standard operating procedures that will be implemented, you must also submit a **Soil Characterization and Management Plan** to the Division for approval. If the Division has pre-approved standard operating procedures that will be implemented, then you only need to submit a completed copy of this form.

The form and plan can be mailed to: Colorado Department of Public Health and Environment, HMWMD-B2 Attn: Solid Waste Unit Leader, 4300 Cherry Creek Drive South, Denver CO 80246-1530
or emailed to: comments.hmwmd@state.co.us .

Date and time reported:			
Contact person for entity performing soil-disturbing activity:		**Phone:**	**Ext:**
Organization, company or agency:			
Address:			
City:	**State:**	**Zip:**	
Name of property owner/operator or property representative:			
Owner/operator contact (if different):		**Phone:**	**Ext:**
Address:		**Fax:**	
City:	**State:**	**Zip:**	
Location of property: (Street address or other location description – e.g. highway mile marker)	**Street Address:**		
	County:	**City:**	**Zip:**
General Site Description:			
Description of planned soil-disturbing activities:			
Description of material that will be disturbed:			
Has the Division pre-approved standard procedures that will be implemented? ☐ **yes** ☐ **no** **If "no," submit a Soil Characterization and Management Plan for Division review and approval.**			

ATTACHMENT C

6 CCR 1007-2, SECTION 5 - ASBESTOS WASTE MANAGEMENT REGULATIONS

SECTION 5

ASBESTOS WASTE MANAGEMENT

5.1 GENERAL PROVISIONS: The provisions of Section 5.1-5.4 shall apply to all asbestos waste disposal areas.

5.1.1 (A) Any person who disposes of asbestos waste and any owner or operator of an asbestos waste disposal area, shall comply with the requirements of Sections 1, 2, 3, and 5 of these regulations.
(B) If a conflict exists between the requirements of this section and Sections 1, 2, or 3, the requirements of Section 5 shall control.

5.1.2 Each asbestos waste disposal area shall comply with the rules and regulations of the Department, the Water Quality Control Commission, the Air Quality Control Commission and each applicable local law and ordinance. Each asbestos waste disposal area shall be located, designed, constructed, operated and maintained so that it will protect public health, worker safety, and the environment.

5.1.3 No asbestos waste management activities shall cause or contribute to the occurrence of any visible emissions.

5.2 NON-FRIABLE ASBESTOS WASTE DISPOSAL AREAS: The provisions of this subsection 5.2 shall apply to each asbestos waste disposal area that receives non-friable asbestos waste.

5.2.1 Within 24 hours following receipt of non-friable asbestos waste and any storage thereof in accordance with Section 5.4 of these regulations, the waste shall be covered with a minimum of nine inches (9”) of soil or eighteen inches (18”) of non-asbestos cover material. The Department and local governing body having jurisdiction may approve on a case-by-case basis alternative materials of an alternative thickness. All other requirements of Sections 1.1 through 1.9 and 2.0 and 3.0 of these regulations regarding placement of "adequate cover" shall also

apply to the disposal of non-friable asbestos waste. Operators shall minimize the potential for release from and exposure to asbestos waste after placement in each disposal area and shall not compact the waste prior to application of cover materials. At no time shall compaction equipment come into contact with asbestos waste, containers, or packaging.

5.2.2 Non-friable asbestos waste management shall be accomplished in a manner that minimizes any change in the friability of the waste.

5.3 FRIABLE ASBESTOS WASTE DISPOSAL AREAS: The provisions of this subsection 5.3 shall apply to each asbestos waste disposal area that receives friable asbestos waste.

5.3.1 (A) No friable asbestos waste shall be received or disposed of at a solid waste facility unless expressly authorized by an approved design and operations plan. This design and operations plan shall describe the friable asbestos disposal area, areas, or work practices used for onsite disposal of friable asbestos waste and shall contain provisions for a response to a spill or release of friable asbestos waste material.

5.3.2 The Department may approve specific disposal activities for friable asbestos waste on a case-by-case basis in accordance with Section 1.5 of these regulations.

5.3.3 No friable asbestos wastes shall be disposed of within one hundred feet (100’) in all directions of the property line of a solid waste disposal site and facility.

5.3.4 Warning signs and fencing, or appropriate controls as approved by the Department, shall be installed and maintained at the perimeter of each asbestos waste disposal area where friable asbestos waste is disposed of, in accordance with the following minimum requirements:

(A) A fence shall be placed around the entire area where there has been or will be disposal of friable asbestos waste to ensure the restriction of activities in that area and to preclude the entry of unauthorized and unprotected personnel.

(B) Warning signs shall be displayed as follows: one at each entrance to each asbestos waste disposal area; and one or more on each side of the fenced area based on the length of the side, at a rate of one for every three hundred linear feet (300') of fence.

(C) Warning signs shall be posted in such a manner and in such locations that the legend can be easily read.

(D) Each warning sign shall be an upright rectangle with minimum measurements of twenty inches by fourteen inches (20"x14").

(E) Each warning sign shall display the legend set out below. The letter sizes used in the legend shall be as specified below or of a visibility at least equal to those specified below.

LEGEND	NOTATION
ASBESTOS WASTE DISPOSAL AREA	1 INCH
DO NOT CREATE DUST	0.75 INCH
BREATHING ASBESTOS IS HAZARDOUS TO YOUR HEALTH	14 POINT

(F) Spacing between any two lines in the legend of the warning signs must be at least equal to the height of the upper of the two lines.

(G) Facilities that have existing signs referring to Asbestos Waste Disposal Sites may continue to use these signs until replacement is warranted.

5.3.5 (A) No friable asbestos waste shall be accepted for disposal unless it is tightly sealed in at least two 6 mil, leak-tight plastic bags or in a wrapping or other container deemed equivalent by the Department.

(B) The outermost layer of any containers holding friable asbestos waste shall be labeled with either of the following legends in type at least .5 inches tall:

(1)	CAUTION CONTAINS ASBESTOS AVOID OPENING OR BREAKING CONTAINER BREATHING ASBESTOS IS HAZARDOUS TO YOUR HEALTH
(2)	DANGER CONTAINS ASBESTOS FIBERS AVOID CREATING DUST CANCER AND LUNG DISEASE HAZARD

5.3.6 All activities involved in the disposal of friable asbestos waste, including placement in an asbestos waste disposal area, covering the asbestos waste, and compacting the fill shall be conducted in a manner that minimizes the potential for the rupture or opening of any bags, wrappers or other containers holding the friable asbestos waste and that prevents the emission of asbestos to the air.

5.3.7 (A) Within 24 hours following receipt of friable asbestos waste and any storage thereof in accordance with Section 5.4 of these regulations, the waste shall be covered with a minimum of nine inches (9”) of soil or eighteen inches (18”) of non-asbestos cover material. The Department and local governing body having jurisdiction may approve on a case-by-case basis alternative materials of an alternative thickness. All other requirements of Sections 1.1 through 1.9 and 2.0 and 3.0 of these regulations regarding placement of "adequate cover" shall also apply to the disposal of friable asbestos waste. Operators shall minimize the potential for release from and exposure to asbestos waste after placement in the disposal area and shall not compact the waste prior to application of cover materials. At no time shall compaction equipment come into contact with asbestos waste, containers or packaging.

5.3.8 Structurally rigid containers that hold friable asbestos waste shall be covered as specified in Section 5.3.7 within seventy-two hours of receipt or termination of storage. Precautions must be taken to avoid damage or rupture of the asbestos containers during handling. Before the owner/operator compacts any friable asbestos waste containers, the containers shall be covered with a minimum of nine inches (9″) of soil or eighteen inches (18″) of non-asbestos cover material.

5.3.9 (A) Any friable asbestos waste received in packaging other than a structurally rigid container shall be received and disposed of only if:

(1)An asbestos waste disposal area necessary for the disposal of such friable asbestos waste is prepared prior to the arrival of such waste at the landfill;

(2) A minimum of nine inches (9″) of soil or eighteen inches (18″) of non-asbestos cover material and the equipment necessary to cover the asbestos waste upon its placement in each asbestos waste disposal area is available to cover the asbestos waste per the requirements of Sections 5.3.7 and 5.3.8;

(3) All unrelated landfill activities within one hundred (100’) feet in all directions of each asbestos waste disposal area are stopped during the placement, covering, and compaction of the asbestos waste;

(4) No non-essential persons are allowed within one hundred (100’) feet in all directions of each asbestos waste disposal area during the placement, covering, and compaction of the asbestos waste;

(5) Sustained wind speeds at the asbestos waste disposal area do not exceed twenty miles per hour (20 mph) and gusts do not exceed thirty miles per hour (30 mph);

(6) A source of water is provided at the site to facilitate wetting the asbestos wastes if any container is breeched during placement of asbestos waste.

(B) Any friable asbestos waste received in packaging other than structurally rigid containers shall be disposed of by placement in an asbestos waste disposal

area that is at least one hundred feet (100’) in all directions from any area being used concurrently for the disposal of other waste.

5.3.10 The owner or operator of an asbestos waste disposal area where friable asbestos waste has been disposed of shall:

(A) Maintain operating records required under subsection 2.4 of these regulations, including permanent records of the date and amount of each receipt of asbestos waste, the location of each asbestos waste disposal area within the boundaries of the solid waste disposal facility and the quantity of asbestos waste at each such location. These records shall be of sufficient specificity to identify the location and depth of the asbestos waste.

(B) Ensure that records made to comply with this subsection are readily available at all times and are made available to the local governing body having jurisdiction and the Department upon request.

(C) Such records shall be submitted to the local governing body having jurisdiction within thirty (30) days after the closure of the asbestos waste disposal area has been completed.

5.4 STORAGE OF ASBESTOS WASTE: Storage of asbestos waste at an asbestos waste disposal area, prior to burial, shall be conducted in accordance with the following requirements:

5.4.1 Asbestos waste shall be stored only in rigid containers and in segregated locations used solely for the purpose of such storage where asbestos waste packages can be handled, stored and maintained without being opened or disturbed.

5.4.2 Asbestos waste shall be stored at an asbestos waste disposal area for no more than twenty (20) calendar days prior to burial.

5.4.3 A warning sign shall be posted on each side of an area where asbestos waste is stored prior to burial. Such signs shall conform to subsection 5.3.4(C), (D) and (F). The legend on each such sign shall conform to the requirements of subsection 5.3.4(E) except that the first line shall read "Asbestos Waste Storage".

5.5 MANAGEMENT OF ASBESTOS-CONTAMINATED SOIL:

5.5.1 APPLICABILITY

(A) The requirements of Section 5.5 apply to the owner or operator of any property with asbestos-contaminated soil at which soil-disturbing activities are occurring or planned for any area containing asbestos-contaminated soil, but excluding asbestos waste disposal areas that have a Certificate of Designation. The requirements of this Section 5.5 are triggered when the owner or operator has reason to know of asbestos-contaminated soil at a site (such as through confirmation by analysis of observed material that is suspected of containing asbestos), or has reason to believe that visible asbestos may be encountered. An owner or operator who has no reason to know of asbestos-contaminated soil at a site, and has no reason to believe that visible asbestos will be encountered, does not have a duty under these regulations to sample or otherwise investigate for asbestos-contaminated soil prior to commencing excavation, or other soil disturbing activities, at the site.

