

Quality Assurance Project Plan

Baltic Mills Building 10
27 Bushnell Hollow Road
Sprague, Connecticut

Submitted to:

The Town of Sprague

US Environmental Protection Agency

CT Department of Environmental Protection

Submitted by:

Paul Burgess, LLC
&
Eagle Environmental, Inc.

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PAUL BURGESS, LLC

Environmental Consulting,
Engineering & Permitting

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1. Purpose and Scope

This Quality Assurance Project Plan (QAPP) details protocols and procedures to ensure that air asbestos analysis are performed in a manner consistent with the data quality objectives (DQOs) established for the project.

This QAPP identifies project responsibilities and prescribes guidance and specifications to make certain that:

- Samples are collected in a manner that ensures that they are representative of the media being collected, and in a manner consistent with the DQOs
- Samples are identified and controlled through sample tracking systems and chain-of-custody protocols
- Field analytical results are valid and useable by adherence to proper protocols and procedures
- Calculations and evaluations are accurate and appropriate
- Generated data are validated so they can be directly applied to the objectives of the investigation
- All aspects of the measurement process are documented to provide data that are technically sound and legally defensible

The asbestos analysis will be conducted in accordance with Eagle Environmental, Inc. Quality Assurance and Quality Control Manual For Phase Contrast Microscopy (Eagle QAQC PCM). This plan is provided in Appendix A. Eagle Environmental is a state certified laboratory for this procedure(Appendix A).

The prime responsibilities detailed in Section 3, Project Organization, extend to all quality-related controls and activities. The quality control (QC) and quality assurance (QA) elements address essential project-specific components. The project-specific QA/QC requirements are aimed at preventing substandard or erroneous actions from occurring in these essential areas.

The *Quality Assurance Guidance for Conducting Brownfields Site Assessment*, EPA, 1998 was used as a guide in developing this QAPP.

2. Project Description

2.1 Site Location and Background

The property is located at 27 Bushnell Hollow Road in Sprague, Connecticut and is owned by the Town of Sprague. The Tax Assessor's designation for the site is Map 26, Block 6, Lot 1; and another small parcel is designated Map 26, Block 5, Lot 4. The site location is shown in Figure 1.

The main mill structures were destroyed by fire in August 1999. The remaining on-site building is the "No. 10 Addition" structure constructed circa 1915 on the eastern end of the former mill complex. It is a four-story granite structure approximately 200 feet long by 80 feet wide. The first floor is a concrete slab-on-grade; no basement areas were apparent. The structure is comprised of granite walls and wood and metal support columns/beams. The floors are wood. All wood floors within the structures are unsafe and have significant water damage from the leaking roof. Other than the first floor (concrete) and the stairwells, the building is unsafe and cannot be inspected. Building debris is located on the interior wood floors. The Town of Sprague plans to have the site and building redeveloped by a private developer.

The Town of Sprague was awarded a USEPA Brownfields Cleanup Grant to perform asbestos and lead paint abatement at this site

The following investigations/reports have been completed for this site.

- *Phase I Environmental Site Assessment*, GEI Consultants, February 2005
- *Draft Targeted Brownfields Assessment*, Tetra Tech NUS, August 2006
- *Analysis of Brownfields Cleanup Alternatives*, Paul Burgess, LLC, March 2008

2.2 Project Goals and Objectives

The objective of this project is to mitigate the risk associated with certain asbestos material within and around Building 10. Currently the asbestos materials (window glazing) are exposed to the elements, and some asbestos roof materials are dispersed on the ground around the mill building. The windows containing asbestos glazing and lead paint, and asbestos containing roof material on the ground surrounding the building, will be removed and properly disposed.

Asbestos air sampling and analysis will be conducted to ensure that the abatement activities are conducted in accordance with regulatory requirements. This sampling and analysis is as required by the CT Department of Public Health (DPH) approval of an Application for Alternative Work Practice (AWP) dated July 29, 2008(Appendix B). The AWP requires that air samples be collected at the downwind boundary of the regulated area on a daily basis to document airborne fiber count. The air sampling is performed to evaluate the effectiveness of the implemented engineering controls and contractor's work practices as it relates to asbestos fiber release and airborne concentrations. The engineering controls may be modified based on air sampling results, when necessary.

2.3 Project Schedule

The asbestos abatement project is scheduled to start on or about October 1, 2008. The first activity will be removal of trees and under story to allow access to the work area, followed by asbestos abatement activities. The entire project is scheduled to be completed in 60 days.

3. Project Organization

Paul Burgess, P.E., LEP is responsible for the overall implementation of the USEPA Brownfields project. Ray Folino, Eagle Environmental, is responsible for the asbestos and lead paint consulting aspects of this project. Pete Folino and is the quality assurance officer (QAO). Paul Burgess, LLC is under contract with the Town of Sprague; Ms. Penny Newbury is the Town of Sprague representative assigned to this project. Kathleen Castagna is the EPA Project Officer and the lead Connecticut Department of Environmental Protection (CTDEP) contact is Michael Senyk. An asbestos abatement contractor is currently being retained by the Town of Sprague.

The QAO will ensure that the QAPP is implemented and that all aspects of the project comply with the requirements of the QAPP; initiate any necessary revisions; and take corrective action where indicated.

4. Quality Assurance Objectives

The quality assurance objectives are to collect and evaluated data as required by DPH asbestos regulations and the AWP, which requires daily downwind asbestos air samples analyzed by phase contrast microscopy (PCM). This will determine if any airborne asbestos fibers are released so corrective action can be taken. The established action level per DPH is 0.010 fibers per cubic centimeter.

5. Sampling Procedures

Daily downwind air samples will be collected and analyzed for asbestos in the field by PCM Methods. Downwind will be determined by observation and smoke tests if required. Details regarding air sampling procedures for this project are provided in Appendix C.

6. Sample Custody

Sample custody and control procedures are an integral part of any field operation. Sample custody is often implemented through chain-of-custody procedures as described in the Eagle Environmental QA/QC manual. A sample chain of custody is provided in Appendix D. Accountability for samples collected will be the responsibility of QAO.

7. Calibration Procedures and Frequency

All analytical equipment will be calibrated according to known standards to maintain QA/QC objectives. Calibration procedures for the PCM equipment will be performed as described in the Eagle QAQC PCM manual.

8. Analytical Procedures

The analytical methods for PCM asbestos analysis are NIOSH Method 7400 as included in Appendix A.

9. Internal Quality Control Checks, Data Reduction, Validation, and Reporting

The Eagle QAQC PMC manual specifies the internal quality control checks, data reduction and validation procedures which complies with NIOSH 7400 to ensure data reliability. It includes analyst training, microscope setup and maintenance, microscope calibration, use of reference slides, blind reference slides, blind recount of field samples, duplicate counts, and replicate counts. These procedures are discussed in the Eagle QAQC PMC manual.

The data is reported on as shown on the sample form provided in Appendix D.

Quality-control checks will be performed as specified in the Eagle QAQC PMC manual and as summarized below. The number of samples is based on assumed project duration of 30 days; the actually number of samples are dependent on the number of abatement days.

Samples	Frequency	Number
Reference Slides	Daily prior to analysis	30
Blind Reference Slides	Daily prior to analysis	30
Blind Recount of Field Samples	10 %	3
Duplicate Counts	10%	3
Replicate Recounts	2% (different analyst)- one per project minimum	1
Blank Cassettes	2 %- one per project minimum	1

This information will be used to validate the data as indicated in the Eagle QA/QC PMC manual. The validated field and analytical data will be used to prepare a technical report. The technical report will include: (1) changes to the original QAPP and the rationale for these changes, and (2) a summary of any limitations to the use of the data with conclusions on how these limitations affect the project objectives. The data will be used to evaluate the project objectives described herein.

10. Performance and System Audits

Audits are an independent means of: (1) evaluating the operation or capability of a measurement system, and (2) documenting the use of QC procedures designed to generate data of known and acceptable quality.

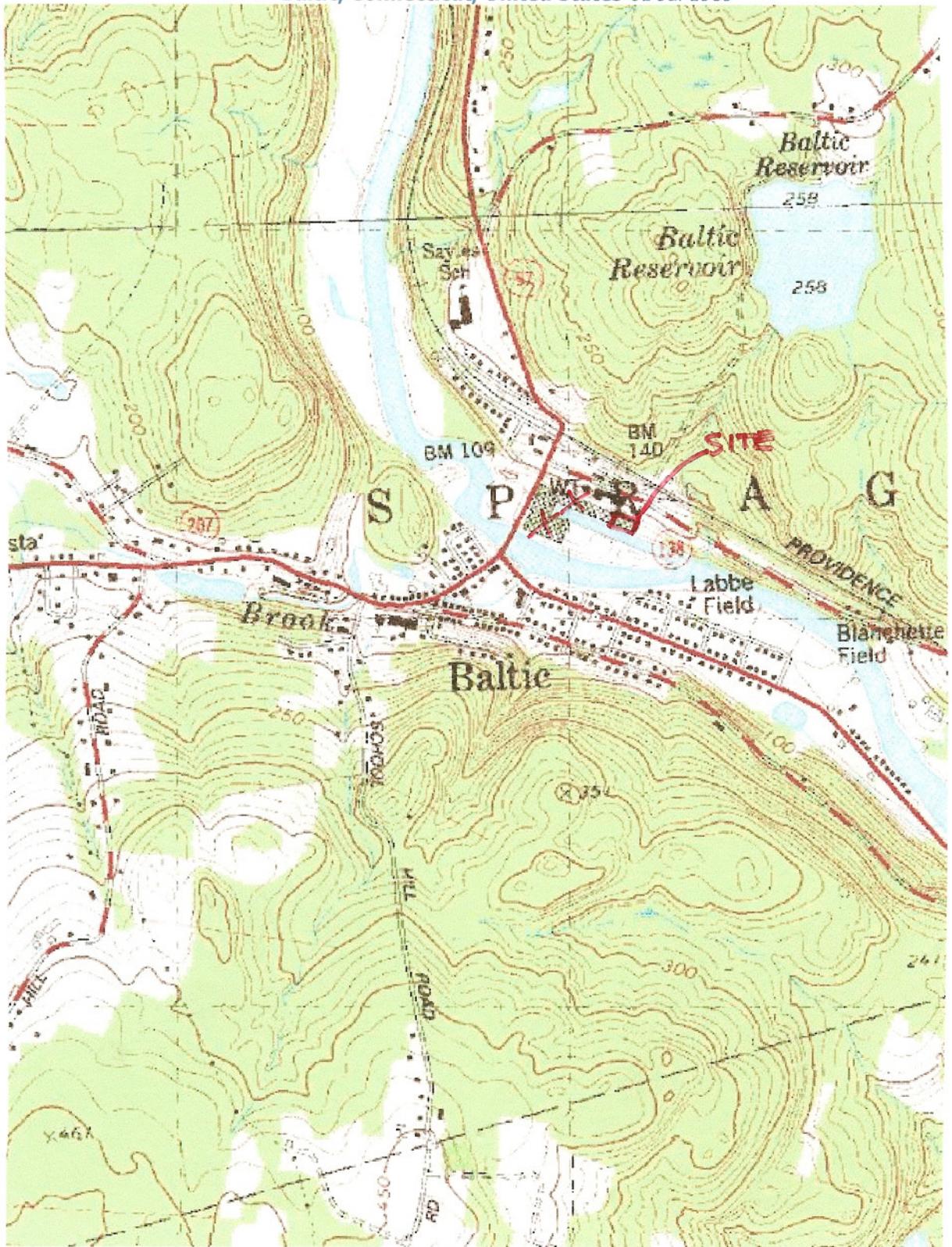
Field audits will assess sample collection protocols, determine the integrity of chain-of-custody procedures, and evaluate sample documentation and data-handling procedures. One field audit is planned for this project. The field audit will be performed by Pete Folino, Eagle Environmental.

11. Corrective Action

If unacceptable conditions are identified as a result of audits or are observed during field sampling and analysis, the condition will be documented and corrective procedures will be initiated. The specific condition or problem will be identified, its cause will be determined, and appropriate corrective action will be implemented.

A corrective action memorandum will be prepared, documenting the problem and detailing the corrective action to be initiated.

Figures



0 1.5 Km

0 1.25 Mi

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FIGURE 1

SITE LOCATION MAP

Appendix A

Eagle Environmental, Inc. Quality Assurance and Quality Control Manual For Phase Contrast Microscopy

State of Connecticut, Department of Public Health

Approved Environmental Laboratory

THIS IS TO CERTIFY THAT THE LABORATORY DESCRIBED BELOW HAS BEEN APPROVED BY THE STATE DEPARTMENT OF PUBLIC HEALTH PURSUANT TO APPLICABLE PROVISIONS OF THE PUBLIC HEALTH CODE AND GENERAL STATUTES OF CONNECTICUT, FOR MAKING THE EXAMINATIONS, DETERMINATIONS OR TESTS SPECIFIED BELOW WHICH HAVE BEEN AUTHORIZED IN WRITING BY THAT DEPARTMENT.

EAGLE ENVIRONMENTAL, INC.

LOCATED AT 531 North Main Street IN Bristol, CT 06010

AND REGISTERED IN THE NAME OF Peter J. Folino

THIS CERTIFICATE IS ISSUED IN THE NAME OF Peter J. Folino WHO HAS BEEN DESIGNATED

BY THE REGISTERED OWNER\AUTHORIZED AGENT TO BE IN CHARGE OF THE LABORATORY WORK COVERED BY THIS CERTIFICATE OF APPROVAL AS FOLLOWS:

ASBESTOS

AIR - FIBER COUNTING - PCM

SEE COMPUTER PRINT-OUT FOR SPECIFIC TESTS APPROVED

THIS CERTIFICATE EXPIRES December 31, 2008 AND IS REVOCABLE FOR CAUSE BY THE STATE DEPARTMENT OF PUBLIC HEALTH

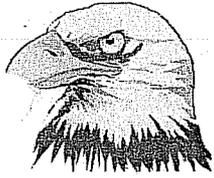
DATED AT HARTFORD, CONNECTICUT, THIS 21st DAY OF December 2006



Registration No.

PH-0237

**SUZANNE BLANCAFLOR, MS
CHIEF, ENVIRONMENTAL HEALTH SECTION**



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QUALITY ASSURANCE AND
QUALITY CONTROL

MANUAL

FOR PHASE CONTRAST
MICROSCOPY

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INTRODUCTION

The Eagle Environmental Quality Assurance and Quality Control Program for Phase Contrast Microscopy Analysis has been developed in accordance with the American Industrial Hygiene Association (AIHA) Laboratory Accreditation Program and the AIHA Asbestos Analysts Registry Program (AAR) which is an integral part of the NIOSH 7400 Method.

Section 11.1 of the "Quality Assurance Procedures for Fiber Counting Using Phase Contrast Microscopy", of the AIHA Quality Assurance Manual for Industrial Hygiene Chemistry has been incorporated as an integral part of this manual.

It is the intent of this manual to provide continual reference and support to each analyst conducting fiber count analysis. A copy of this manual shall be kept with each Phase Contrast Microscope and shall be maintained by the analyst. The QA coordinator shall provide program support as outlined in the manual and shall provide continual review of the QA/QC program requirements.

It is the responsibility of each analyst to perform QA/QC procedures as outlined in this manual and it is the responsibility of the QA coordinator to ensure that each analyst is performing their QA/QC duties correctly and consistently.

QA/QC meetings will be held as necessary to review the program and discuss analyst and company performance.

The QA/QC manual will be reviewed and updated at least annually or in accordance with industry requirements.

IA

REFERENCE METHOD

"Asbestos and Other Fibers by PCM", NIOSH 7400, Issue 2, August 15, 1994, or the most current issue, shall be followed by each analyst. The NIOSH 7400 method is provided in Appendix A of the manual.

II. ANALYST TRAINING

Each analyst shall successfully complete a 30 contact hour course in the Analysis of Fibers, equivalent to the NIOSH 582 course.

A probationary period has been established for each new analyst. This probationary training period shall include instruction in the required quality control procedures. A minimum of 10% replicate counts shall be conducted by a senior analyst and shall be acceptable before results are reported. The blind recount equation in Method 7400, Part 13 shall be utilized to determine if count pairs are accepted or rejected. The probationary analyst shall successfully have a minimum of fifteen (15) count pairs accepted prior to being taken off probationary status.

III. MICROSCOPE SET UP AND DAILY MAINTENANCE

The daily microscope set up and maintenance procedures have been developed to ensure that microscopes are being properly set up and maintained while in the office or in the field. It is imperative that each microscope is functioning properly and that all microscope set up procedures are being conducted correctly and consistently.

The following set of set up and maintenance procedures are to be followed in the office or in the field whenever a microscope is set up. The set up and maintenance procedures are to be recorded on Form QA/QC PCM-01.

- A. Field set up of microscopes should be conducted in areas which are clean and free of dust. This is sometimes difficult due to obvious field conditions. Select the cleanest environment possible for microscope set up and use.
- B. Ensure that the microscope is properly grounded and plugged into a GFCI device and that the microscope is set up on a stable surface.
- C. Routine cleaning of the following microscope components should be conducted prior to each use. Utilize Olympus lense cleaning tissues.
 1. Eyepieces
 2. Objective
 3. Observation tube
 4. Field iris diaphragm
 5. Filter

- D. Ensure that all movable parts are functioning correctly including focus adjustment knobs, mechanical stage, stage controls, and specimen holder.

IMPORTANT: DO NOT HANDLE TUNGSTEN BULB WITH BARE HANDS. BULBS ARE SUBJECT TO MALFUNCTIONING FROM GREASE.

IV. MICROSCOPE CALIBRATION

Calibration checks of the microscope are to be completed prior to fiber count analyses. The microscope calibration information is to be recorded on Form QA/QC PCM-02. The following set of calibration procedures shall be conducted:

- A. Center the phase contrast condenser
- B. Focus the eyepiece
- C. Align the phase annulus and phase plate

Procedures A through C shall be conducted with a mounted slide in view at 400 magnifications.

- D. Utilize the "Health Safety Executive/National Physical Laboratory (HSE/NPL) Test Slide to test for phase shift. The NIOSH Method 7400 section 10b states to "Check the phase-shift detection limit of the microscope periodically for each analyst/microscope combination." One (1) test slide shall accompany each microscope. Analysts shall read the test slide prior to each use of a microscope.

The HSE/NPL test slide consists of seven sets of grooved lines in descending order of visibility from sets 1 to 7. The requirements for fiber counting are that the microscope optics must resolve the grooved lines in sets 1 through 3 completely. Sets 4 and 5 should be at least partially visible. Sets 6 and 7 must be invisible. Failure to meet these requirements indicates that the microscope's resolution is either too high or too low to be used for fiber counting.

- E. Conduct the Walton-Beckett Graticule Diameter field area measurement. The field area measurement shall be conducted using a stage micrometer and the measurement shall be 100+/-2 micrometers.

Procedure D shall be conducted prior to each use of the microscope. Procedure E shall be conducted by Absolute Clarity on an annual basis.

V. QUALITY ASSURANCE

1.0 PERMANENTLY MOUNTED REFERENCE SLIDES

The following set of procedures shall be strictly adhered to and shall be followed prior to fiber count analysis of field samples.

- A. A set of known reference slides accompanies each microscope. The upper and lower ranges as well as the mean result for each reference slide are provided within the specific microscope QA/QC manual.
- B. Prior to fiber count analysis the analyst shall read a known reference slide. These slides are from past AAR rounds or PAT samples.
- C. The analyst shall record his/her result, in fibers/mm², on form QA/QC PCM-03. The analyst shall then reference the range for the analyzed sample to determine if he or she is within the acceptable proficiency range. The analyst may begin reading samples if he/she is proficient.
 - 1. If the analyst is not within range, he/she shall read another known reference slide. Results of the second slide shall be recorded and the analyst shall check the results to determine if he or she is within the acceptable proficiency range. The analyst may begin analyzing samples if the results of the second slide are within range.
 - 2. If the results of the second slide are not within limits the analyst shall repeat microscope set up and microscope calibration including utilizing the HSE/NPL test slide and recount the two reference slides. The analyst may begin counting if one or both of the reference slides is within limits.
 - 3. If both known slides are outside the limits, the slides shall be read by a second analyst. If the second analyst's results are not within range the slides are discarded; and the original analyst begins with a new known reference slide.
 - 4. If the second analyst's results are within range, a third analyst shall read the slides. If a slide is outside the acceptable range, the slide is discarded; if the result is acceptable, the original analyst shall count a new known reference slide and if acceptable may begin counting.
 - 5. If the analyst's result of the slide is not within limits, the QA/QC coordinator is notified and the reason for the outliers shall be determined. The analyst shall not conduct analysis until he/she has successfully counted five known reference slides.

2.0 BLIND REFERENCE SLIDES

The blind reference slides are field samples that have previously been analyzed on a project. The slides will be assigned a QC number. Each microscope shall contain a set of blind reference slides in the ranges listed below.

The results of the reference slides analyses are used to calculate the intra- and inter- relative standard deviation (Sr) for the following ranges:

- * 5 to 20 fibers in 100 graticle fields
- * > 20 to 50 fibers in 100 graticle fields
- * > 50 to 100 fibers in 100 graticle fields
- * 100 fibers in less than 100 graticle fields

Control charts shall be maintained for each of these data fields.

Results of the blind recounts shall be maintained on Form PCM 05 – Blind Reference Slide Log. Sr values and control limits for the results will also be maintained manually and shall be kept in the QA coordinators “Method 7400 QC Notebook.”

3.0 10% BLIND RECOUNT OF FIELD SAMPLES

Each analyst shall conduct blind recounts on the greater of one filter or 10% of the field samples counted. The recounts shall be conducted by the same analyst whom initially analyzed the slide.

The following protocol for blind recounts shall be followed:

- A. Each analyst shall submit their slides bimonthly to the QA coordinator.
- B. The QA coordinator shall record the job number, analyst, the field sample number, QA/QC sample number, the initial result, the recount result and if the count pair was accepted or rejected. This information shall be maintained on Form QA/QC PCM-04 and shall be maintained by the QA/QC Coordinator.
- C. The QA coordinator shall redistribute the slides with the new QC sample number to the analyst who initially analyzed the slide. The slide shall then be re-analyzed by the analyst.
- D. Each analyst shall submit the recounts of the QC samples within two weeks of distribution.
- E. The QA coordinator shall calculate the Accept/Reject values for each slide. The calculation for determining Accept/Reject values is listed in Method 7400 Section 13 (Appendix 1) and AIHA QA Manual Chapter 11, Section 11.1.3.4 (Appendix 3).
- F. If a count pair is rejected, a second analyst shall count the slide and compare the result to the first count. If the count pair is accepted, the results are considered acceptable. If the count pair is rejected, a new sample is mounted from the sample cassette and is analyzed. The results of the new mounted slide are compared to the original result. If the count pair is accepted, the results are considered acceptable. If the count pair is rejected, the project manager is notified and the samples are analyzed by a senior analyst.

- G. Count pairs that are rejected will be evaluated by the QA/QC Coordinator and the analyst to determine why the count pair was rejected. Corrective actions will be taken based on the determination for the rejection of the count pair.