(B) Removal of asbestos-containing material on a facility component, that is located on or in soil that will be disturbed, shall be conducted under this Section 5.5, in accordance with work practices in Air Quality Control Commission Regulation No. 8 (5 CCR 1001-10, Part B), Section III.O, but is not subject to the permit requirements of 5 CCR 1001-10, Part B, as long as the total quantity of asbestos-containing material is below the following trigger levels:

(1) 260 linear feet on pipes,

(2) 160 square feet on other surfaces, or

(3) The volume of a 55-gallon drum.

Removal of asbestos-containing material on a facility component with asbestos quantities above the trigger levels is subject to the permit and abatement requirements of Air Quality Control Commission Regulation No. 8 (5 CCR 1001-10, Part B), and is therefore outside the scope of this Section 5.5 as provided in Section 5.5.2(B) of these regulations.

(C) Removal of pieces of asbestos-containing material, that are not on a facility component, and are located on or in soil that will be disturbed, shall be conducted under this Section 5.5, in accordance with work practices in Air Quality Control Commission Regulation No. 8 (5 CCR 1001-10, Part B), Section III.O, but is not subject to the permit requirements of 5 CCR 1001-10, Part B.

5.5.2 EXEMPTIONS

(A) If visible asbestos is solely nonfriable material containing asbestos, that has not been rendered friable, as determined by an asbestos building inspector in accordance with Section 5.5.6(A)(3), the nonfriable material can be removed from the soil and properly disposed. If all reasonably available information does not suggest that friable asbestos may also be present, the surrounding soil is not considered to be subject to the requirements of this Section 5.5.

(B) Asbestos abatement of facility components (including pipes, ducts and boilers) conducted in accordance with Air Quality Control Commission Regulation No. 8 (5 CCR 1001-10, Part B) is not subject to the requirements of Section 5.5, but must still comply with Sections 5.1 through 5.4 of these regulations.

(C) Spill response activities that are subject to the requirements of Air Quality Control Commission Regulation No. 8 (5 CCR 1001-10, Part B) are not subject to the requirements of Section 5.5, but must still comply with Sections 5.1 through 5.4 of these regulations.

(D) Ambient occurrences of asbestos in soil that are not due to site specific activities are not subject to the requirements of this Section 5.5. Ambient occurrences of asbestos may include, but are not limited to, naturally occurring asbestos or distribution of asbestos from normal wear of automotive products.

(E) De minimis projects involving excavations with a total volume of less than 1 cubic yard of soil using low-emission excavation methods such as hand held tools or light equipment.

(F) Projects conducted directly by a homeowner on their primary residence, including residential landscaping projects and other private residential soil-disturbing projects conducted after the primary dwelling is built, e.g. planting trees, digging holes for fence posts, installing sign posts, gardening, other projects done by private individuals on their primary place of residence.

5.5.3 RESPONSE FOR UNPLANNED ASBESTOS DISCOVERY

Properties where visible material containing asbestos or asbestos-contaminated soil is unexpectedly encountered during soil-disturbing activities are subject to the following requirements:

(A) IMMEDIATE ACTIONS: Immediate actions shall be taken by the person conducting the soil-disturbing activity, or representative of the owner or operator, to prevent release of, and/or exposure to, asbestos. These actions shall include, but not be limited to, the following:

(1) Stopping all soil-disturbing activities, related to asbestos-contaminated soil, until the 24-hour notification requirements in Section 5.5.3(B), and the interim action requirements in Section 5.5.3(C), are met. In the event of an emergency in which a soil disturbing activity must continue or commence at once, notification shall be made as soon as possible, but within 24 hours of discovery.

(2) Taking measures to prevent site access by unauthorized persons, and minimize the risk of asbestos exposure.

(3) Conducting surface soil stabilization such as covering with tarps or dust suppressant.

(B) 24-HOUR NOTIFICATION REQUIREMENTS: The person who discovers the presence of, or has knowledge of the presence of, asbestos-contaminated soil (including the representative of the owner or operator), shall notify the

Department’s Hazardous Materials and Waste Management Division within 24 hours of the discovery of visible material containing asbestos in soil or asbestos-contaminated soil during a soil-disturbing activity. This notification shall include, but not be limited to, the following:

(1) Property location.
(2) General site description.
(3) Description of activities resulting in the discovery of asbestos-contaminated soil.
(4) Description of type and amount of material containing asbestos or asbestos-contaminated soil encountered.
(5) Description of any access and emission controls already implemented at the site.
(6) Property representative’s name and phone number.
(7) Contact name and phone number for the party performing soil-disturbing activities.

(C) INTERIM ACTIONS: Interim actions, including characterization to support the management practices, shall be taken by the owner or operator to prevent the release of, and/or exposure to, asbestos until such time as an asbestos Soil Characterization and Management Plan, in accordance with Section 5.5.4(B) is approved by the Department. Such interim actions shall include, but are not limited to, measures listed in Section 5.5.4(B)(5)(c). To minimize potential delays, site owners and operators may proactively collaborate with the Department, in advance of any soil-disturbing activities, to jointly develop approved standard procedures that site owners and operators will implement as needed for all future applicable soil-disturbing activities.

(D) Once the requirements of Sections 5.5.3(A),(B),and(C) are completed, soil disturbing activities can proceed in accordance with applicable requirements.

5.5.4 RESPONSE FOR PLANNED ASBESTOS MANAGEMENT

Planned soil-disturbing activities in areas of known or suspected asbestos-contaminated soil, or material containing asbestos, are subject to the following requirements:

(A) 10 WORKING DAY NOTIFICATION REQUIREMENTS: The Department’s Hazardous Materials and Waste Management

Division shall be notified at least 10 working days prior to any planned soil-disturbing activity, or a shorter time as approved by the Department, at sites that are subject to this Section 5.5. This notification shall include, but not be limited to, the following:

(1) Property location.
(2) General site description.
(3) A Soil Characterization and Management Plan, in accordance with Section 5.5.4(B).
(4) Property representative's name and phone number.
(5) Contact name and phone number for the party performing soil-disturbing activities.

(B) SOIL CHARACTERIZATION AND MANAGEMENT PLAN: At least 10 working days prior to any soil disturbing activity in an area with known or potential material suspected of containing asbestos in or on the soil, or asbestos-contaminated soil, a Soil Characterization and Management Plan shall be submitted to the Department for review and approval. The Department will use its best efforts to review and respond to the plan within ten (10) working days of receipt. The Soil Characterization and Management Plan shall include, but not be limited to, the following:

(1) Property location.

(2) General site description, including a description of the types of known or potential material suspected of containing asbestos, or asbestos-contaminated soil, and the location on the site.

(3) Description of any proposed soil sampling or soil characterization, including:

(a) Work practices to be utilized during any proposed soil sampling or characterization that will eliminate or minimize opportunity for asbestos fiber release, and/or dust emissions.

(b) The location of any proposed sampling.

(c) Proposed sampling plan and methodology.

(d) Proposed analytical method.

(4) Description of planned soil-disturbing activities.

(5) Description of proposed exposure mitigation and asbestos fiber control measures, including:

(a) Measures to prevent site access by unauthorized persons, and minimize the risk of asbestos exposure.

(b) An air monitoring plan that demonstrates dust-control measures to ensure the safety of people in and around the work area and prevent release of asbestos fibers outside the work area. The air monitoring plan shall include a contingency plan for immediate work stoppage, or modification of dust control measures, in the event that approved measured or visible dust limits, as defined in the air monitoring plan, are exceeded in or around the work area.

(c) An emissions control plan that describes work practices that will be implemented to prevent the release of and/or exposure to asbestos fibers. The emissions control plan shall include any of the following measures, as appropriate:

(i) Assuring that the soil is adequately wet (as that term is defined in Section 1.2 of 6 CCR 1007-2), stabilized, or covered during soil disturbing activities.

(ii) Erecting wind fences around the area(s) being disturbed that contain asbestos-contaminated soil during the entire time that it is being disturbed.

(iii) Establishing equipment decontamination procedures and/or track-out prevention measures.

(iv) Covering soil piles or inactive working surfaces with tarps or dust suppressants.

And may also include:

(v) Erecting a structure maintained at a negative pressure differential sufficient to contain all dust, with off-gas from the evacuation system treated with HEPA filtration.

(d) A plan for filling, covering, or otherwise mitigating possible exposure to asbestos fibers from any remaining asbestos-contaminated soil that has been exposed by the soil-disturbing activity, but is not disturbed, such as an excavation side-wall or bottom. At a minimum, covering shall constitute paving or covering asbestos-contaminated soil with an amount of clean soil appropriate to future uses.

(e) A plan for disposal of asbestos waste and/or asbestos-contaminated soil, which shall include:

(i)Characterization of the asbestos waste and/or disturbed soils, if appropriate.

(ii)Segregation of the asbestos waste and/or disturbed soils, if necessary.

(iii)Disposal destination for any asbestos waste and/or asbestos-contaminated soil.

(iv)Notification of receiving facility.

To minimize potential delays, site owners and operators may proactively collaborate with the Department, in advance of any soil-disturbing activities, to jointly develop approved standard procedures that site owners and operators will implement as needed for all future applicable soil-disturbing activities.

(C) Once the notification requirements of Section 5.5.4(A) are completed, and the Soil Characterization and Management Plan required in Section 5.5.4(B) is approved, soil disturbing activities can proceed in accordance with applicable requirements.

5.5.5 REMEDIATION OF ASBESTOS-CONTAMINATED SOIL.

(A) If the owner of a property chooses to remediate (rather than just manage) all or a portion of the property containing asbestos-contaminated soil, an Asbestos Remediation Plan shall be submitted to the Department’s Hazardous Materials and Waste Management Division for review and approval prior to commencement of soil disturbing activities. The Asbestos Remediation Plan shall comply with

this Section 5.5 and include, but not be limited to, the following:

(1) a Soil Characterization and Management Plan, submitted in accordance with Section 5.5.4(B).

(2) A detailed description of planned remediation activities, including proposed depth and areal extent of remediation, and work practices to be implemented.

(3) The proposed use of the property and area of remediation.

(4) Any planned engineering controls to prevent exposure to any asbestos left in place.

(B) The Department shall use its best efforts to provide written notification that an Asbestos Remediation Plan has been approved or disapproved within no more than forty-five (45) days after a request by a property owner, unless the property owner and the Department agree to an extension of the review to a date certain.

5.5.6 TRAINING AND CERTIFICATION REQUIREMENTS.

(A) The following minimum training requirements shall apply to any person performing work subject to these regulations, pursuant to the Applicability and Exemption provisions of subsections 5.5.1 and 5.5.2 of this regulation:

(1) Each individual performing soil-disturbing activities shall complete an on-the-job asbestos-contaminated soil awareness training that provides information necessary to perform their duties in a way that ensures compliance with the requirements of this Section 5.5. This training must be conducted by an asbestos Supervisor, Building Inspector or Project Designer who has been certified in accordance with Air Quality Control Commission Regulation No. 8 (5 CCR 1001-10, Part B), and who has a minimum of six (6) months experience in asbestos-contaminated soil management.

(2) Each individual performing soil-disturbing activities in an area with asbestos waste or asbestos-contaminated soil shall complete asbestos awareness

training in accordance with the Occupational Safety and Health Administration (OSHA) standards set forth at 29 CFR 1926.1101(k)(9)(vii)(2005)(not including later amendments or additions) and asbestos-contaminated soil training that provides information necessary to perform their duties in a way that ensures compliance with the requirements of this Section 5.5. The asbestos-contaminated soil training must be conducted by an asbestos Supervisor, Building Inspector or Project Designer who has been certified in accordance with Air Quality Control Commission Regulation No. 8 (5 CCR 1001-10, Part B), and who has a minimum of six (6) months experience in asbestos-contaminated soil management.

(3) Inspection and identification of asbestos in soil shall be conducted by an asbestos Building Inspector who has been certified in accordance with Air Quality Control Commission Regulation No. 8 (5 CCR 1001-10, Part B), and who has a minimum of six (6) months experience in asbestos-contaminated soil inspections.

(4) Soil Characterization and Management Plans shall be prepared and signed by an Asbestos Project Designer who has been certified in accordance with Air Quality Control Commission Regulation No. 8 (5 CCR 1001-10, Part B).

(5) Any individual performing air monitoring shall be a certified Air Monitoring Specialist in accordance with Air Quality Control Commission Regulation No. 8 (5 CCR 1001-10, Part B).

(B) Records that document the training, experience, or certification required in Section 5.5.6(A) shall be available for department review throughout the duration of soil-disturbing activities.

5.5.7 DISPOSAL OF ASBESTOS-CONTAMINATED SOIL

(A) Asbestos-contaminated soils containing visible friable asbestos must be transported and disposed in a leak tight container as friable asbestos waste in accordance with the requirements of Section 5.3 of this Part 5. Documentation stating that the soil originating from the site shall not be used as daily cover or sold as clean fill must accompany

each load of asbestos-contaminated soil removed from the site.

(B) Asbestos-contaminated soil containing only visible non-friable asbestos that has not been rendered friable must be transported in a leak tight container and disposed of as non-friable asbestos in accordance with Section 5.2 of this Part 5. Documentation stating that the soil originating from the site shall not be used as daily cover or sold as clean fill must accompany each load of asbestos-contaminated soil removed from the site.

(C) Asbestos-contaminated soils containing no visible asbestos must be transported in a leak tight container and disposed in a manner similar to non-friable asbestos waste, as described in Section 5.2 of this Part 5. Documentation stating that the soil originating from the site shall not be used as daily cover or sold as clean fill must accompany each load of asbestos-contaminated soil removed from the site.

(D) Soils that are not asbestos-contaminated, based on analysis showing no detectable amounts of asbestos, may be replaced into the disturbed area as needed, used as fill, or disposed as solid waste.

5.5.8 FEES.

The Department shall collect fees, from the owner, operator, or person conducting the soil-disturbing activity, based on total documented costs, in accordance with Section 1.7.2, for the review of the Soil Characterization and Management Plan, related documents, and the performance of oversight activities by the Department.

ATTACHMENT D

NATIONAL INSTITUTE FOR OCCUPATIONAL SAFETY AND HEALTH (NIOSH) METHOD 7400, ISSUE 2, 15 AUGUST 1994 *(SAMPLING METHODS)*

ASBESTOS and OTHER FIBERS by PCM

Various MW: Various CAS: Various RTECS: Various

METHOD: 7400, Issue 2 **EVALUATION: FULL** **Issue 1: Rev. 3 on 15 May 1989**
Issue 2: 15 August 1994

OSHA : 0.1 asbestos fiber (> 5 µm long)/cc; 1 f/cc/30 min excursion; carcinogen
MSHA: 2 asbestos fibers/cc
NIOSH: 0.1 f/cc (fibers > 5 µm long)/400 L; carcinogen
ACGIH: 0.2 crocidolite; 0.5 amosite; 2 chrysotile and other asbestos, fibers/cc; carcinogen

PROPERTIES: solid, fibrous, crystalline, anisotropic

SYNONYMS [CAS #]: actinolite **[77536-66-4]** or ferroactinolite **[15669-07-5]**; amosite **[12172-73-5]**; anthophyllite **[77536-67-5]**; chrysotile **[12001-29-5]**; serpentine **[18786-24-8]**; crocidolite **[12001-28-4]**; tremolite **[77536-68-6]**; amphibole asbestos **[1332-21-4]**; refractory ceramic fibers **[142844-00-6]**; fibrous glass.

SAMPLING

SAMPLER: FILTER (0.45- to 1.2-µm cellulose ester membrane, 25-mm; conductive cowl on cassette)

FLOW RATE*: 0.5 to 16 L/min

VOL-MIN*: 400 L @ 0.1 fiber/cc
-MAX*: (step 4, sampling)
*Adjust to give 100 to 1300 fiber/mm^2

SHIPMENT: routine (pack to reduce shock)

SAMPLE STABILITY: stable

BLANKS: 2 to 10 field blanks per set

ACCURACY

RANGE STUDIED: 80 to 100 fibers counted

BIAS: see EVALUATION OF METHOD

OVERALL PRECISION ($\hat{S}_{rT}$): 0.115 to 0.13 [1]

ACCURACY: see EVALUATION OF METHOD

MEASUREMENT

TECHNIQUE: LIGHT MICROSCOPY, PHASE CONTRAST

ANALYTE: fibers (manual count)

SAMPLE PREPARATION: acetone - collapse/triacetin - immersion method [2]

COUNTING RULES: described in previous version of this method as "A" rules [1,3]

EQUIPMENT:
1. positive phase-contrast microscope
2. Walton-Beckett graticule (100-µm field of view) Type G-22
3. phase-shift test slide (HSE/NPL)

CALIBRATION: HSE/NPL test slide

RANGE: 100 to 1300 fibers/mm^2 filter area

ESTIMATED LOD: 7 fibers/mm^2 filter area

PRECISION ($\hat{S}_r$): 0.10 to 0.12 [1]; see EVALUATION OF METHOD

APPLICABILITY: The quantitative working range is 0.04 to 0.5 fiber/cc for a 1000-L air sample. The LOD depends on sample volume and quantity of interfering dust, and is <0.01 fiber/cc for atmospheres free of interferences. The method gives a n index of airborne fibers. It is primarily used for estimating asbestos concentrations, though PCM does not differentiate betwe en asbestos and other fibers. Use this method in conjunction with electron microscopy (e.g., Method 7402) for assistance in identifi cation of fibers. Fibers < ca. 0.25 µm diameter will not be detected by this method [4]. This method may be used for other materia ls such as fibrous glass by using alternate counting rules (see Appendix C).

INTERFERENCES: If the method is used to detect a specific type of fiber, any other airborne fiber may interfere since all particles meeting the counting criteria are counted. Chain-like particles may appear fibrous. High levels of non-fibrous dust part icles may obscure fibers in the field of view and increase the detection limit.

OTHER METHODS: This revision replaces Method 7400, Revision #3 (dated 5/15/89).

REAGENTS:

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

* See SPECIAL PRECAUTIONS.

EQUIPMENT:

1. Sampler: field monitor, 25-mm, three-piece cassette with ca. 50-mm electrically conductive extension cowl and cellulose ester filter, 0.45- to 1.2-µm pore size, and backup pad.
   NOTE 1: Analyze representative filters for fiber background before use to check for clarity and background. Discard the filter lot if mean is ≥5 fibers per 100 graticule fields. These are defined as laboratory blanks. Manufacturer-provided quality assurance checks on filter blanks are normally adequate as long as field blanks are analyzed as described below.
   NOTE 2: The electrically conductive extension cowl reduces electrostatic effects. Ground the cowl when possible during sampling.
   NOTE 3: Use 0.8-µm pore size filters for personal sampling. The 0.45-µm filters are recommended for sampling when performing TEM analysis on the same samples. However, their higher pressure drop precludes their use with personal sampling pumps.
   NOTE 4: Other cassettes have been proposed that exhibit improved uniformity of fiber deposit on the filter surface, e.g., bellmouthed sampler (Environmetrics, Charleston, SC). These may be used if shown to give measured concentrations equivalent to sampler indicated above for the application.
2. Personal sampling pump, battery or line-powered vacuum, of sufficient capacity to meet flow-rate requirements (see step 4 for flow rate), with flexible connecting tubing.
3. Wire, multi-stranded, 22-gauge; 1", hose clamp to attach wire to cassette.
4. Tape, shrink- or adhesive-.
5. Slides, glass, frosted-end, pre-cleaned, 25 x 75-mm.
6. Cover slips, 22- x 22-mm, No. 1-1/2, unless otherwise specified by microscope manufacturer.
7. Lacquer or nail polish.
8. Knife, #10 surgical steel, curved blade.
9. Tweezers.

EQUIPMENT:

10. Acetone flash vaporization system for clearing filters on glass slides (see ref. [5] for specifications or see manufacturer's instructions for equivalent devices).
11. Micropipets or syringes, 5-µL and 100- to 500-µL.
12. Microscope, positive phase (dark) contrast, with green or blue filter, adjustable field iris, 8 to 10X eyepiece, and 40 to 45X phase objective (total magnification ca. 400X); numerical aperture = 0.65 to 0.75.
13. Graticule, Walton-Beckett type with 100-µm diameter circular field (area = 0.00785 mm^2) at the specimen plane (Type G-22). Available from Optometrics USA, P.O. Box 699, Ayer, MA 01432 [phone (508)-772-1700], and McCrone Accessories and Components, 850 Pasquinelli Drive, Westmont, IL 60559 [phone (312) 887-7100].
    NOTE: The graticule is custom-made for each microscope. (see APPENDIX A for the custom-ordering procedure).
14. HSE/NPL phase contrast test slide, Mark II. Available from Optometrics USA (address above).
15. Telescope, ocular phase-ring centering.
16. Stage micrometer (0.01-mm divisions).

SPECIAL PRECAUTIONS: Acetone is extremely flammable. Take precautions not to ignite it. Heating of acetone in volumes greater than 1 mL must be done in a ventilated laboratory fume hood using a flameless, spark-free heat source.

SAMPLING:

1. Calibrate each personal sampling pump with a representative sampler in line.
2. To reduce contamination and to hold the cassette tightly together, seal the crease between the cassette base and the cowl with a shrink band or light colored adhesive tape. For personal sampling, fasten the (uncapped) open-face cassette to the worker's lapel. The open face should be oriented downward.
    NOTE: The cowl should be electrically grounded during area sampling, especially under conditions of low relative humidity. Use a hose clamp to secure one end of the wire (Equipment, Item 3) to the monitor's cowl. Connect the other end to an earth ground (i.e., cold water pipe).
3. Submit at least two field blanks (or 10% of the total samples, whichever is greater) for each set of samples. Handle field blanks in a manner representative of actual handling of associated samples in the set. Open field blank cassettes at the same time as other cassettes just prior to sampling. Store top covers and cassettes in a clean area (e.g., a closed bag or box) with the top covers from the sampling cassettes during the sampling period.
4. Sample at 0.5 L/min or greater [6]. Adjust sampling flow rate, Q (L/min), and time, t (min), to produce a fiber density, E, of 100 to 1300 fibers/mm^2 ($3.85 \cdot 10^4$ to $5 \cdot 10^5$ fibers per 25-mm filter with effective collection area A_c = 385 mm^2) for optimum accuracy. These variables are related

to the action level (one-half the current standard), L (fibers/cc), of the fibrous aerosol being sampled by:

$$t = \frac{A_c \cdot E}{Q \cdot L \cdot 10^3}, \text{ min.}$$

NOTE 1: The purpose of adjusting sampling times is to obtain optimum fiber loading on the filter. The collection efficiency does not appear to be a function of flow rate in the range of 0.5 to 16 L/min for asbestos fibers [7]. Relatively large diameter fibers (>3 µm) may exhibit significant aspiration loss and inlet deposition. A sampling rate of 1 to 4 L/min for 8 h is appropriate in atmospheres containing ca. 0.1 fiber/cc in the absence of significant amounts of non-asbestos dust. Dusty atmospheres require smaller sample volumes (≤400 L) to obtain countable samples. In such cases take short, consecutive samples and average the results over the total collection time. For documenting episodic exposures, use high flow rates (7 to 16 L/min) over shorter sampling times. In relatively clean atmospheres, where targeted fiber concentrations are much less than 0.1 fiber/cc, use larger sample volumes (3000 to 10000 L) to achieve quantifiable loadings. Take care, however, not to overload the filter with background dust. If ≥ 50% of the filter surface is covered with particles, the filter may be too overloaded to count and will bias the measured fiber concentration.