4.0 DUPLICATE COUNTS

- A. Each analyst shall conduct a "Duplicate Count" on 10% of the field samples counted. The recounts shall be conducted by the same analyst whom initially analyzed the slide.
- B. When less than ten samples are collected, such as a final air clearance, the analyst shall conduct a duplicate field count prior to releasing the results and shall record the information in the duplicate count row on the "Air Sampling Data Sheet". The analyst shall calculate the "Accept/Reject" equation to determine if the count pair is accepted or rejected. This information shall then be transferred to Form QA/QC PCM-06.

5.0 2% REPLICATE RECOUNTS

- A. Replicate counts of 2% of the field samples shall be analyzed by a different analyst. The results shall be compared using the recount equation. Reject counts shall be recounted by a third analyst. If the recounts are rejected by both analysts, the original analyst shall be notified. If greater than 2 out of 10 replicate counts are rejected, the analyst shall be placed on probationary period.
- B. Results of the 2% replicate recounts shall be maintained on Form QA/QC PCM-07.

6.0 BLANK CASSETTES

One blank PCM cassette from each box of 50 shall be analyzed prior to the cassettes being utilized in the field. Blank fiber counts in excess of 7 fibers per 100 fields shall be an indication of possible contamination. This batch of cassettes shall not be utilized in the field. Blank cassette analysis results shall be recorded on Form QA/QC PCM-06.

The limit of detection for this method shall be calculated at least annually from the laboratory blank results. The Limit for Detection is the Mean plus three (3) Standard Deviations of a minimum of 20 blank results.

Field blanks shall be submitted with samples at the rate of at least 10% or a minimum of two (2) per sample set.

7.0 ROTOMETER CALIBRATION

- A. Each analyst shall be assigned a low flow (1 to 5 L/minute) and a high flow (2 to 20 L/minute) rotometer. The maintenance and calibration of the rotometers shall be the sole responsibility of each analyst. The QA/QC Coordinator will conduct random periodic audits of each analyst to evaluate rotometer maintenance and calibration.
- B. Rotometers shall be calibrated biannually by each analyst.
- C. Rotometers shall be calibrated on a primary standard. The primary standard available for calibration shall be the soap bubble burette.
- D. The procedure for performing rotometer calibration shall be maintained with the soap bubble burette.
- E. The QA/QC Coordinator shall be available for assistance during rotometer calibration.
- F. Rotometer calibration data and curves shall be maintained on the prescribed forms available in the lab table. The rotometer calibration data shall be maintained with each rotometer and a copy shall be maintained in the file for the specific rotometer.
- G. Each analyst shall submit the rotometer calibration data to the QA/QC Coordinator for review prior to use in the field.

VI. INTERLABORATORY QUALITY CONTROL

1.0 PROFICIENCY PROGRAMS

The laboratory shall be enrolled in the AIHA NIOSH PAT Program and each field analyst shall be enrolled in the AIHA Asbestos Analyst Registry. Each analyst shall maintain a proficiency rating to be "Board Approved". PAT samples shall be analyzed by all laboratory personnel, but only one analyst's results shall be reported.

2.0 ROUND ROBIN

The laboratory shall take part in a Round Robin fiber count exchange program with at least two other AIHA-accredited organizations. A minimum of five slides shall be exchanged at least semi-annually. Each organization taking part in the program shall rotate responsibilities for each round. This includes originating round robin samples, compiling the results, calculating the mean, standard deviation, and control limits for each slide. A report shall be submitted to each participating organization detailing the results.

3.0 AIR SAMPLE RETENTION

- A. PCM air sampling cassettes collected in the field will be placed in large zip lock bags for storage prior to disposal. Each bag will be labeled with the job name, job number, dates of sample collection, analyst name and type of samples, (i.e., background, final air clearance, OSHA personnel, etc.).
- B. The bags shall be placed in the appropriate bins in the laboratory to await disposal. Air samples shall be retained by Eagle for a minimum of three (3) months.
- C. Air samples will be properly disposed of after three (3) months.
- D. Data associated with the air samples shall be logged into the PCM Disposal Log book prior to depositing into the appropriate bin.

4.0 SLIDE MOUNT RETENTION

- A. Slide mounts for all PCM air samples shall be maintained for a minimum of six (6) months.
- B. Slides will be stored in hard shell slide boxes in the laboratory. Slide boxes will be labeled in an ascending order.
- C. Slides will be properly disposed of after three years.
- D. Data associated with slides shall be logged into the PCM Slide Disposal Log book prior to depositing into the appropriate slide box.

5.0 RECORD RETENTION

- A. PCM air sampling results will be stored in permanent job files according to each job. These records will be maintained by Eagle indefinitely.
- B. QA/QC records will be maintained for an indefinite time period.

APPENDIX A

ASBESTOS and OTHER FIBERS by PCM

7400

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 : 2 asbestos fiber ($\geq 5 \mu\text{m}$ long)/cc;
 C 10 f/cc; carcinogen
 MSHA: 5 asbestos fibers ($> 5 \mu\text{m}$ long)/cc
 NIOSH: 0.1 f/cc (fibers $> 5 \mu\text{m}$ 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 ferractinolite [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]; fibrous glass.

SAMPLING		MEASUREMENT	
SAMPLER:	FILTER (0.45- to 1.2- μm cellulose ester membrane, 25-mm; conductive cowl on cassette)	TECHNIQUE:	LIGHT MICROSCOPY, PHASE CONTRAST
FLOW RATE*:	0.5 to 16 L/min	ANALYTE:	fibers (manual count)
VOL-MIN*: -MAX*:	400 L @ 0.1 fiber/cc (step 4, sampling) *Adjust to give 100 to 1300 fiber/mm ²	SAMPLE PREPARATION:	acetone - collapse/triacetin - immersion method [2]
SHIPMENT:	routine (pack to reduce shock)	COUNTING RULES:	described in previous version of this method as "A" rules [1,3]
SAMPLE STABILITY:	stable	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)
BLANKS:	2 to 10 field blanks per set	CALIBRATION:	HSE/NPL test slide
ACCURACY		RANGE:	100 to 1300 fibers/mm ² filter area
RANGE STUDIED:	80 to 100 fibers counted	ESTIMATED LOD:	7 fibers/mm ² filter area
BIAS:	see EVALUATION OF METHOD	PRECISION (\bar{S}_r):	0.10 to 0.12 [1]; see EVALUATION OF METHOD
OVERALL PRECISION (\bar{S}_{rT}):	0.115 to 0.13 [1]		
ACCURACY:	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 an index of airborne fibers. It is primarily used for estimating asbestos concentrations, though PCM does not differentiate between asbestos and other fibers. Use this method in conjunction with electron microscopy (e.g., Method 7402) for assistance in identification of fibers. Fibers $< \text{ca. } 0.25 \mu\text{m}$ diameter will not be detected by this method [4]. This method may be used for other materials 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 particles may obscure fibers in the field of view and increase the detection limit.

OTHER METHODS: This revision replaces Method 7400, Revision #3 (dated 8/15/89).

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- μ m 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- μ m pore size filters for personal sampling. The 0.45- μ m 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 (Envirometrics, 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.

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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- μ L and 100- to 500- μ L.
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- μ m diameter circular field (area = 0.00785 mm²) 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 PTR Optics Ltd. (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/mm² ($3.85 \cdot 10^4$ to $5 \cdot 10^5$ fibers per 25-mm filter with effective collection area $A_c = 385$ mm²) for optimum accuracy. These variables are related

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to the action level (one-half the current standard), L (fibers/mL), 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 ($> 3 \mu\text{m}$) 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 $\geq 50\%$ 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.

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- 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 $^{\circ}\text{C}$) 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/mm²) exceeds $2.77 (X)S'_r$, where X = average of the square roots of the two fiber counts

(in fiber/mm²) 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 [11].

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.
NOTE: OSHA requires that each analyst performing this method take the NIOSH direct training course #582 or equivalent [3]. Instructors of equivalent courses should have attended the NIOSH #582 course at NIOSH within three years of presenting an equivalent course.

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 rules a and b 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 $> 1 \mu\text{m}$), 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):

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

NOTE: Fiber counts above 1300 fibers/mm² 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/mm² range should be reported as having "greater than optimal variability" and as being "probably biased."

21. Calculate and report the concentration, C (fibers/mL), of fibers in the air volume sampled, V (L), using the effective collection area of the filter, A_c (approx. 385 mm² 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-m³ 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:

- The Walton-Beckett graticule standardizes the area observed [14,18,19].
- The HSE/NPL test slide standardizes microscope optics for sensitivity to fiber diameter [4,14].
- Because of past inaccuracies associated with low fiber counts, the minimum recommended loading has been increased to 100 fibers/mm² filter area (a total of 78.5 fibers counted in 100 fields, each with field area = .00785 mm².) 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_i in the range of 0.10 to 0.17 [21,22,23].

B. Interlaboratory comparability:

At 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:

	<u>Intralaboratory S_r</u>	<u>Interlaboratory S_r</u>	<u>Overall S_r</u>
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 $3 \mu\text{m}$ are counted and fibers attached to particles larger than $3 \mu\text{m}$ 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 indicate 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 mm² 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., $0.16 + 2.13 \times 0.16 = 0.5$.

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.

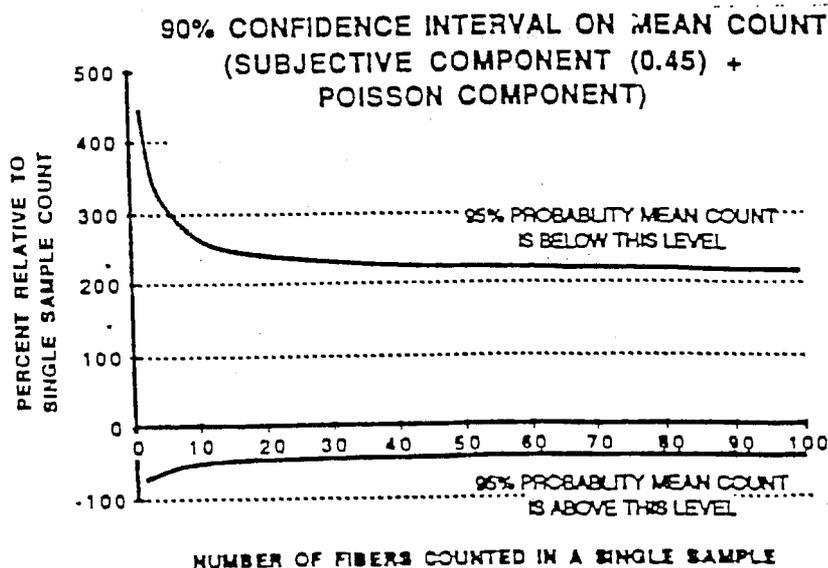


Figure 1. Interlaboratory Precision of Fiber Counts

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

$$\text{UCL} = \frac{2X + 2.25 + [(2.25 + 2X)^2 - 4(1 - 2.25S_r^2)X^2]^{1/2}}{2(1 - 2.23S_r^2)} \quad (3)$$

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

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_g (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:

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

<u>FIBER COUNT</u>		
<u>Object</u>	<u>Count</u>	<u>DISCUSSION</u>
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 $>5 \mu\text{m}$ 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 ($>3 \mu\text{m}$), 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 $\leq 5 \mu\text{m}$ 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.
9	Do not count	Ignore fibers that lie outside the graticule boundary.

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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

<u>fiber density on filter*</u>		<u>fiber concentration in air, f/cc</u>	
<u>fibers</u>		<u>400-L air</u>	<u>1000-L air</u>
<u>per 100 fields</u>	<u>fibers/mm²</u>	<u>sample</u>	<u>sample</u>
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 mm² effective filter collection area, and field area = 0.00785 mm², for relatively "clean" (little particulate aside from fibers) filters.