NOTE 2: OSHA regulations specify a minimum sampling volume of 48 L for an excursion measurement, and a maximum sampling rate of 2.5 L/min [3].

5. At the end of sampling, replace top cover and end plugs.
6. Ship samples with conductive cowl attached in a rigid container with packing material to prevent jostling or damage.

   NOTE: Do not use untreated polystyrene foam in shipping container because electrostatic forces may cause fiber loss from sample filter.

SAMPLE PREPARATION:

NOTE 1: The object is to produce samples with a smooth (non-grainy) background in a medium with refractive index ≤1.46. This method collapses the filter for easier focusing and produces permanent (1 - 10 years) mounts which are useful for quality control and interlaboratory comparison. The aluminum "hot block" or similar flash vaporization techniques may be used outside the laboratory [2]. Other mounting techniques meeting the above criteria may also be used (e.g., the laboratory fume hood procedure for generating acetone vapor as described in Method 7400 - revision of 5/15/85, or the non-permanent field mounting technique used in P&CAM 239 [3,7,8,9]). Unless the effective filtration area is known, determine the area and record the information referenced against the sample ID number [1,9,10,11].

NOTE 2: Excessive water in the acetone may slow the clearing of the filter, causing material to be washed off the surface of the filter. Also, filters that have been exposed to high humidities prior to clearing may have a grainy background.

7. Ensure that the glass slides and cover slips are free of dust and fibers.
8. Adjust the rheostat to heat the "hot block" to ca. 70 °C [2].

   NOTE: If the "hot block" is not used in a fume hood, it must rest on a ceramic plate and be isolated from any surface susceptible to heat damage.

9. Mount a wedge cut from the sample filter on a clean glass slide.
   a. Cut wedges of ca. 25% of the filter area with a curved-blade surgical steel knife using a rocking motion to prevent tearing. Place wedge, dust side up, on slide.

      NOTE: Static electricity will usually keep the wedge on the slide.

b. Insert slide with wedge into the receiving slot at base of "hot block". Immediately place tip of a micropipet containing ca. 250 µL acetone (use the minimum volume needed to consistently clear the filter sections) into the inlet port of the PTFE cap on top of the "hot block" and inject the acetone into the vaporization chamber with a slow, steady pressure on the plunger button while holding pipet firmly in place. After waiting 3 to 5 sec for the filter to clear, remove pipet and slide from their ports.
   CAUTION: Although the volume of acetone used is small, use safety precautions. Work in a well-ventilated area (e.g., laboratory fume hood). Take care not to ignite the acetone. Continuous use of this device in an unventilated space may produce explosive acetone vapor concentrations.
c. Using the 5-µL micropipet, immediately place 3.0 to 3.5 µL triacetin on the wedge. Gently lower a clean cover slip onto the wedge at a slight angle to reduce bubble formation. Avoid excess pressure and movement of the cover glass.
   NOTE: If too many bubbles form or the amount of triacetin is insufficient, the cover slip may become detached within a few hours. If excessive triacetin remains at the edge of the filter under the cover slip, fiber migration may occur.
d. Mark the outline of the filter segment with a glass marking pen to aid in microscopic evaluation.
e. Glue the edges of the cover slip to the slide using lacquer or nail polish [12]. Counting may proceed immediately after clearing and mounting are completed.
   NOTE: If clearing is slow, warm the slide on a hotplate (surface temperature 50 °C) for up to 15 min to hasten clearing. Heat carefully to prevent gas bubble formation.

CALIBRATION AND QUALITY CONTROL:

10. Microscope adjustments. Follow the manufacturers instructions. At least once daily use the telescope ocular (or Bertrand lens, for some microscopes) supplied by the manufacturer to ensure that the phase rings (annular diaphragm and phase-shifting elements) are concentric. With each microscope, keep a logbook in which to record the dates of microscope cleanings and major servicing.
    a. Each time a sample is examined, do the following:
       (1) Adjust the light source for even illumination across the field of view at the condenser iris. Use Kohler illumination, if available. With some microscopes, the illumination may have to be set up with bright field optics rather than phase contract optics.
       (2) Focus on the particulate material to be examined.
       (3) Make sure that the field iris is in focus, centered on the sample, and open only enough to fully illuminate the field of view.
    b. Check the phase-shift detection limit of the microscope periodically for each analyst/microscope combination:
       (1) Center the HSE/NPL phase-contrast test slide under the phase objective.
       (2) Bring the blocks of grooved lines into focus in the graticule area.
          NOTE: The slide contains seven blocks of grooves (ca. 20 grooves per block) in descending order of visibility. For asbestos counting the microscope optics must completely resolve the grooved lines in block 3 although they may appear somewhat faint, and the grooved lines in blocks 6 and 7 must be invisible when centered in the graticule area. Blocks 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 resolution either too low or too high for fiber counting.
       (3) If image quality deteriorates, clean the microscope optics. If the problem persists, consult the microscope manufacturer.
11. Document the laboratory's precision for each counter for replicate fiber counts.
    a. Maintain as part of the laboratory quality assurance program a set of reference slides to be used on a daily basis [13]. These slides should consist of filter preparations including a range of loadings and background dust levels from a variety of sources including both field

and reference samples (e.g., PAT, AAR, commercial samples). The Quality Assurance Officer should maintain custody of the reference slides and should supply each counter with a minimum of one reference slide per workday. Change the labels on the reference slides periodically so that the counter does not become familiar with the samples.

b. From blind repeat counts on reference slides, estimate the laboratory intra- and intercounter precision. Obtain separate values of relative standard deviation (S_r) for each sample matrix analyzed in each of the following ranges: 5 to 20 fibers in 100 graticule fields, >20 to 50 fibers in 100 graticule fields, and >50 to 100 fibers in 100 graticule fields. Maintain control charts for each of these data files.

NOTE: Certain sample matrices (e.g., asbestos cement) have been shown to give poor precision [9]

12. Prepare and count field blanks along with the field samples. Report counts on each field blank.

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

NOTE 2: If a field blank yields greater than 7 fibers per 100 graticule fields, report possible contamination of the samples.

13. Perform blind recounts by the same counter on 10% of filters counted (slides relabeled by a person other than the counter). Use the following test to determine whether a pair of counts by the same counter on the same filter should be rejected because of possible bias: Discard the sample if the absolute value of the difference between the square roots of the two counts (in fiber/mm^2) exceeds 2.77 (X)S_r', where X = average of the square roots of the two fiber counts (in fiber/mm^2) and $S_r' = \frac{S_r}{2}$, where S_r is the intracounter relative standard deviation for the appropriate count range (in fibers) determined in step 11. For more complete discussions see reference [13].

NOTE 1: Since fiber counting is the measurement of randomly placed fibers which may be described by a Poisson distribution, a square root transformation of the fiber count data will result in approximately normally distributed data [13].

NOTE 2: If a pair of counts is rejected by this test, recount the remaining samples in the set and test the new counts against the first counts. Discard all rejected paired counts. It is not necessary to use this statistic on blank counts.

14. The analyst is a critical part of this analytical procedure. Care must be taken to provide a non-stressful and comfortable environment for fiber counting. An ergonomically designed chair should be used, with the microscope eyepiece situated at a comfortable height for viewing. External lighting should be set at a level similar to the illumination level in the microscope to reduce eye fatigue. In addition, counters should take 10-to-20 minute breaks from the microscope every one or two hours to limit fatigue [14]. During these breaks, both eye and upper back/neck exercises should be performed to relieve strain.

15. All laboratories engaged in asbestos counting should participate in a proficiency testing program such as the AIHA-NIOSH Proficiency Analytical Testing (PAT) Program for asbestos and routinely exchange field samples with other laboratories to compare performance of counters.

MEASUREMENT:

16. Center the slide on the stage of the calibrated microscope under the objective lens. Focus the microscope on the plane of the filter.

17. Adjust the microscope (Step 10).

NOTE: Calibration with the HSE/NPL test slide determines the minimum detectable fiber diameter (ca. 0.25 µm) [4].

18. Counting rules: (same as P&CAM 239 rules [1,10,11]: see examples in APPENDIX B).

a. Count any fiber longer than 5 µm which lies entirely within the graticule area.
   (1) Count only fibers longer than 5 µm. Measure length of curved fibers along the curve.
   (2) Count only fibers with a length-to-width ratio equal to or greater than 3:1.

b. For fibers which cross the boundary of the graticule field:

(1) Count as 1/2 fiber any fiber with only one end lying within the graticule area, provided that the fiber meets the criteria of rule a above.
(2) Do not count any fiber which crosses the graticule boundary more than once.
(3) Reject and do not count all other fibers.

c. Count bundles of fibers as one fiber unless individual fibers can be identified by observing both ends of a fiber.
d. Count enough graticule fields to yield 100 fibers. Count a minimum of 20 fields. Stop at 100 graticule fields regardless of count.

19. Start counting from the tip of the filter wedge and progress along a radial line to the outer edge. Shift up or down on the filter, and continue in the reverse direction. Select graticule fields randomly by looking away from the eyepiece briefly while advancing the mechanical stage. Ensure that, as a minimum, each analysis covers one radial line from the filter center to the outer edge of the filter. When an agglomerate or bubble covers ca. 1/6 or more of the graticule field, reject the graticule field and select another. Do not report rejected graticule fields in the total number counted.

NOTE 1: When counting a graticule 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. A minimum counting time of 15 seconds per field is appropriate for accurate counting.

NOTE 2: This method does not allow for differentiation of fibers based on morphology. Although some experienced counters are capable of selectively counting only fibers which appear to be asbestiform, there is presently no accepted method for ensuring uniformity of judgment between laboratories. It is, therefore, incumbent upon all laboratories using this method to report total fiber counts. If serious contamination from non-asbestos fibers occurs in samples, other techniques such as transmission electron microscopy must be used to identify the asbestos fiber fraction present in the sample (see NIOSH Method 7402). In some cases (i.e., for fibers with diameters >1 µm), polarized light microscopy (as in NIOSH Method 7403) may be used to identify and eliminate interfering non-crystalline fibers [15].

NOTE 3: Do not count at edges where filter was cut. Move in at least 1 mm from the edge.

NOTE 4: Under certain conditions, electrostatic charge may affect the sampling of fibers. These electrostatic effects are most likely to occur when the relative humidity is low (below 20%), and when sampling is performed near the source of aerosol. The result is that deposition of fibers on the filter is reduced, especially near the edge of the filter. If such a pattern is noted during fiber counting, choose fields as close to the center of the filter as possible [5].

NOTE 5: Counts are to be recorded on a data sheet that provides, as a minimum, spaces on which to record the counts for each field, filter identification number, analyst's name, date, total fibers counted, total fields counted, average count, fiber density, and commentary. Average count is calculated by dividing the total fiber count by the number of fields observed. Fiber density (fibers/mm ^{2}) is defined as the average count (fibers/field) divided by the field (graticule) area (mm ^{2}/field).

CALCULATIONS AND REPORTING OF RESULTS

20. Calculate and report fiber density on the filter, E (fibers/mm ^{2}), by dividing the average fiber count per graticule field, F/n_f, minus the mean field blank count per graticule field, B/n_b, by the graticule field area, A_f (approx. 0.00785 mm ^{2}):

$$E = \frac{\left(\frac{F}{n_f} - \frac{B}{n_b}\right)}{A_f}, \text{ fibers/mm}^2.$$

NOTE: Fiber counts above 1300 fibers/mm ^{2} and fiber counts from samples with >50% of filter area covered with particulate should be reported as "uncountable" or "probably biased." Other fiber counts outside the 100-1300 fiber/mm ^{2} range should be reported as having "greater than optimal variability" and as being "probably biased."

21. Calculate and report the concentration, C (fibers/cc), of fibers in the air volume sampled, V (L), using the effective collection area of the filter, A_c (approx. 385 mm ^{2} for a 25-mm filter):

$$C = \frac{(E)(A_c)}{V \cdot 10^3}.$$

NOTE: Periodically check and adjust the value of A_c, if necessary.

22. Report intralaboratory and interlaboratory relative standard deviations (from Step 11) with each set of results.

NOTE: Precision depends on the total number of fibers counted [1,16]. Relative standard deviation is documented in references [1,15-17] for fiber counts up to 100 fibers in 100 graticule fields. Comparability of interlaboratory results is discussed below. As a first approximation, use 213% above and 49% below the count as the upper and lower confidence limits for fiber counts greater than 20 (Fig. 1).

EVALUATION OF METHOD:

A. This method is a revision of P&CAM 239 [10]. A summary of the revisions is as follows:
   1. Sampling:
      The change from a 37-mm to a 25-mm filter improves sensitivity for similar air volumes. The change in flow rates allows for 2-m ^{3} full-shift samples to be taken, providing that the filter is not overloaded with non-fibrous particulates. The collection efficiency of the sampler is not a function of flow rate in the range 0.5 to 16 L/min [10].
   2. Sample Preparation Technique:
      The acetone vapor-triacetin preparation technique is a faster, more permanent mounting technique than the dimethyl phthalate/diethyl oxalate method of P&CAM 239 [2,4,10]. The aluminum "hot block" technique minimizes the amount of acetone needed to prepare each sample.
   3. Measurement:
      a. The Walton-Beckett graticule standardizes the area observed [14,18,19].
      b. The HSE/NPL test slide standardizes microscope optics for sensitivity to fiber diameter [4,14].
      c. Because of past inaccuracies associated with low fiber counts, the minimum recommended loading has been increased to 100 fibers/mm ^{2} filter area (a total of 78.5 fibers counted in 100 fields, each with field area = .00785 mm ^{2}.) Lower levels generally result in an overestimate of the fiber count when compared to results in the recommended analytical range [20]. The recommended loadings should yield intracounter S_r in the range of 0.10 to 0.17 [21,22,23].

B. Interlaboratory comparability:
   An international collaborative study involved 16 laboratories using prepared slides from the asbestos cement, milling, mining, textile, and friction material industries [9]. The relative standard deviations (S_r) varied with sample type and laboratory. The ranges were:

	Intralaboratory S_r	Interlaboratory S_r	Overall S_r
AIA (NIOSH A Rules)*	0.12 to 0.40	0.27 to 0.85	0.46
Modified CRS (NIOSH B Rules)**	0.11 to 0.29	0.20 to 0.35	0.25

* Under AIA rules, only fibers having a diameter less than 3 µm are counted and fibers attached to particles larger than 3 µm are not counted. NIOSH A Rules are otherwise similar to the AIA rules.
** See Appendix C.

A NIOSH study conducted using field samples of asbestos gave intralaboratory S_r in the range 0.17 to 0.25 and an interlaboratory S_r of 0.45 [21]. This agrees well with other recent studies [9,14,16].

At this time, there is no independent means for assessing the overall accuracy of this method. One measure of reliability is to estimate how well the count for a single sample agrees with the mean count from a large number of laboratories. The following discussion indicates how this estimation can be carried out based on measurements of the interlaboratory variability, as well as showing how the results of this method relate to the theoretically attainable counting precision and to measured intra- and interlaboratory S_r. (NOTE: The following discussion does not include bias estimates and should not be taken to indicated that lightly loaded samples are as accurate as properly loaded ones).

Theoretically, the process of counting randomly (Poisson) distributed fibers on a filter surface will give an S_r that depends on the number, N, of fibers counted:

$$S_r = 1/(N)^{1/2} \quad (1)$$

Thus S_r is 0.1 for 100 fibers and 0.32 for 10 fibers counted. The actual S_r found in a number of studies is greater than these theoretical numbers [17,19,20,21].

An additional component of variability comes primarily from subjective interlaboratory differences. In a study of ten counters in a continuing sample exchange program, Ogden [15] found this subjective component of intralaboratory S_r to be approximately 0.2 and estimated the overall S_r by the term:

$$\frac{[N + (0.2 \cdot N)^2]^{1/2}}{N} \quad (2)$$

Ogden found that the 90% confidence interval of the individual intralaboratory counts in relation to the means were +2 S_r and - 1.5 S_r. In this program, one sample out of ten was a quality control sample. For laboratories not engaged in an intensive quality assurance program, the subjective component of variability can be higher.

In a study of field sample results in 46 laboratories, the Asbestos Information Association also found that the variability had both a constant component and one that depended on the fiber count [14]. These results gave a subjective interlaboratory component of S_r (on the same basis as Ogden's) for field samples of ca. 0.45. A similar value was obtained for 12 laboratories analyzing a set of 24 field samples [21]. This value falls slightly above the range of S_r (0.25 to 0.42 for 1984-85) found for 80 reference laboratories in the NIOSH PAT program for laboratory-generated samples [17].

A number of factors influence S_r for a given laboratory, such as that laboratory's actual counting performance and the type of samples being analyzed. In the absence of other information, such as from an interlaboratory quality assurance program using field samples, the value for the subjective component of variability is chosen as 0.45. It is hoped that the laboratories will carry out the recommended interlaboratory quality assurance programs to improve their performance and thus reduce the S_r.

The above relative standard deviations apply when the population mean has been determined. It is more useful, however, for laboratories to estimate the 90% confidence interval on the mean count from a single sample fiber count (Figure 1). These curves assume similar shapes of the count distribution for interlaboratory and intralaboratory results [16].

For example, if a sample yields a count of 24 fibers, Figure 1 indicates that the mean interlaboratory count will fall within the range of 227% above and 52% below that value 90% of the time. We can apply these percentages directly to the air concentrations as well. If, for instance, this sample (24 fibers counted) represented a 500-L volume, then the measured concentration is 0.02 fibers/mL (assuming 100 fields counted, 25-mm filter, 0.00785 mm^2 counting field area). If this same sample were counted by a group of laboratories, there is a 90% probability that the mean would fall between 0.01 and 0.08 fiber/mL. These limits should be reported in any comparison of results between laboratories.

Note that the S_r of 0.45 used to derive Figure 1 is used as an estimate for a random group of laboratories. If several laboratories belonging to a quality assurance group can show that their interlaboratory S_r is smaller, then it is more correct to use that smaller S_r. However, the estimated S_r of 0.45 is to be used in the absence of such information. Note also that it has been found that S_r can be higher for certain types of samples, such as asbestos cement [9].

Quite often the estimated airborne concentration from an asbestos analysis is used to compare to a regulatory standard. For instance, if one is trying to show compliance with an 0.5 fiber/mL standard using a single sample on which 100 fibers have been counted, then Figure 1 indicates that the 0.5 fiber/mL standard must be 213% higher than the measured air concentration. This indicates that if one measures a fiber concentration of 0.16 fiber/mL (100 fibers counted), then the mean fiber count by a group of laboratories (of which the compliance laboratory might be one) has a 95% chance of being less than 0.5 fibers/mL; i.e., 0.16 + 2.13 x 0.16 = 0.5.

It can be seen from Figure 1 that the Poisson component of the variability is not very important unless the number of fibers counted is small. Therefore, a further approximation is to simply use +213% and -49% as the upper and lower confidence values of the mean for a 100-fiber count.

Figure 1. Interlaboratory Precision of Fiber Counts

The curves in Figures 1 are defined by the following equations:

$$UCL = \frac{2X + 2.25 + [(2.25 + 2X)^2 - 4(1 - 2.25 S_r^2) X^2]^{1/2}}{2(1 - 2.25 S_r^2)} \quad (3)$$

$$LCL = \frac{2X + 4 - [(4 + 2X)^2 - 4(1 - 4 S_r^2) X^2]^{1/2}}{2(1 - 4 S_r^2)} \quad (4)$$

where S_r = subjective interlaboratory relative standard deviation, which is close to the total interlaboratory S_r when approximately 100 fibers are counted.
X = total fibers counted on sample
LCL = lower 95% confidence limit.
UCL = upper 95% confidence limit.
Note that the range between these two limits represents 90% of the total range.

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METHOD WRITTEN BY:

Paul A. Baron, Ph.D., NIOSH/DPSE.

APPENDIX A: CALIBRATION OF THE WALTON-BECKETT GRATICULE:

Before ordering the Walton-Beckett graticule, the following calibration must be done to obtain a counting area (D) 100 µm in diameter at the image plane. The diameter, d_c (mm), of the circular counting area and the disc diameter must be specified when ordering the graticule.

1. Insert any available graticule into the eyepiece and focus so that the graticule lines are sharp and clear.
2. Set the appropriate interpupillary distance and, if applicable, reset the binocular head adjustment so that the magnification remains constant.
3. Install the 40 to 45X phase objective.
4. Place a stage micrometer on the microscope object stage and focus the microscope on the graduated lines.
5. Measure the magnified grid length of the graticule, L_o (µm), using the stage micrometer.
6. 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.
7. Calculate the circle diameter, d_c (mm), for the Walton-Beckett graticule:

$$d_c = \frac{L_a}{L_o} \times D. \quad (5)$$

Example: If L_o = 112 µm, L_a = 4.5 mm and D = 100 µm, then d_c = 4.02 mm.

8. Check the field diameter, D (acceptable range 100 µm ± 2 µm) with a stage micrometer upon receipt of the graticule from the manufacturer. Determine field area (acceptable range 0.00754 mm^2 to 0.00817 mm^2).

APPENDIX B: COMPARISON OF COUNTING RULES:

Figure 2 shows a Walton-Beckett graticule as seen through the microscope. The rules will be discussed as they apply to the labeled objects in the figure.

Figure 2. Walton-Beckett graticule with fibers.

These rules are sometimes referred to as the "A" rules.