APPENDIX B

Quality Assurance Manual for Industrial Hygiene Chemistry

Chapter 11 Quality Assurance Procedures for Fiber Counting and Asbestos Identification

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Chapter 11

Quality Assurance Procedures for Fiber Counting and Asbestos Identification

11.1 Quality Assurance Procedures for Fiber Counting Using Phase Contrast Microscopy

11.1.1 Sample Shipping and Handling

11.1.1.1 Sample Shipment

- Ship bulk samples in a separate container from air samples. Bulk samples and air samples delivered to the analytical laboratory in the same container shall be rejected.
- Select a rigid shipping container and pack the cassettes upright in a non-contaminating non-electrostatic medium.
- Include a shipping bill and a detailed listing of samples shipped, their descriptions and all identifying numbers or marks, sampling data, shipper's name, and contact information
- Choose a mode of transportation least likely to jar the samples in transit.

11.1.1.2 Receiving and Log-in

Upon receipt in the laboratory, the condition of each sample is checked. The information provided on the customer request form is checked against the samples for accuracy and agreement. The samples are stopped at receiving and the client is notified if:

- Bulk samples are packaged with air samples.
- Documentation on the samples is not complete (e.g., air volumes not supplied, method not specified).
- Sample integrity is compromised (e.g., open cassettes).
- The samples are not uniquely identified.
- The samples do not meet the qualifications of the method requested.

Each sample batch is given a unique project number and each sample is given a unique laboratory number.

11.1.2 Microscope Calibration

11.1.2.1 Phase Contrast Microscope Optics

On a daily basis, before routine fiber count analyses, the microscope optics are to be properly aligned as listed below. The microscope instruction manual provided with the microscope details the specific procedures to accomplish the following:

- Center the phase contrast condenser
- Align the phase annulus and phase plate

11.1.2.2 Health Safety Executive/National Physical Laboratory (HSE/NPL) Test Slide

- Phase-shift detection limit of the microscope shall be about 3° measured using the HSE/NPL test slide, which consists of seven sets of grooved lines in descending order of visibility from sets 1 to 7. The requirements for fiber counting are that the microscope optics must resolve the grooved lines in sets 1 through 3 completely. Sets 4 and 5 should be at least partially visible. Sets 6 and 7 must be invisible. Failure to meet these requirements indicate that the microscope's resolution is either too high or too low to be used for fiber counting.

The Sampling and Laboratory Analysis Committee wishes to thank Vincent G. Ginnetti, CIH (Senior Environmental Hygiene Chemist, Olin Corporation, New Haven, CT) for preparation of this chapter.

- The microscope is fitted with an eyepiece graticle (Walton-Beckett type) calibrated for a field diameter of 100 μm . OSHA requirements are that the field diameter be $100 \pm 2 \mu\text{m}$.

11.1.3 Fiber Count Analysis and Quality Assurance

11.1.3.1 Analysis

All samples, with the exception of the reference slide, are mounted prior to analysis following the steps outlined in the procedure for the Evaluation of Airborne Fibers in accordance with the most current revision of NIOSH Method No. 7400. Attachment A may be used to document the individual fiber count results.

Before mounting field samples, the quality assurance guidelines listed below must be met.

11.1.3.2 Quality Assurance

11.1.3.3 Permanently Mounted Reference Slides

The Quality Assurance Officer will assign a permanently mounted reference slide to the analyst. In the absence of the officer, another analyst will provide a reference slide to the analyst who is counting. This reference slide will be counted and its fiber density (fibers/ mm^2) must fall within the documented standard deviation (95% confidence) for that slide; only then can a fiber count analysis be conducted on field samples. If the fiber count does not fall within the standard deviation, the procedures listed below must be followed.

- The same reference slide must be counted by another analyst. If the second count does not fall within the standard deviation, this reference slide is discarded. Follow the criteria for discarding a reference slide in Section 11.1.4.1.
- If the second count falls within the standard deviation, a third analyst must count the reference slide. If the third count falls within the standard deviation, the original counter must count another reference slide.
- If the third count does not fall within the standard deviation, the reference slide must be discarded in accordance with the Criteria for Discarding detailed in Section 11.1.4.1, and a new reference slide must be counted.

NOTE: These procedures are designed for multi-analyst (three or more persons) laboratories and not for a single-person laboratory.

From the blind repeat counts of the reference slides, the laboratory intra- and intercounter relative standard deviation (S_r) are determined. Obtain separate S_r values for intra- and intercounter standard deviation in the following ranges:

- 5 to 20 fibers in 100 graticle fields.
- >20 to 50 fibers in 100 graticle fields.
- >50 to 100 fibers in 100 graticle fields.
- 100 fibers in less than 100 graticle fields.

Maintain updated control charts for each of these ranges. When possible, the use of a computer will make this task easier (see Attachment B).

11.1.3.4 Recount of Field Samples

Blind recounts are performed by the same counter on at least one filter or 10% of the field samples counted. The following criterion is used to determine whether a count pair (count and recount) is to be rejected.

- Reject the count pair if:

$$|\sqrt{X_2} - \sqrt{X_1}| > 2.8 (X) (S_r)$$

where:

X_1 = original count, fibers/ mm^2

X_2 = recount value, fibers/ mm^2

X = average of the square roots of the two fiber counts (fibers/ mm^2) $(\sqrt{X_2} + \sqrt{X_1})/2$

$|\sqrt{X_2} - \sqrt{X_1}|$ = absolute value of the difference between the square roots of the two fiber counts (in fibers/ mm^2)

S_r = One-half the intracounter relative standard deviation for the appropriate count range (fibers) obtained from the appropriate quality control chart.

If the count pair is rejected, the remaining samples in the set must be recounted using new mounts. Test the new counts against the first counts and discard all rejected paired counts.

- Computerized recount results (see Attachment C) shall be stored with the raw data for each set of samples analyzed.

11.1.4 Record Retention of Permanently Mounted Quality Control Reference Slides

Data from permanently mounted field and PAT (Proficiency Analytical Testing) samples shall be recorded on the "Quality Control Fiber Counts" form (see Attachment D). These samples will be used as reference slides. One slide will be distributed by the Quality Assurance Officer before each fiber count analysis. However, if the Quality Assurance Officer is conducting a fiber count analysis, another analyst will take a reference slide and tape over the number in order to perform a true blind count.

The reference slides should consist of a range of loadings and background dust levels from a variety of sources, including field and PAT samples. The loading ranges are listed in section 11.1.3.3.

The following information will be supplied on Attachment D by each analyst who prepares a permanently mounted slide.

- Laboratory number/PAT number
- Date mounted
- Fibers/mm²
- Initials of analyst

Permanently mounted slides will be prepared as needed. Once the Quality Assurance Officer receives a sheet with new permanently mounted reference slide data, a new quality assurance number is assigned in the designated column on Attachment D. These forms will be maintained in a separate loose-leaf binder, which will be controlled by the Quality Assurance Officer only.

The Quality Assurance Officer will use the above information to choose a new set of reference slides every two months. The information will be transferred to an identical sheet labeled with the date of the current two-month period. These sheets will be retained in a loose-leaf binder, which will be in the possession of the Quality Assurance Officer.

Periodically, a reference slide will be reassigned a new Quality Assurance Number by the Quality Assurance Officer (see Attachment D). The purpose for reassigning a new number is to prevent the analyst from becoming familiar with the sample.

Initially, a permanently mounted reference slide will be counted three times before a standard deviation (95% confidence), average, (fibers/mm²), and relative standard deviation can be determined. The following information is recorded by the analyst on the appropriate form (see Attachment E):

- Date counted
- Analyst initials
- Fibers/mm²
- Average (fibers/mm²)—after three counts
- Standard Deviation (95% confidence)—after three counts

With each recount of the reference slide, the value in fibers/mm² is recorded in Attachment E. The average and standard deviation should be updated every two months using a computer. These values are then recorded in the appropriate columns in Attachment E. These sheets will be maintained in a loose-leaf binder available to all analysts.

11.1.4.1 Criteria for Discarding a Reference Slide

Discard a reference slide when:

- A reference slide is counted by an analyst and falls out of the standard deviation (95% confidence) determined for that slide in fibers/mm².
- Discard the slide if the second analyst counts it and the result is still out of range.
- Discard it if the second analyst's count falls in range and the third analyst's count falls out of range.
- The record of Individual Fiber Count Results for Quality Control Samples (Attachment E) that contains the reference slide information is stamped invalid, dated, and signed by each analyst who determined that the permanent mount no longer is valid. This slide is then physically discarded.
- The date of discard and the initials of the two or three analysts are noted on Attachment D in the Quality Assurance binder. This is entered next to the appropriate Quality Control Number, under the heading Reassigned Quality Control Number.

11.1.5 Interlaboratory Quality control

It is recommended that the laboratory be enrolled in either the AIHA/NIOSH PAT program or the Asbestos Analyst Registry (AAR) program for airborne fiber counts. The analyses are performed by all qualified personnel; however, only one analyst's results will be reported when analyzing PAT samples.

The laboratory should be enrolled in a round-robin fiber count exchange program with at least two other laboratories. Permanently mounted samples are exchanged between each laboratory at least semiannually. The originating laboratory statistically compares the results with those of the respective laboratories. If there is a discrepancy concerning a sample or samples, a recount is conducted to rectify the problem.

11.1.6 Training

Before analyzing any field samples, each analyst must have completed the NIOSH 582 or equivalent course for sampling and evaluating airborne fibers. After completing the course, a new analyst will be monitored for a two-week probationary period to determine whether that individual can meet the established quality assurance guidelines as determined according to the most current revision of NIOSH Method No. 7400. If the results fall within the laboratory guidelines, the analyst may work without any further monitoring. If not, analysts will be monitored until their work is in compliance.

[Special thanks to Lisa A. Constantine, CIH, Olin Corporation, for her time and effort in contributing to this section.]

11.2 Quality Assurance Procedures for Airborne Asbestos Fibers by Transmission Electron Microscopy

11.2.1 Overview

The following quality assurance procedures are a general treatment of measures that should be used to ensure adequacy of analytical procedures, equipment calibration, and sample handling for transmission electron microscope (TEM) analysis of airborne asbestos. They do not necessarily meet all of the specific requirements of the individual TEM analytical methods that might be used by a laboratory. To meet the requirements of a particular method, the specific criteria of that method must be implemented. Many of the criteria specified here come from Asbestos Hazard Emergency Response Act (AHERA) and National Voluntary Laboratory Accreditation Program (NVLAP) criteria.

11.2.2 Sample Shipping and Handling

See Section 11.1.1.

11.2.3 Instrumentation Calibration

11.2.3.1 Transmission Electron Microscope Magnification

The magnification at the fluorescent screen of the TEM must be calibrated at the grid-opening magnification (unless an optical microscope is used for this) and also at the magnification used for fiber counting. This is done with a cross grating replica. A logbook must be maintained. 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 is calibrated, the analyst must ensure that the cross grating replica is placed at the eucentric position.

11.2.3.2 Electron Diffraction Spectrum (EDS) Calibration

The EDS system must be calibrated by using two reference elements to calibrate the energy scale of the instrument. This should be completed in accordance with the manufacturer's instructions.

11.2.3.3 Camera Constant Calibration

The camera constant of the TEM in electron diffraction (ED) operation mode must be calibrated before ED patterns on unknown samples are indexed. This can be achieved by using a carbon-coating grid on which a thin film of gold has been sputtered or evaporated. An average camera constant using multiple gold rings measurements can be determined. The camera constant is one-half the diameter (D) of the rings \times the interplanar spacing (d) of the ring being measured. This calibration should be done at least monthly.