FIBER COUNT

Object	Count	DISCUSSION
1	1 fiber	Optically observable asbestos fibers are actually bundles of fine fibrils. If the fibrils seem to be from the same bundle the object is counted as a single fiber. Note, however, that all objects meeting length and aspect ratio criteria are counted whether or not they appear to be asbestos.
2	2 fiber	If fibers meeting the length and aspect ratio criteria (length >5 µm and length-to-width ratio >3 to 1) overlap, but do not seem to be part of the same bundle, they are counted as separate fibers.
3	1 fiber	Although the object has a relatively large diameter (>3 µm), it is counted as fiber under the rules. There is no upper limit on the fiber diameter in the counting rules. Note that fiber width is measured at the widest compact section of the object.
4	1 fiber	Although long fine fibrils may extend from the body of a fiber, these fibrils are considered part of the fiber if they seem to have originally been part of the bundle.
5	Do not count	If the object is ≤5 µm long, it is not counted.
6	1 fiber	A fiber partially obscured by a particle is counted as one fiber. If the fiber ends emanating from a particle do not seem to be from the same fiber and each end meets the length and aspect ratio criteria, they are counted as separate fibers.
7	1/2 fiber	A fiber which crosses into the graticule area one time is counted as 1/2 fiber.
8	Do not count	Ignore fibers that cross the graticulate boundary more than once. count
9	Do not count	Ignore fibers that lie outside the graticule boundary.

APPENDIX C. ALTERNATE COUNTING RULES FOR NON-ASBESTOS FIBERS

Other counting rules may be more appropriate for measurement of specific non-asbestos fiber types, such as fibrous glass. These include the "B" rules given below (from NIOSH Method 7400, Revision #2, dated 8/15/87), the World Health Organization reference method for man-made mineral fiber [24], and the NIOSH fibrous glass criteria document method [25]. The upper diameter limit in these methods prevents measurements of non-thoracic fibers. It is important to note that the aspect ratio limits included in these methods vary. NIOSH recommends the use of the 3:1 aspect ratio in counting fibers.

It is emphasized that hybridization of different sets of counting rules is not permitted. Report specifically which set of counting rules are used with the analytical results.

"B" COUNTING RULES:

1. Count only ends of fibers. Each fiber must be longer than 5 µm and less than 3 µm diameter.
2. Count only ends of fibers with a length-to-width ratio equal to or greater than 5:1.
3. Count each fiber end which falls within the graticule area as one end, provided that the fiber meets rules 1 and 2 above. Add split ends to the count as appropriate if the split fiber segment also meets the criteria of rules 1 and 2 above.
4. Count visibly free ends which meet rules 1 and 2 above when the fiber appears to be attached to another particle, regardless of the size of the other particle. Count the end of a fiber obscured by another particle if the particle covering the fiber end is less than 3 µm in diameter.
5. Count free ends of fibers emanating from large clumps and bundles up to a maximum of 10 ends (5 fibers), provided that each segment meets rules 1 and 2 above.
6. Count enough graticule fields to yield 200 ends. Count a minimum of 20 graticule fields. Stop at 100 graticule fields, regardless of count.
7. Divide total end count by 2 to yield fiber count.

APPENDIX D. EQUIVALENT LIMITS OF DETECTION AND QUANTITATION

fiber density on filter*		fiber concentration in air, f/cc	
fibers per 100 fields	fibers/mm^2	400-L air sample	1000-L air sample
200	255	0.25	0.10
100	127	0.125	0.05
LOQ.....80	102	.....0.10	.....0.04
50	64	0.0625	0.025
25	32	0.03	0.0125
20	25	0.025	0.010
10	12.7	0.0125	0.005
8	10.2	0.010	0.004
LOD.....5.5	7	.....0.00675	.....0.0027

* Assumes 385 mm^2 effective filter collection area, and field area = 0.00785 mm^2, for relatively "clean" (little particulate aside from fibers) filters.

ATTACHMENT E

AHERA METHOD, APPENDIX A TO SUBPART E OF PART 763 - INTERIM TRANSMISSION ELECTRON MICROSCOPY *(ANALYTICAL METHODS)*

ATTACHMENT E
AHERA Method, Appendix A to Subpart E of Part 763 - Interim Transmission Electron Microscopy *(Analytical Methods)*

As extracted from the Electronic Code of Federal Regulations:

http://ecfr.gpoaccess.gov/cgi/t/text/text-idx?c=ecfr&sid=1ddcedc56483dad548cb7fee1c166b29&rgn=div5&view=text&node=40:30.0.1.1.18&idno=40#40:30.0.1.1.18.2.1.17.2

1.1.1.1.1 Appendix A to Subpart E of Part 763—Interim Transmission Electron Microscopy Analytical Methods—Mandatory and Nonmandatory—and Mandatory Section To Determine Completion of Response Actions

top

I. Introduction

The following appendix contains three units. The first unit is the mandatory transmission electron microscopy (TEM) method which all laboratories must follow; it is the minimum requirement for analysis of air samples for asbestos by TEM. The mandatory method contains the essential elements of the TEM method. The second unit contains the complete non-mandatory method. The non-mandatory method supplements the mandatory method by including additional steps to improve the analysis. EPA recommends that the non-mandatory method be employed for analyzing air filters; however, the laboratory may choose to employ the mandatory method. The non-mandatory method contains the same minimum requirements as are outlined in the mandatory method. Hence, laboratories may choose either of the two methods for analyzing air samples by TEM.

The final unit of this Appendix A to subpart E defines the steps which must be taken to determine completion of response actions. This unit is mandatory.

II. Mandatory Transmission Electron Microscopy Method

A. Definitions of Terms

1. *Analytical sensitivity*—Airborne asbestos concentration represented by each fiber counted under the electron microscope. It is determined by the air volume collected and the proportion of the filter examined. This method requires that the analytical sensitivity be no greater than 0.005 structures/cm ^{3} .

2. *Asbestiform*—A specific type of mineral fibrosity in which the fibers and fibrils possess high tensile strength and flexibility.

3. *Aspect ratio*—A ratio of the length to the width of a particle. Minimum aspect ratio as defined by this method is equal to or greater than 5:1.

4. *Bundle*—A structure composed of three or more fibers in a parallel arrangement with each fiber closer than one fiber diameter.

5. *Clean area*—A controlled environment which is maintained and monitored to assure a low probability of asbestos contamination to materials in that space. Clean areas used in this method have HEPA filtered air under positive pressure and are capable of sustained operation with an open laboratory blank which on subsequent analysis has an average of less than 18 structures/mm ^{2} in an area of 0.057 mm ^{2} (nominally 10 200-mesh grid openings) and a maximum of 53 structures/mm ^{2} for any single preparation for that same area.

6. *Cluster*—A structure with fibers in a random arrangement such that all fibers are intermixed and no single fiber is isolated from the group. Groupings must have more than two intersections.

7. *ED*—Electron diffraction.

8. *EDXA*—Energy dispersive X-ray analysis.

9. *Fiber*—A structure greater than or equal to 0.5 µm in length with an aspect ratio (length to width) of 5:1 or greater and having substantially parallel sides.

10. *Grid*—An open structure for mounting on the sample to aid in its examination in the TEM. The term is used here to denote a 200-mesh copper lattice approximately 3 mm in diameter.

11. *Intersection*—Nonparallel touching or crossing of fibers, with the projection having an aspect ratio of 5:1 or greater.

12. *Laboratory sample coordinator*—That person responsible for the conduct of sample handling and the certification of the testing procedures.

13. *Filter background level*—The concentration of structures per square millimeter of filter that is considered indistinguishable from the concentration measured on a blank (filters through which no air has been drawn). For this method the filter background level is defined as 70 structures/mm ^{2} .

14. *Matrix*—Fiber or fibers with one end free and the other end embedded in or hidden by a particulate. The exposed fiber must meet the fiber definition.

15. *NSD*—No structure detected.

16. *Operator*—A person responsible for the TEM instrumental analysis of the sample.

17. *PCM*—Phase contrast microscopy.

18. *SAED*—Selected area electron diffraction.

19. *SEM*—Scanning electron microscope.

20. *STEM*—Scanning transmission electron microscope.

21. *Structure*—a microscopic bundle, cluster, fiber, or matrix which may contain asbestos.

22. *S/cm 3*—Structures per cubic centimeter.

23. *S/mm 2*—Structures per square millimeter.

24. *TEM*—Transmission electron microscope.

B. Sampling

1. The sampling agency must have written quality control procedures and documents which verify compliance.

2. Sampling operations must be performed by qualified individuals completely independent of the abatement contractor to avoid possible conflict of interest (References 1, 2, 3, and 5 of Unit II.J.).

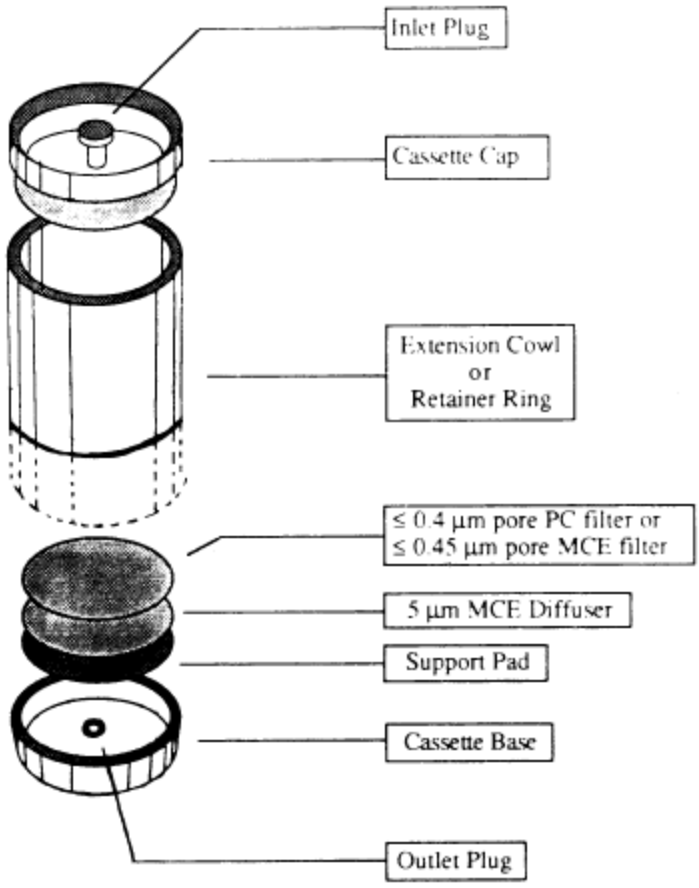
3. Sampling for airborne asbestos following an abatement action must use commercially available cassettes.

4. Prescreen the loaded cassette collection filters to assure that they do not contain concentrations of asbestos which may interfere with the analysis of the sample. A filter blank average of less than 18 s/mm ^{2} in an area of 0.057 mm ^{2} (nominally 10 200-mesh grid openings) and a single preparation with a maximum of 53 s/mm ^{2} for that same area is acceptable for this method.

5. Use sample collection filters which are either polycarbonate having a pore size less than or equal to 0.4 µm or mixed cellulose ester having a pore size less than or equal to 0.45 µm.

6. Place these filters in series with a 5.0 µm backup filter (to serve as a diffuser) and a support pad. See the following Figure 1:

FIGURE I--SAMPLING CASSETTE CONFIGURATION



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7. Reloading of used cassettes is not permitted.

8. Orient the cassette downward at approximately 45 degrees from the horizontal.

9. Maintain a log of all pertinent sampling information.

10. Calibrate sampling pumps and their flow indicators over the range of their intended use with a recognized standard. Assemble the sampling system with a representative filter (not the filter which will be used in sampling) before and after the sampling operation.

11. Record all calibration information.

12. Ensure that the mechanical vibrations from the pump will be minimized to prevent transferral of vibration to the cassette.

13. Ensure that a continuous smooth flow of negative pressure is delivered by the pump by damping out any pump action fluctuations if necessary.

14. The final plastic barrier around the abatement area remains in place for the sampling period.

15. After the area has passed a thorough visual inspection, use aggressive sampling conditions to dislodge any remaining dust. (See suggested protocol in Unit III.B.7.d.)