11.2.4 Other Calibrations

- *Beam Dose*

A chrysotile standard is examined in the microscope and a Selected Area Electron Diffraction (SAED) pattern is obtained for a single fibril $> 1 \mu\text{m}$ in length. The pattern is checked to ensure it is still visible after 15 seconds.

- *Spot Size*

Using a magnification of 15,000X–20,000X a spot size of approximately 200 nm is obtained and measured. (The measurement should indicate the spot size is ≤ 250 nm.)

- *Chrysotile Standard Check*

An EDS spectrum is obtained from a single fiber of a chrysotile standard to demonstrate the presence of both Mg and Si peaks in the correct ratios.

- *Mn K-alpha Peak Check*

A carbon/manganese coated grid is examined to determine the resolution of the Mn K-alpha peak (175 eV or better is required).

- *Standard Reference Material (SRM) 2063 Check*

The SRM 2063 is examined to determine detector sensitivity by monitoring the background-corrected peak intensities for Na, Mg, Al, Si, Ca, and Fe EDS peaks.

- *Crocidolite Standard Check*

A crocidolite standard is examined to check for the ability of the EDS to detect the Na peak.

- *Plasma Asher Check*

The plasma asher must be checked periodically to regulate the ash rate. Approximately 10% of the sample filter should be ashed during the ashing step of sample preparation (methyl cellulose ester filters only).

- *Laboratory Area Air Monitoring*

Air samples of the TEM sample preparation area and microscope rooms must be collected periodically and analyzed by TEM. Any identification of asbestos necessitates a determination of the source of contamination before continuing TEM analysis.

11.2.5 Sample Preparation:

- Items used during sample preparation (such as petri dishes, forceps, screens, scalpels, slides, and glassware) are meticulously cleaned before use, and before contact with subsequent samples.
- Filter lots used for sample preparation must be checked for background contamination levels before use. Contaminated filter batches must be rejected if the average asbestos fiber count exceeds $18 \text{ fibers}/\text{mm}^2$, or if a single asbestos fiber count exceeds $53 \text{ fibers}/\text{mm}^2$.
- Grid batches must be examined for uniformity and size of grid openings (20 grids at 20 openings each per batch of 1000).
- Reagents used during sample preparation must be of spectroscopic grade (not reagent grade). Aliquots used for any given sample preparation must not be used for subsequent samples.

- The area in which the filters are prepared must be kept as free of contamination as possible, helped by use of a laminar flow clean bench and use of a fume hood during prep stages requiring volatile chemicals. All prep instruments and tools must be quarantined from other areas of the laboratory, particularly where bulk samples are analyzed or stored. No interchange of tools, chemicals, filters, cleaning aids, etc., is allowed.
- The plasma asher must be cleaned between each operation, and the vacuum evaporator must be cleaned daily (on days when samples are prepared).
- A portion of all samples prepared should be prepared again by a second analyst to ensure uniformity in preparation procedures.

11.2.6 Sample Analysis

- *Blanks*

One laboratory blank must be prepared and analyzed in the TEM with each sample set to verify lack of contamination during sample preparation procedures. If an asbestos fiber count on a laboratory blank exceeds 53 fibers/mm², the entire sample set is suspect and the sample set is re-prepped.

- *Intra-/Inter-Analyst Reanalysis*

At least 2% of all TEM samples must be reanalyzed by the original analyst (intra-analyst) and analyzed by a second analyst (inter-analyst). The original grid squares should be reanalyzed for both reanalyses. This information is used to determine a laboratory coefficient of variation (relative standard deviation) which is used to determine acceptability of future reanalyses.

- *Analysis of Standards*

The National Institute of Standards and Technology (NIST) Standard Reference Material 1876 should be analyzed at least annually by all analysts. The laboratory mean should fall within 80% of the 95% confidence limits as published on the NIST certificate. If the SRM result is out of this range, however, it should be reanalyzed by the analyst and the Quality Assurance Officer to correct any problems encountered originally.

- *Verified Counting*

For a minimum of 0.5% (NVLAP criteria) of TEM grid openings analyzed, a verified counting analysis should be conducted. The verified counting is done on a field sample that meets the fiber density criterion (4-15 fibers per grid opening) and is archived for this purpose.

- *Use of Standards/References*

- A library of asbestos standards and potential interferences should be maintained and analyzed periodically to facilitate recognition of asbestos and other fibrous materials and to verify instrument sensitivity to the materials.
- All samples should have all data entries reviewed and verified.
- At least 1% (AHERA Criteria) of the samples should have any automated data reduction system verified by hand calculations, or an independent recalculation of any hand-calculated data.

11.2.7 Interlaboratory Quality Control:

The laboratory should be enrolled in a round-robin sample exchange program with at least two other laboratories that perform TEM analyses.

Samples are exchanged between the laboratories at least semiannually. The results are statistically evaluated by the originating laboratory. If there is a discrepancy concerning a sample or samples, a recount is conducted to correct the problem.

All samples used in the program should be typical of the laboratory's own work load and have had the fiber counts thoroughly verified internally.

[Special thanks to Owen S. Crankshaw of Research Triangle Institute in Research Triangle Park, N.C., for his time and effort in writing this section.]

11.3 Quality Assurance Procedures for Asbestos Bulk Identification Using Polarized Light Microscopy

11.3.1 Sample Shipping and Handling

See Section 11.1.1.

11.3.2 Microscope Setup and Calibration

Refer to the microscope instruction manual.

11.3.3 Cargille Immersion Oil Calibration

These oils are calibrated quarterly using a refractometer or equivalent method. The refractive index of each oil is measured and the results, the stated refractive index of that oil, the date, and the analyst's signature are recorded in a small notebook placed near the microscope. Any noticeable color change of an oil might indicate a change in its refractive index. Any oil that has a refractive index greater than ± 0.004 of the theoretical value must be replaced, and the expired oil disposed of in a manner consistent with waste disposal practices.

All immersion oils should be stored at a temperature between 12°C (54°F) and 35°C (95°F).

11.3.4 Asbestos Identification Proficiency Testing Program

The laboratory should be enrolled in the NIST Proficiency Testing Program under the National Voluntary Laboratory Accreditation Program, or the AIHA Asbestos Bulk Proficiency Testing Program. This helps to evaluate the laboratory's ability to identify and quantitate the contents of known bulk samples for asbestos.

All NIST/NVLAP or AIHA samples are analyzed independently by qualified laboratory personnel using the Asbestos Identification Data Sheet (see Attachment F). The results are compared, and if any are questionable a reanalysis is performed to eliminate any discrepancies.

The laboratory manager or supervisor evaluates the data, and the results from one analyst are reported to NIST/NVLAP or to the Research Triangle Institute (RTI).

11.3.5 Record Keeping—Retention of Samples and Reference Data (NIST/NVLAP; AIHA)

Reference data are recorded in a separate file that includes the following information:

- Sample Identification Number
- Date of receipt
- Results for each sample to include the following:
 - Identity of all asbestiform or non-asbestiform material
 - The percentage of each component

All reference samples should be retained indefinitely for use as quality control samples.

11.3.6 Interlaboratory Quality Control

It is recommended that a laboratory enroll in a round-robin exchange program with at least one other laboratory performing polarizing light microscopy analysis of asbestos bulk material.

Samples are exchanged between the two laboratories at least semiannually. The results are compared with those of the respective laboratories that issued the samples. If there is any discrepancy concerning result(s) of a sample or samples, a reanalysis is conducted to rectify the problem.

All samples used in this program are ones that have had their composition verified thoroughly.

These quality control samples are selected on the following criteria:

- Asbestos type
- Non-asbestos fiber type
- Non-fibrous material

The results of these analyses are recorded in a notebook in the following manner:

- Sample number (Laboratory No.)
- Date analyzed
- Notebook reference
- Results
- Analyst's signature

11.3.7 Quality Assurance

11.3.7.1 Proficiency Samples

One NIST Standard Reference Material containing asbestos is analyzed initially before the subsequent analysis of the NIST/NVLAP or AIHA bulks. Also, an NIST Standard Reference Material of fiber glass is used as a blank to check for contamination that would affect the accuracy and limits of detection of asbestos analysis. If a problem arises related to the identification of a particular type of asbestos in a sample, an NIST Standard Reference Material that contains the type of asbestos suspected in the bulk is mounted and analyzed. The NIST Reference and NIST/NVLAP or AIHA sample are then compared to determine whether the characteristics of the bulk match those of the NIST Standard Reference.

11.3.7.2 Field Samples

An NIST/NVLAP or AIHA bulk sample is analyzed with each set of samples submitted to the laboratory. This NIST/NVLAP or AIHA sample serves to check the microscope optics, the integrity of the refractive index oil (Cargille), and the analyst's ability to perform dispersion staining/polarized light microscopy.

A replicate analysis must be performed on a minimum of one sample or on 10% of the total samples analyzed. If these results are different, another analyst should analyze the sample. If this reanalysis verifies a problem, the entire set of samples should be analyzed again.

All results will be recorded properly.

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Yamate, G., S.C. Agarwall, and R.D. Gibbons: *Methodology for the Measurement of Airborne Asbestos by Electron Microscopy* (Draft report U.S. EPA Contract 68-02-3266). IIT Research Institute, 1984.

FIBER COUNT WORKSHEET

Microscope calibrated in accordance with NIOSH Method 7400 Revision #3 dated May, 1989

Date: _____

SAMPLE # _____ DATE _____

1µm FLOW _____ Min TIME _____

VOLUME 1 _____ fibers/field BLANK COUNT

0.00785 mm² FIELD AREA _____ fibers/field AVERAGE COUNT

FIBERS / CC

SIGNATURE _____

NOTES _____

CALCULATION FOR CONCENTRATION

$$\frac{\text{fibers field}}{\text{field area}} \cdot \frac{\text{filter area}}{\text{flow rate} \cdot \text{time}} \cdot \frac{1000 \text{ cc}}{\text{liter}}$$

$$= \frac{(\quad)}{\text{mm}^2} \cdot \frac{(\quad)}{(\text{1µm})} \cdot \frac{(\quad)}{(\text{min})} \cdot \frac{(\quad)}{(\text{1000 cc})} \cdot \frac{(\quad)}{(\text{liter})}$$

SAMPLE # _____ DATE _____

1µm FLOW _____ Min TIME _____

VOLUME 1 _____ fibers/field BLANK COUNT

0.00785 mm² FIELD AREA _____ fibers/field AVERAGE COUNT

FIBERS / CC

SIGNATURE _____

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$$= \frac{(\quad)}{\text{mm}^2} \cdot \frac{(\quad)}{(\text{1µm})} \cdot \frac{(\quad)}{(\text{min})} \cdot \frac{(\quad)}{(\text{1000 cc})} \cdot \frac{(\quad)}{(\text{liter})}$$

File: QC1.DAT

REALITIVE STANDARD DEVIATION (2 SIGMA)

Comment: INTERCOUNTER RSD FOR 5 TO 20 FIBERS

Individ.

NAME	DATE	RSD	0	0.333333	0.666667	1
FC-6	11/29/90	.52	I	:	*	I
FC-8	11/29/90	.46	I	*	:	I
FC-9	11/29/90	.38	I	*	:	I
FC-15	11/29/90	.50	I	:	*	I
FC-15	3/8/91	.60	I	:	*	I
FC-6	5/13/91	.55	I	:	*	I
FC-9	5/13/91	.37	I	*	:	I
FC-9	06/28/91	.37	I	*	:	I
FC-15	06/28/91	.57	I	:	*	I
FC-6	09/18/91	.58	+	:	*	+
FC-8	11/15/91	.48	I	*	:	I
FC-6	11/15/91	.56	I	:	*	I
FC-15	11/15/91	.58	I	:	*	I
FC-6	1/9/92	.58	I	:	*	I
FC-9	1/9/92	.36	I	*	:	I
FC-15	1/9/92	.56	I	:	*	I

C CL C

Individ. Parameters

CL: 0.50125
 UCL: 0.675587 LCL: 0.326913
 Actual average: 0.50125

Number of observations per Subgroup: 1
 Number of Subgroups: 16
 Number of Out-of-Control Points: 0

BLIND RECOUNT TEST

Today's Date: 01/29/94

Sample #: R001 - - - - - Original Count (Fibers/mm²): 11.5

Sample #: R001 - - - - - Recount (Fibers/mm²): 15.5

Sample #: R001 - - - - - Recount is Accepted

ASBESTOS IDENTIFICATION DATA SHEET

This Report Relates Only to the Item(s) Tested

Plant Location _____ Date Analyzed _____

Analyst Signature _____

Microscope aligned and calibrated for Köehler illumination on: Date _____ Time _____

Logbook Reference Page					
Sample I.D.					
Lab No.					
Gross Sample Appearance	Is the sample homogeneous?				
	Does it contain obvious layers?				
	Is the sample fibrous?				
	Sample color				
Sample Treatment (enter number)	1. None				
	2. Homogenized				
	3. Other, specify				
Does the Sample Contain Any Asbestos Fibers?					
Pleochroism (Yes or No)					
Birefringence (enter number and asbestos type)	1. None (isotropic)				
	2. Low				
	3. Medium				
	4. High				
Sign of Elongation	(+) amosite and chrysotile				
	(-) Crocidolite				
Asbestos Present (enter number and percent)	1. Amosite - 1.680				
	2. Chrysotile - 1.550				
	3. Crocidolite - 1.700				
	4. Other, specify				
Total Percent Asbestos Present in Sample					
Other Fibrous Materials Present (enter number and percent)	1. Fibrous glass				
	2. Cellulose				
	3. Other, specify				
Nonfibrous Material Present (description and percent)					
Dispersion Staining Colors					

APPENDIX C

INSTRUCTIONS

MODELS **CHS/CHT**
BIOLOGICAL MICROSCOPES

This instruction manual is for use of the Olympus Biological Microscopes Models CHS & CHT. We recommend you read this manual carefully in order to familiarize yourself fully with the use of your microscope so that you can obtain optimum performance.

OLYMPUS

AY571

BEFORE USE

Observe the following procedures carefully:

1 Operation

- ① Since the microscope is a precision instrument, always handle it with care, and avoid abrupt motions or shocks.
 - ② Avoid exposure to direct sunlight, high temperature and humidity, dust and vibration.
 - ③ Before bulb or fuse replacement, unplug the power cord from the AC outlet.
 - ④ Always ground the microscope to prevent electric hazard.
 - ⑤ Only use the tension adjustment ring for altering the tension of the coarse adjustment knobs.
 - ⑥ Be careful not to soil lens surfaces with dust, fingerprints, etc.
 - ⑦ Be certain the voltage selector switch on the base plate of the microscope is set to conform with the local line voltage before use. (CHS only)
- ★ Specifications of the electrical components differ from others than the equipment with 120 V of supply circuit, as the equipment is in compliance with the requirements of Underwriters Laboratories. Also, the equipment is not needed to select voltage.

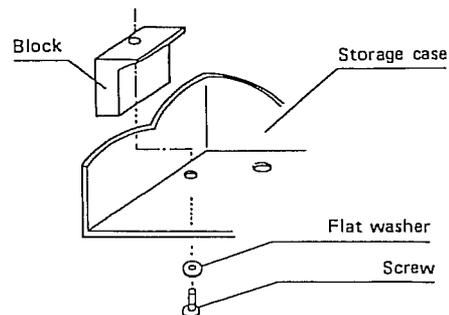
2 Maintenance and Storage

- ① Use a clean brush or lens tissue paper to clean the lens surfaces. If the lens surfaces are soiled with oil or fingerprints, wipe them off carefully with gauze moistened with a small amount of a cleaning medium (alcohol and ether 3:7), or xylene.
- ② Do not use organic solutions (e.g. thinner, xylene, ether, alcohol) to wipe painted surfaces or plastic parts of various components. They should be cleaned with a neutral detergent.
- ③ Never disassemble each component of the microscope for repair yourself, since the integrated performance may be impaired.
- ④ When not in use, the microscope should be covered with the dust cover provided or contained in a storage case, and kept in a place free from humidity and mold.

Assembly of the microscope fixing blocks inside the wooden storage case (CHS-WB/CHT-WB) (optionally available)

Install two blocks at the bottom of the wooden case in the following procedure:

- 1) Insert one of the two screws into a flat washer and one of the two holes (8 mm dia.) as illustrated at the right.
- 2) Insert the screw into the block from below, and clamp with the spanner provided.
- 3) Clamp the other block with the other screw on the opposite side in the same manner as mentioned above.



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STANDARD CONFIGURATIONS

STANDARD CONFIGURATIONS

Component		CHS-213E	CHT-213E
Microscope stand with quadruple revolving nosepiece, square plain stage, low voltage illuminator base, including dust plug AA7808, filter 32.5C-2, immersion oil 8cc and dust cover CO11	CHS-F	○	
Microscope stand with quadruple revolving nosepiece, square plain stage, 30W illuminator base, including dust plug AA7808, filter 32.5C-2, immersion oil 8cc and dust cover CO11	CHT-F		○
Power cord	UYCP	○	○
Binocular observation tube, inclined 45°	CH-BI45-W	○	○
Attachable mechanical stage with right-hand low drive controls	CH-MVR	○	○
Condenser	CH2-CD	○	○
Filter holder	CH2-FH	○	○
6V 20W halogen bulb, 2 pcs.	6V 20W HAL	○	
30W tungsten bulb, 2 pcs.	30W SB		○
E D achromatic objective 4X	ED4X	○	○
E D achromatic objective 10X	ED10X	○	○
E D achromatic objective 40X (spring)	ED40X/R	○	○
E D achromatic objective 100X (spring, oil)	ED100X/RO	○	○
LB eyepiece 10X, 2 pcs.	CWHK10X	○	○

Note: ○ indicates the compatible components for each model.

Optional accessories:

Field iris diaphragm attachment	CH2-FS
Phase contrast attachment	CH2-PCD-PL
Simple phase contrast attachment	CH2-PC-PL
Simple polarizing attachment	CH2-POL SET
Dual viewing attachment	CH2-DO
Magnification changer	BH2-CA
Vertical illuminator	BH2-KMA
Dry darkfield condenser	BH-DCD
Immersion darkfield condenser	BH-DCW
Wooden storage case	CHS-/CHT-WB

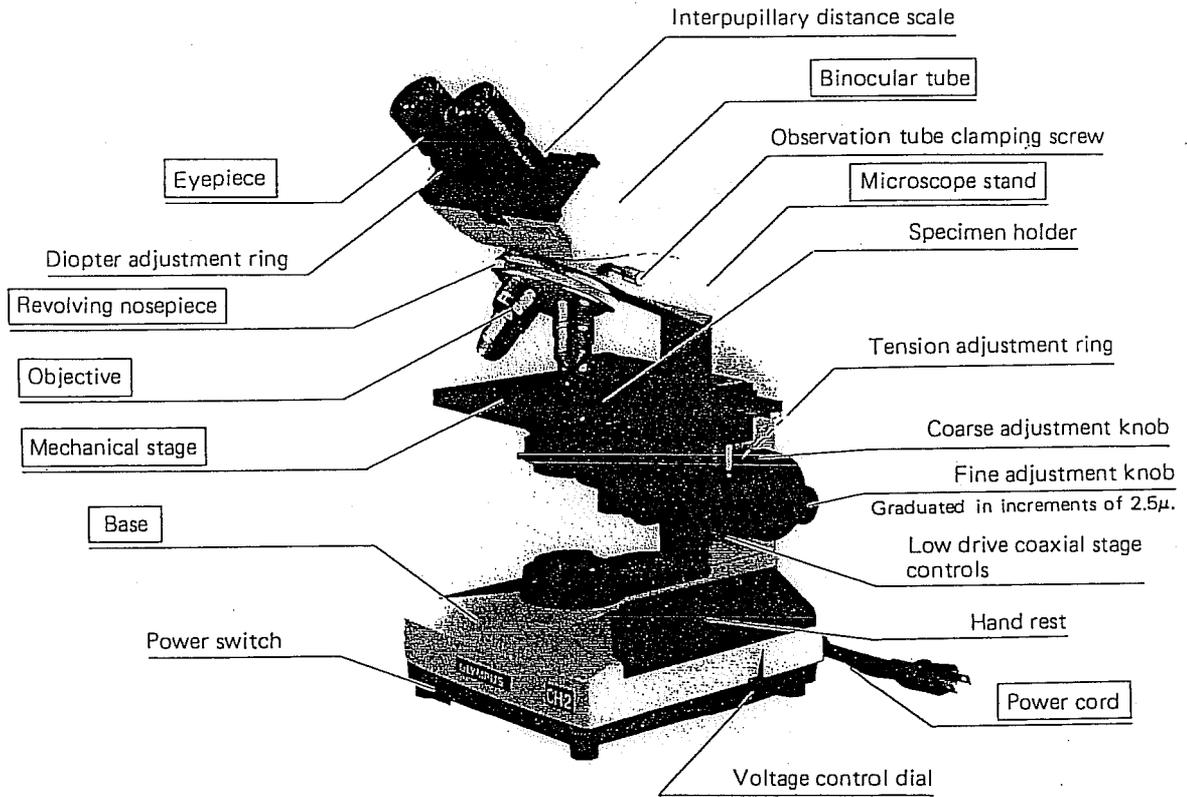
2 SPECIFICATIONS

Item		Description
Microscope stand	Microscope limb	Circular dovetail mount for observation tube with accommodation to accept an analyzer; built-on quadruple nosepiece and plain stage 124 mm (X) x 153 mm (Y)
	Focus adjustments	Coaxial coarse and fine focusing controls within a focus adjustment range of 25 mm. Fine adjustment knobs graduated in increments of 2.5 μ . Tension adjustment ring for coarse adjustment knobs and pre-focusing lever for coarse focusing.
	Condenser holder	Rack and pinion condenser height displacement up to 28 mm.
	Base	Illuminators built-in bases: 6V 20W halogen bulb with transformer built-in CHS-F 110V/120V 30W tungsten bulb with reflector built-in CHT-F Light intensity variable by means of coil winding resistance. Mount at the light exit on the base for field iris diaphragm and 45 mm-dia. filter. Power cord is detachable.
Observation tube	Binocular	Inclined 45°; interpupillary distance adjustment with a scale between 53 mm and 72 mm. Left-side eyepiece tube equipped with diopter adjustment ring.
Mechanical stage		Low-positioned coaxial control knobs; X-Y traversing area 76 mm x 50 mm, compatible with two standard slides simultaneously.
Condenser		N.A. 1.25 (in immersion oil), with graduated aperture diaphragm. Provided with accommodation to accept a filter holder and an attachment lens for field iris diaphragm.
Filter holder		Accepts a 32.5 mm dia. filter.
Field iris diaphragm attachment (optionally available)	Iris diaphragm frame	Attachable on the light exit mount and accepts a 45 mm dia. filter. Diaphragm image can be formed in conjunction with objectives from 10X to 40X.
	Attachment lens	Attachable at the lower end of the condenser and accepts a 32.5 mm dia. filter; provided with centering screws for iris diaphragm.
Filter		Blue filter (32.5 mm dia.)
Objectives		ED4X, ED10X, ED40X (spring-loaded), and ED100X (spring-loaded, oil immersion)
Eyepiece		CWHK10X. Field No. 18; compatible with an eyepiece micrometer.
Dimensions		180 mm (W) x 223 mm (D) x 392 mm (H) (binocular version)
Eyepoint height		391 mm
Weight		CHS-213E: 6.2 kg (13.7 lb) CHT-213E: 5.8 kg (12.8 lb)
Power consumption (maximum)		CHS: 32 VA CHT: 32 VA