16. Select an appropriate flow rate equal to or greater than 1 liter per minute (L/min) or less than 10 L/min for 25 mm cassettes. Larger filters may be operated at proportionally higher flow rates.

17. A minimum of 13 samples are to be collected for each testing site consisting of the following:

a. A minimum of five samples per abatement area.

b. A minimum of five samples per ambient area positioned at locations representative of the air entering the abatement site.

c. Two field blanks are to be taken by removing the cap for not more than 30 seconds and replacing it at the time of sampling before sampling is initiated at the following places:

i. Near the entrance to each abatement area.

ii. At one of the ambient sites. (DO NOT leave the field blanks open during the sampling period.)

d. A sealed blank is to be carried with each sample set. This representative cassette is not to be opened in the field.

18. Perform a leak check of the sampling system at each indoor and outdoor sampling site by activating the pump with the closed sampling cassette in line. Any flow indicates a leak which must be eliminated before initiating the sampling operation.

19. The following Table I specifies volume ranges to be used:

TABLE 1--NUMBER OF 200 MESH EM GRID OPENINGS ($0.0057\ MM^2$) THAT NEED TO BE ANALYZED TO MAINTAIN SENSITIVITY OF 0.005 STRUCTURES/CC BASED ON VOLUME AND EFFECTIVE FILTER AREA

Effective Filter Area 385 sq mm		Effective Filter Area 855 sq mm	
Volume (liters)	# of grid openings	Volume (liters)	# of grid openings
560	*24*	*1,250*	*24*
600	23	1,300	23
700	19	1,400	21
800	17	1,600	19
900	15	1,800	17
1,000	14	2,000	15
1,100	12	2,200	14
1,200	**11**	2,400	13
1,300	**10**	2,600	12
1,400	**10**	**2,800**	**11**
1,500	**9**	**3,000**	**10**
1,600	**8**	**3,200**	**9**
1,700	**8**	**3,400**	**9**
1,800	**8**	**3,600**	**8**
1,900	7	**3,800**	**8**
2,000	7	**4,000**	**8**
2,100	6	4,200	7
2,200	6	4,400	7
2,300	6	4,600	7
2,400	6	4,800	6
2,500	5	5,000	6
2,600	5	5,200	6
2,700	5	5,400	6
2,800	5	5,600	5
2,900	5	5,800	5
3,000	5	6,000	5
3,100	4	6,200	5
3,200	4	6,400	5
3,300	4	6,600	5
3,400	4	6,800	4
3,500	4	7,000	4
3,600	4	7,200	4
3,700	4	7,400	4
3,800	4	7,600	4

Recommended Volume Range

Recommended Volume Range

Note minimum volumes required:
25 mm : 560 liters
37 mm : 1250 liters

Filter diameter of 25 mm = effective area of 385 sq mm
Filter diameter of 37 mm = effective area of 855 sq mm

20. Ensure that the sampler is turned upright before interrupting the pump flow.

21. Check that all samples are clearly labeled and that all pertinent information has been enclosed before transfer of the samples to the laboratory.

22. Ensure that the samples are stored in a secure and representative location.

23. Do not change containers if portions of these filters are taken for other purposes.

24. A summary of Sample Data Quality Objectives is shown in the following Table II:

TABLE II--SUMMARY OF SAMPLING AGENCY DATA QUALITY OBJECTIVES

This table summarizes the data quality objectives from the performance of this method in terms of precision, accuracy, completeness, representativeness, and comparability. These objectives are assured by the periodic control checks and reference checks listed here and described in the text of the method.

Unit Operation	QC Check	Frequency	Conformance Expectation
Sampling materials	Sealed blank	1 per I/O site	95%
Sample procedures	Field blanks	2 per I/O site	95%
	Pump calibration	Before and after each field series	90%
Sample custody	Review of chain-of-custody record	Each sample	95% complete
Sample shipment	Review of sending report	Each sample	95% complete

C. Sample Shipment

Ship bulk samples to the analytical laboratory in a separate container from air samples.

D. Sample Receiving

1. Designate one individual as sample coordinator at the laboratory. While that individual will normally be available to receive samples, the coordinator may train and supervise others in receiving procedures for those times when he/she is not available.

2. Bulk samples and air samples delivered to the analytical laboratory in the same container shall be rejected.

E. Sample Preparation

1. All sample preparation and analysis shall be performed by a laboratory independent of the abatement contractor.

2. Wet-wipe the exterior of the cassettes to minimize contamination possibilities before taking them into the clean room facility.

3. Perform sample preparation in a well-equipped clean facility.

Note: The clean area is required to have the following minimum characteristics. The area or hood must be capable of maintaining a positive pressure with make-up air being HEPA-filtered. The cumulative analytical blank concentration must average less than 18 s/mm ^{2} in an area of 0.057 mm ^{2} (nominally 10 200-mesh grid openings) and a single preparation with a maximum of 53 s/mm ^{2} for that same area.

4. Preparation areas for air samples must not only be separated from preparation areas for bulk samples, but they must be prepared in separate rooms.

5. Direct preparation techniques are required. The object is to produce an intact film containing the particulates of the filter surface which is sufficiently clear for TEM analysis.

a. TEM Grid Opening Area measurement must be done as follows:

i. The filter portion being used for sample preparation must have the surface collapsed using an acetone vapor technique.

ii. Measure 20 grid openings on each of 20 random 200-mesh copper grids by placing a grid on a glass and examining it under the PCM. Use a calibrated graticule to measure the average field diameters. From the data, calculate the field area for an average grid opening.

iii. Measurements can also be made on the TEM at a properly calibrated low magnification or on an optical microscope at a magnification of approximately 400X by using an eyepiece fitted with a scale that has been calibrated against a stage micrometer. Optical microscopy utilizing manual or automated procedures may be used providing instrument calibration can be verified.

b. TEM specimen preparation from polycarbonate (PC) filters. Procedures as described in Unit III.G. or other equivalent methods may be used.

c. TEM specimen preparation from mixed cellulose ester (MCE) filters.

i. Filter portion being used for sample preparation must have the surface collapsed using an acetone vapor technique or the Burdette procedure (Ref. 7 of Unit II.J.)

ii. Plasma etching of the collapsed filter is required. The microscope slide to which the collapsed filter pieces are attached is placed in a plasma asher. Because plasma ashers vary greatly in their performance, both from unit to unit and between different positions in the asher chamber, it is difficult to specify the conditions that should be used. Insufficient etching will result in a failure to expose embedded filters, and too much etching may result in loss of particulate from the surface. As an interim measure, it is recommended that the time for ashing of a known weight of a collapsed filter be established and that the etching rate be calculated in terms of micrometers per second. The actual etching time used for the particulate asher and operating conditions will then be set such that a 1–2 μm (10 percent) layer of collapsed surface will be removed.

iii. Procedures as described in Unit III. or other equivalent methods may be used to prepare samples.

F. TEM Method

1. An 80–120 kV TEM capable of performing electron diffraction with a fluorescent screen inscribed with calibrated gradations is required. If the TEM is equipped with EDXA it must either have a STEM attachment or be capable of producing a spot less than 250 nm in diameter at crossover. The microscope shall be calibrated routinely for magnification and camera constant.

2. *Determination of Camera Constant and ED Pattern Analysis.* The camera length of the TEM in ED operating mode must be calibrated before ED patterns on unknown samples are observed. This can be achieved by using a carbon-coated grid on which a thin film of gold has been sputtered or evaporated. A thin film of gold is evaporated on the specimen TEM grid to obtain zone-axis ED patterns superimposed with a ring pattern from the polycrystalline gold film. In practice, it is desirable to optimize the thickness of the gold film so that only one or two sharp rings are obtained on the superimposed ED pattern. Thicker gold film would normally give multiple gold rings, but it will tend to mask weaker diffraction spots from the unknown fibrous particulate. Since the unknown d-spacings of most interest in asbestos analysis are those which lie closest to the transmitted beam, multiple gold rings are unnecessary on zone-axis ED patterns. An average camera constant using multiple gold rings can be determined. The camera constant is one-half the diameter of the rings times the interplanar spacing of the ring being measured.

3. *Magnification Calibration.* The magnification calibration must be done at the fluorescent screen. The TEM must be calibrated at the grid opening magnification (if used) and also at the magnification used for fiber counting. This is performed with a cross grating replica (e.g., one containing 2,160 lines/mm). Define a field of view on the fluorescent screen either by markings or physical boundaries. The field of view must be measurable or previously inscribed with a scale or concentric circles (all scales should be metric). A logbook must be maintained, and the dates of calibration and the values obtained must be recorded. The frequency of calibration depends on the past history of the particular microscope. After any maintenance of the microscope that involved adjustment of the power supplied to the lenses or the high-voltage system or the mechanical disassembly of the electron optical column apart from filament exchange, the magnification must be recalibrated. Before the TEM calibration is performed, the analyst must ensure that the cross grating replica is placed at the same distance from the objective lens as the specimens are. For instruments that incorporate a eucentric tilting specimen stage, all specimens and the cross grating replica must be placed at the eucentric position.

4. While not required on every microscope in the laboratory, the laboratory must have either one microscope equipped with energy dispersive X-ray analysis or access to an equivalent system on a TEM in another laboratory.

5. Microscope settings: 80–120 kV, grid assessment 250–1,000X, then 15,000–20,000X screen magnification for analysis.

6. Approximately one-half (0.5) of the predetermined sample area to be analyzed shall be performed on one sample grid preparation and the remaining half on a second sample grid preparation.

7. Individual grid openings with greater than 5 percent openings (holes) or covered with greater than 25 percent particulate matter or obviously having nonuniform loading must not be analyzed.

8. Reject the grid if:

a. Less than 50 percent of the grid openings covered by the replica are intact.

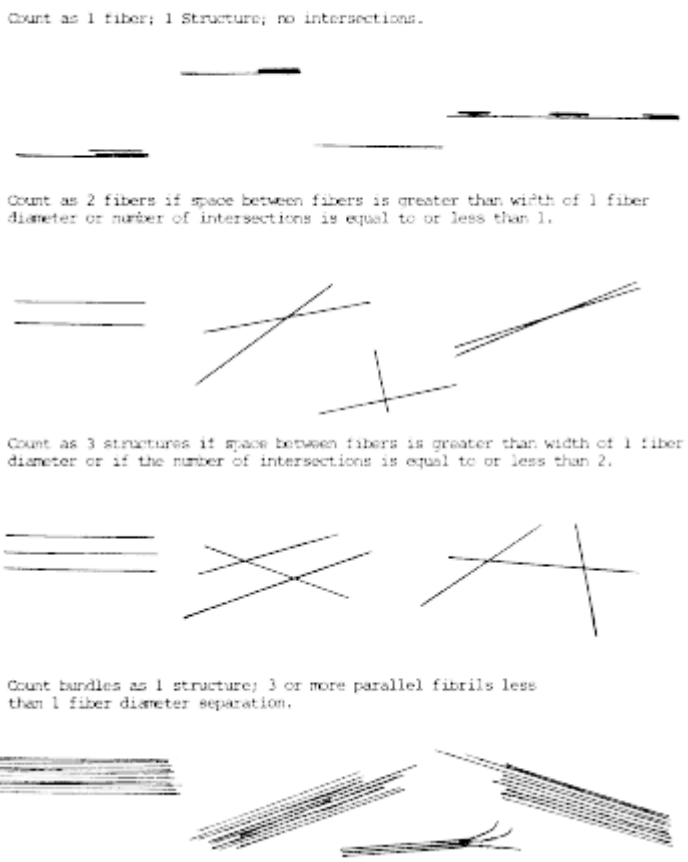
b. The replica is doubled or folded.

c. The replica is too dark because of incomplete dissolution of the filter.