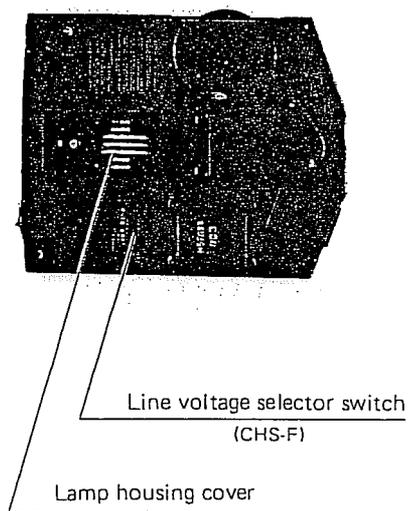
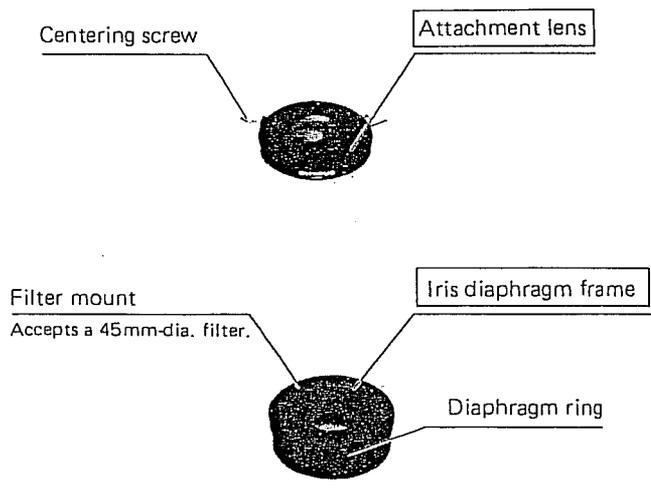
3 NOMENCLATURE

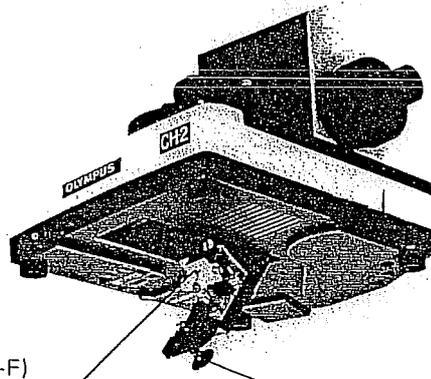
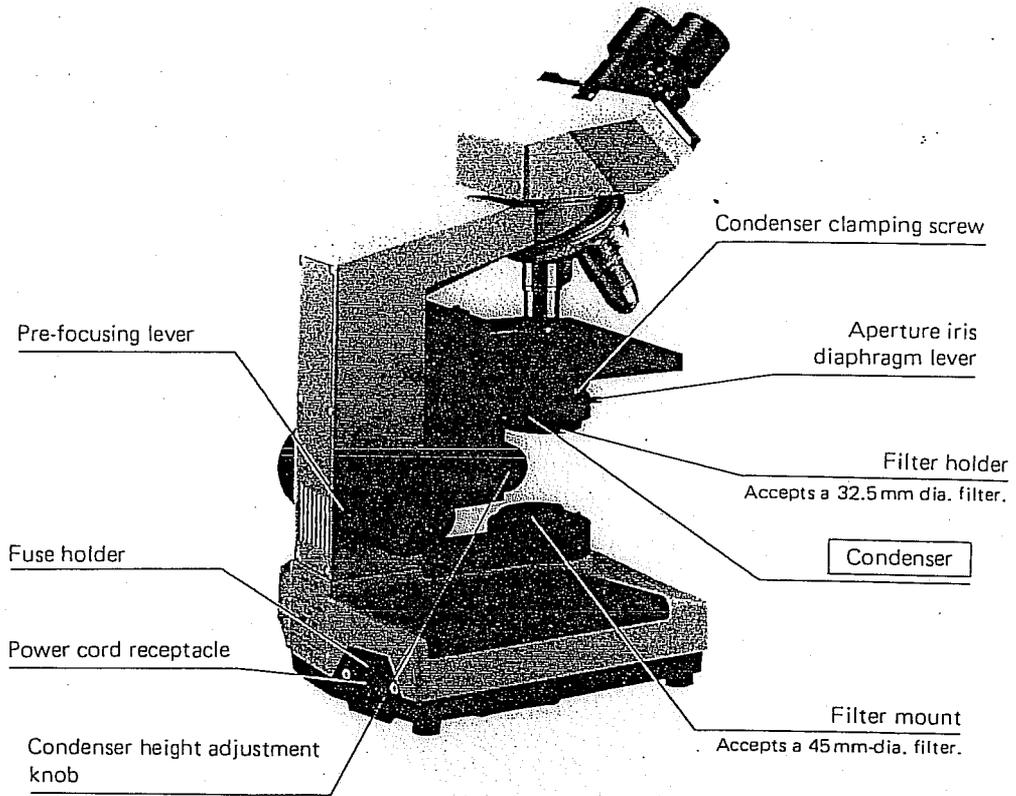


NOMENCLATURE



Field iris diaphragm attachment CH2-FS (optionally available)



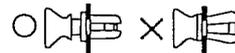


Bulb socket (CHS-F)
For 6V 20W halogen bulb.

Lamp housing knob

The lamp housing cover can be opened by pulling down the knob; or closed by pushing it up until it snaps in place.

Bulb socket (CHT-F)
For 110V/120V 30W tungsten bulb.

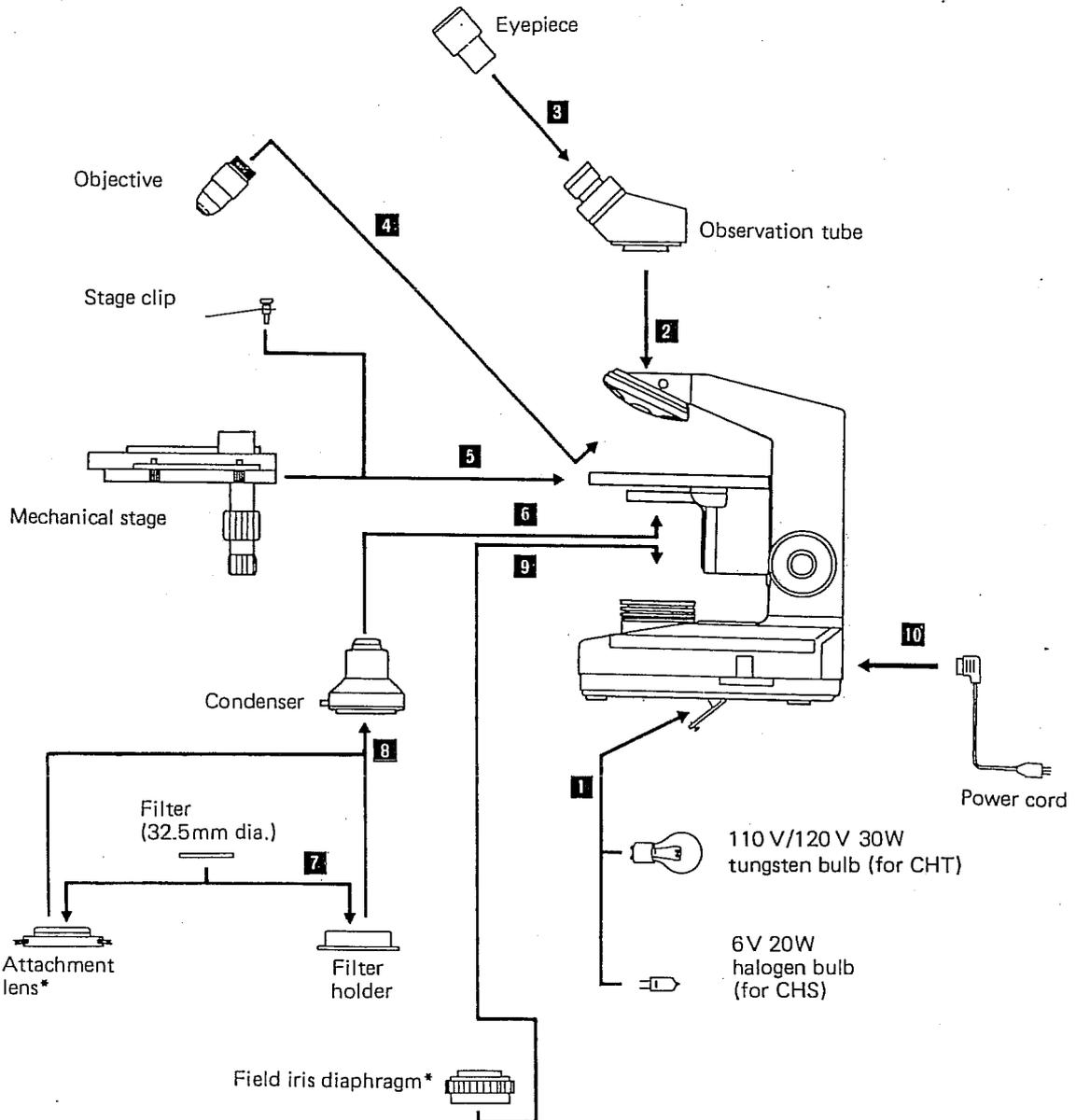


Before pushing the lamp housing cover, be certain the knob is positioned as shown in the picture left (marked with a circle).

4 ASSEMBLY

4-1. Assembly Diagram

- ★ Assemble each component in the order of the numbers with care to keep all glass surfaces clean and avoid scratching the lens surfaces.
- *Optional accessories



4-2 Explanation for Assembly Procedure

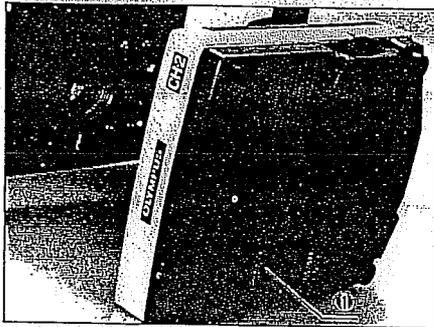


Fig. 1

Setting of the line voltage selector switch in position (for CHS only.)

Ascertain that the line voltage selector switch ① is set in conformity with the local line voltage. If not, the switch should be set at 100V (for 110V to 120V) or 200V (for 220V to 240V) correctly by means of a screwdriver. (Fig. 1)

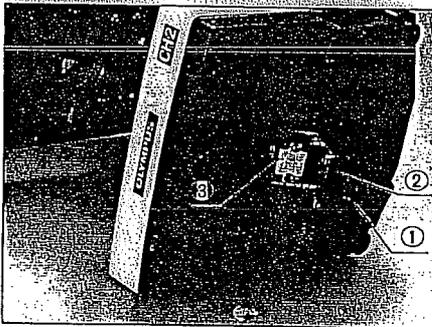


Fig. 2

1 Bulb installation and replacement

1) Turn the microscope on its side and pull the lamp housing knob ① to open the lamp housing cover ②. (Fig. 2)

2) Install the bulb.