9. *Recording Rules*.

a. Any continuous grouping of particles in which an asbestos fiber with an aspect ratio greater than or equal to 5:1 and a length greater than or equal to 0.5 µm is detected shall be recorded on the count sheet. These will be designated asbestos structures and will be classified as fibers, bundles, clusters, or matrices. Record as individual fibers any contiguous grouping having 0, 1, or 2 definable intersections. Groupings having more than 2 intersections are to be described as cluster or matrix. An intersection is a nonparallel touching or crossing of fibers, with the projection having an aspect ratio of 5:1 or greater. See the following Figure 2:

FIGURE 2--COUNTING GUIDELINES USED IN DETERMINING ASBESTOS STRUCTURES



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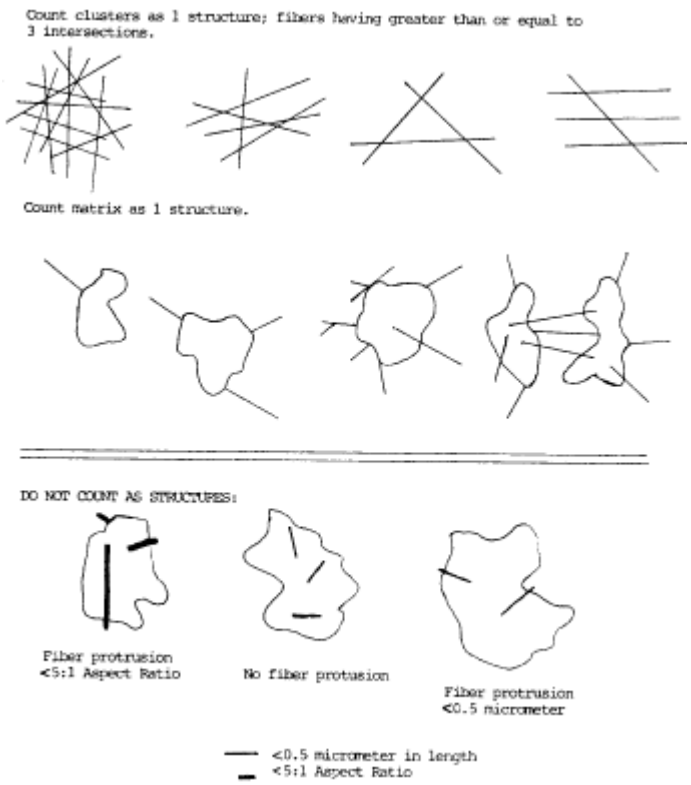

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i. *Fiber.* A structure having a minimum length greater than or equal to 0.5 µm and an aspect ratio (length to width) of 5:1 or greater and substantially parallel sides. Note the appearance of the end of the fiber, i.e., whether it is flat, rounded or dovetailed.

ii. *Bundle.* A structure composed of three or more fibers in a parallel arrangement with each fiber closer than one fiber diameter.

iii. *Cluster.* A structure with fibers in a random arrangement such that all fibers are intermixed and no single fiber is isolated from the group. Groupings must have more than two intersections.

iv. *Matrix.* Fiber or fibers with one end free and the other end embedded in or hidden by a particulate. The exposed fiber must meet the fiber definition.

b. Separate categories will be maintained for fibers less than 5 µm and for fibers equal to or greater than 5 µm in length.

c. Record NSD when no structures are detected in the field.

d. Visual identification of electron diffraction (ED) patterns is required for each asbestos structure counted which would cause the analysis to exceed the 70 s/mm ^{2} concentration. (Generally this means the first four fibers identified as asbestos must exhibit an identifiable diffraction pattern for chrysotile or amphibole.)

e. The micrograph number of the recorded diffraction patterns must be reported to the client and maintained in the laboratory's quality assurance records. In the event that examination of the pattern by a qualified individual indicates that the pattern has been misidentified visually, the client shall be contacted.

f. Energy Dispersive X-ray Analysis (EDXA) is required of all amphiboles which would cause the analysis results to exceed the 70 s/mm ^{2} concentration. (Generally speaking, the first 4 amphiboles would require EDXA.)

g. If the number of fibers in the nonasbestos class would cause the analysis to exceed the 70 s/mm ^{2} concentration, the fact that they are not asbestos must be confirmed by EDXA or measurement of a zone axis diffraction pattern.

h. Fibers classified as chrysotile must be identified by diffraction or X-ray analysis and recorded on a count sheet. X-ray analysis alone can be used only after 70 s/mm ^{2} have been exceeded for a particular sample.

i. Fibers classified as amphiboles must be identified by X-ray analysis and electron diffraction and recorded on the count sheet. (X-ray analysis alone can be used only after 70 s/mm ^{2} have been exceeded for a particular sample.)

j. If a diffraction pattern was recorded on film, record the micrograph number on the count sheet.

k. If an electron diffraction was attempted but no pattern was observed, record N on the count sheet.

l. If an EDXA spectrum was attempted but not observed, record N on the count sheet.

m. If an X-ray analysis spectrum is stored, record the file and disk number on the count sheet.

10. Classification Rules.

a. *Fiber.* A structure having a minimum length greater than or equal to 0.5 µm and an aspect ratio (length to width) of 5:1 or greater and substantially parallel sides. Note the appearance of the end of the fiber, i.e., whether it is flat, rounded or dovetailed.

b. *Bundle.* A structure composed of three or more fibers in a parallel arrangement with each fiber closer than one fiber diameter.

c. *Cluster.* A structure with fibers in a random arrangement such that all fibers are intermixed and no single fiber is isolated from the group. Groupings must have more than two intersections.

d. *Matrix.* Fiber or fibers with one end free and the other end embedded in or hidden by a particulate. The exposed fiber must meet the fiber definition.

11. After finishing with a grid, remove it from the microscope, and replace it in the appropriate grid holder. Sample grids must be stored for a minimum of 1 year from the date of the analysis; the sample cassette must be retained for a minimum of 30 days by the laboratory or returned at the client's request.

G. Sample Analytical Sequence

1. Under the present sampling requirements a minimum of 13 samples is to be collected for the clearance testing of an abatement site. These include five abatement area samples, five ambient samples, two field blanks, and one sealed blank.

2. Carry out visual inspection of work site prior to air monitoring.

3. Collect a minimum of 5 air samples inside the work site and 5 samples outside the work site. The indoor and outdoor samples shall be taken during the same time period.

4. Remaining steps in the analytical sequence are contained in Unit IV of this Appendix.

H. Reporting

1. The following information must be reported to the client for each sample analyzed:

a. Concentration in structures per square millimeter and structures per cubic centimeter.

b. Analytical sensitivity used for the analysis.

c. Number of asbestos structures.

d. Area analyzed.

e. Volume of air sampled (which must be initially supplied to lab by client).

f. Copy of the count sheet must be included with the report.

g. Signature of laboratory official to indicate that the laboratory met specifications of the method.

h. Report form must contain official laboratory identification (e.g., letterhead).

i. Type of asbestos.

I. Quality Control/Quality Assurance Procedures (Data Quality Indicators)

Monitoring the environment for airborne asbestos requires the use of sensitive sampling and analysis procedures. Because the test is sensitive, it may be influenced by a variety of factors. These include the supplies used in the sampling operation, the performance of the sampling, the preparation of the grid from the filter and the actual examination of this grid in the microscope. Each of these unit operations must produce a product of defined quality if the analytical result is to be a reliable and meaningful test result. Accordingly, a series of control checks and reference standards are to be performed along with the sample analysis as indicators that the materials used are adequate and the operations are within acceptable limits. In this way, the quality of the data is defined and the results are of known value. These checks and tests also provide timely and specific warning of any problems which might develop within the sampling and analysis operations. A description of these quality control/quality assurance procedures is summarized in the following Table III:

TABLE III--SUMMARY OF LABORATORY DATA QUALITY OBJECTIVES

Unit Operation	QC Check	Frequency	Conformance Expectation
Sample receiving	Review of receiving report	Each sample	95% complete
Sample custody	Review of chain-of-custody record	Each sample	95% complete
Sample preparation	Supplies and reagents	On receipt	Meet specs. or reject
	Grid opening size	20 openings/20 grids/lot of 1000 or 1 opening/sample	100%
	Special clean area monitoring	After cleaning or service	Meet specs or reclean
	Laboratory blank	1 per prep series or 10%	Meet specs. or reanalyze series
	Plasma etch blank	1 per 20 samples	75%
	Multiple preps (3 per sample)	Each sample	One with cover of 15 complete grid sqs.
Sample analysis	System check	Each day	Each day
	Alignment check	Each day	Each day
	Magnification calibration with low and high standards	Each month or after service	95%
	ED calibration by gold standard	Weekly	95%
	EDS calibration by copper line	Daily	95%
Performance check	Laboratory blank (measure of cleanliness)	Prep 1 per series or 10% read 1 per 25 samples	Meet specs or reanalyze series
	Replicate counting (measure of precision)	1 per 100 samples	1.5 x Poisson Std. Dev.
	Duplicate analysis (measure of reproducibility)	1 per 100 samples	2 x Poisson Std. Dev.
	Known samples of typical materials (working standards)	Training and for comparison with unknowns	100%
	Analysis of NBS SRM 1876 and/or RM 8410 (measure of accuracy and comparability)	1 per analyst per year	1.5 x Poisson Std. Dev.
	Data entry review (data validation and measure of completeness)	Each sample	95%
	Record and verify ID electron diffraction pattern of structure	1 per 5 samples	80% accuracy
Calculations and data reduction	Hand calculation of automated data reduction procedure or independent recalculation of hand-calculated data	1 per 100 samples	85%

1. When the samples arrive at the laboratory, check the samples and documentation for completeness and requirements before initiating the analysis.

2. Check all laboratory reagents and supplies for acceptable asbestos background levels.

3. Conduct all sample preparation in a clean room environment monitored by laboratory blanks. Testing with blanks must also be done after cleaning or servicing the room.

4. Prepare multiple grids of each sample.

5. Provide laboratory blanks with each sample batch. Maintain a cumulative average of these results. If there are more than 53 fibers/mm ^{2} per 10 200-mesh grid openings, the system must be checked for possible sources of contamination.

6. Perform a system check on the transmission electron microscope daily.

7. Make periodic performance checks of magnification, electron diffraction and energy dispersive X-ray systems as set forth in Table III under Unit II.I.

8. Ensure qualified operator performance by evaluation of replicate analysis and standard sample comparisons as set forth in Table III under Unit II.I.

9. Validate all data entries.

10. Recalculate a percentage of all computations and automatic data reduction steps as specified in Table III under Unit II.I.

11. Record an electron diffraction pattern of one asbestos structure from every five samples that contain asbestos. Verify the identification of the pattern by measurement or comparison of the pattern with patterns collected from standards under the same conditions. The records must also demonstrate that the identification of the pattern has been verified by a qualified individual and that the operator who made the identification is maintaining at least an 80 percent correct visual identification based on his measured patterns.

12. Appropriate logs or records must be maintained by the analytical laboratory verifying that it is in compliance with the mandatory quality assurance procedures.