- 6V 20W halogen bulb (for CHS):

Hold the halogen bulb contained in a polyethylene bag to avoid leaving fingerprints on the bulb, and insert the contact pins into the bulb socket ③ all the way. (Fig. 2)

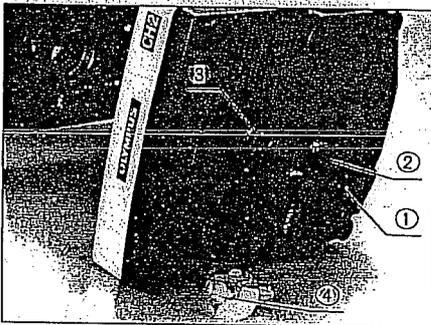


Fig. 3

- 110 V/120 V 30W tungsten bulb (for CHT):

Insert the tungsten bulb with its mirror portion ④ located at the lower side into the bulb socket ③; then, pressing it against the socket, rotate the bulb clockwise. (Fig. 3)

★ Before use, wipe off fingerprints or soils on the bulb.

★ 110 V bulb for local line voltage 110 V, and 120 V bulb for local line voltage 120 V or higher.

3) After bulb installation, close the lamp housing cover ②, pushing in the cover knob ①. (Fig. 3)

★ If the bulb burns out during observation, be certain to cool the defective bulb completely before replacement.

2 Mounting the observation tube

1) Loosen the clamping screw ① fully, and mount the observation tube on the stand. Reclamp the screw ① to securely hold the observation tube on the stand. (Fig. 4)

2) The binocular tube is normally located in the direction of the microscope front, but it can be turned to any other direction, if necessary.

3 Eyepiece insertion

Insert the eyepieces into the eyepiece tubes ②. (Fig. 4)

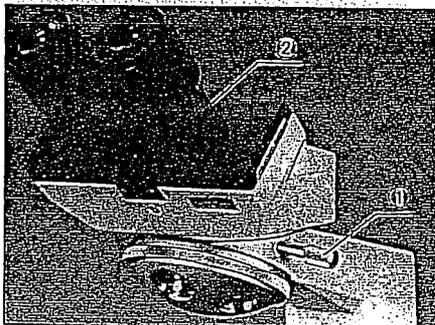


Fig. 4

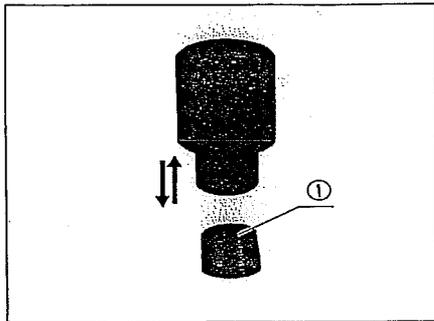


Fig. 5

Use of an eyepiece micrometer (19 mm in diameter)

An eyepiece micrometer (10 mm/100) (optionally available) can be inserted into the eyepiece CWHK10X in the following procedure:

- 1) Remove the retaining ring ① from the lower end of the eyepiece and place the micrometer on the retaining ring with the reticle-engraved surface, facing downward. (Fig. 5)
 - ★ Be certain to clean the micrometer disc before inserting into the eyepiece.
- 2) Return the retaining ring into the eyepiece and insert the eyepiece into the eyepiece tube.

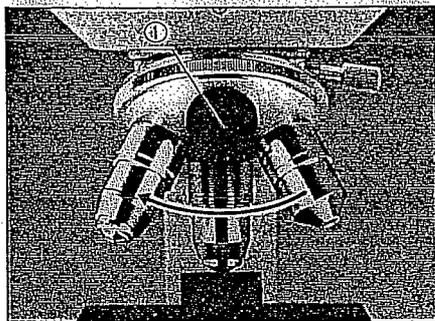


Fig. 6

4. Mounting the objectives

- 1) Lower the stage by means of the coarse adjustment knobs.
- 2) Screw the objectives into the nosepiece, from low power to higher power in a clockwise direction. (Fig. 6)
 - ★ Close the empty aperture in the nosepiece with a plug ① provided. (Fig. 6)

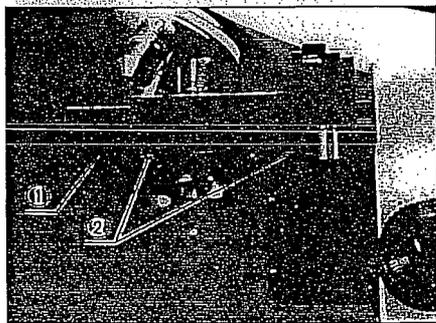


Fig. 7

5. Mounting the mechanical stage

Place the mechanical stage on the plain stage ①, with the specimen traversing guide closest to the microscope pillar, and tighten the stage clamping knobs ② with a coin. (Fig. 7)

- Insertion of stage clips

The plain stage is pre-drilled for insertion of the stage clips when the mechanical stage is not attached (see page 4).

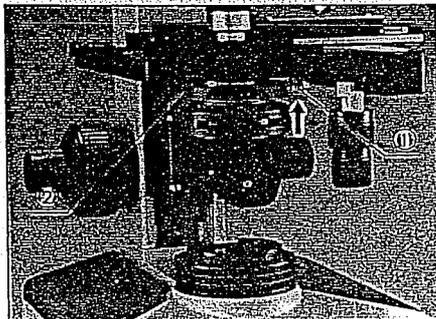


Fig. 8

6. Mounting the condenser

Insert the condenser into the condenser holder ② from below, with the condenser iris diaphragm lever, pointing in the microscope front, and tighten the clamping screw ①. (Fig. 8)

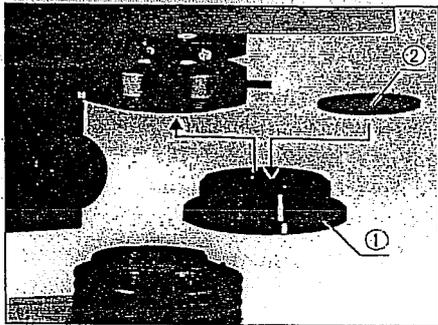


Fig. 9

7 Insertion of the blue filter

Slip the blue filter (32.5 mm dia.) ② into the filter holder ① (or into the filter mount at the top of the attachment lens). (Fig. 9)

8 Insertion of the filter holder

Insert the filter holder ① into the condenser from below. (Fig. 9)

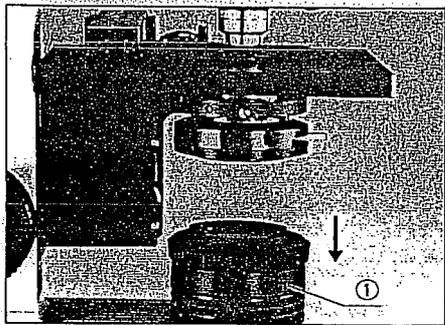


Fig. 10

9 Mounting the field iris diaphragm attachment (optionally available)

- 1) Aligning the positioning clips of the iris diaphragm frame to the cut-outs in the filter mount ① on the base, insert the iris diaphragm until it clicks in position. (Fig. 10)
- 2) Place the blue filter on the attachment lens and insert the attachment lens into the condenser from below, with the letters "OLYMPUS" facing in the microscope front.

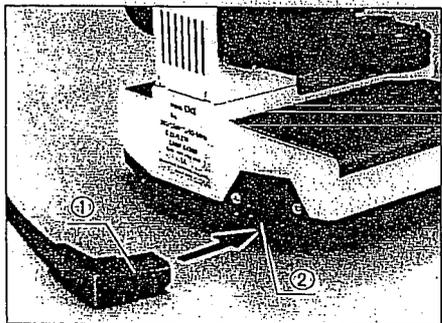


Fig. 11

10 Connecting the power cord

- 1) Plug the power cord ① into the receptacle ② on the microscope base. (Fig. 11)

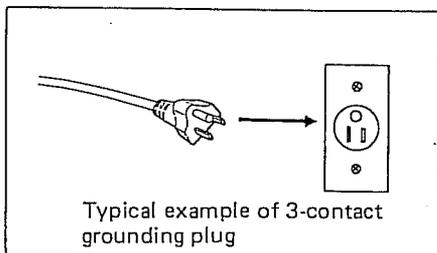


Fig. 12

- 2) Connect the primary cord with a 3-contact plug (it will fit into a ground type power outlet, and no need to connect it to any other grounding device) to an AC outlet.

★ If a 2-contact grounding plug is used, ground the microscope to a properly grounded device (except a gas pipe). If necessary, use an extension cord.

★ This microscope incorporates a noise filter in the electric circuit built-in the microscope stand, bleeding a very low voltage current in order to reduce effect of any external noises. Therefore, if the conductive part of the stand is touched without grounding, an electric shock may sometimes be felt depending upon the humidity conditions of the hands and foot wears.

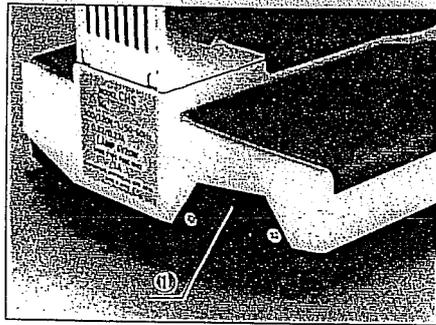


Fig. 13

- Fuse replacement

- 1) The fuse box ① is located at the back of the microscope base. (Fig. 13)
 - 2) Disconnect the power cord from the AC outlet, and remove the fuse box ① from the base by means of a screw driver. (Fig. 13)
 - ★ Apply the tip of the screw driver at the lower edge of the fuse box to remove it.
 - ★ The fuse box can accommodate a spare fuse in it.
- Use a fuse as designated by the manufacturer:

Microscope	Fuse amperage
CHS	100V 1A
	200V 0.63A
CHT	100V 0.8A
	200V 0.63A

5 OBSERVATION (Putting the Microscope in Operation)

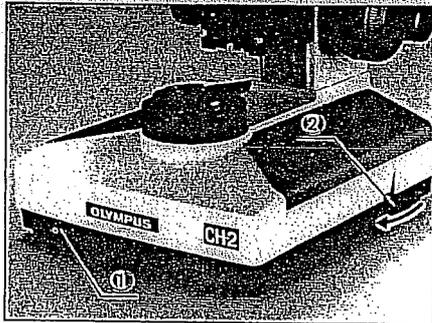


Fig. 14

1 Switching on the bulb

- 1) Turn the power switch ① on and adjust the voltage control dial ② until proper intensity is obtained. (Fig. 14)
- 2) Rotate the dial ② toward the operator (clockwise) to darken intensity (in the direction of the arrow), or reverse the dial (counterclockwise) to brighten.

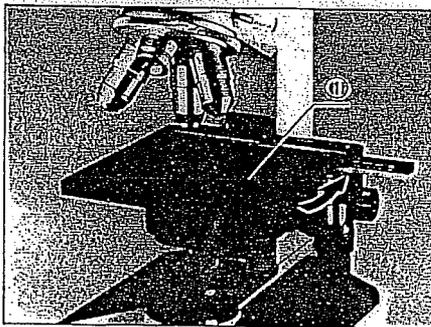


Fig. 15

2 Specimen placement

- 1) Open the spring-loaded finger ① of the specimen holder with one hand, and insert the specimen slide with the cover glass above the specimen into the holder with the other hand. (Fig. 15)
 - ★ Be careful to release the finger ① gently after the specimen is placed inside the holder.
 - ★ A sudden release of the finger may cause damage to the slide. If fragments of the specimen slide fall on the sliding surfaces of the stage or condenser, malfunctions may result.
- 2) For use of the stage clips in place of the specimen holder, attach a pair of stage clips on the stage, and insert the specimen slide between the stage surface and the clips near the clip stems; then move the slide toward the stage center.

- Cover glass

Use cover glasses of 0.17 mm thickness in conjunction with the objectives marked with the inscription "160/0.17" for optimum performance of these objectives.

- Specimen slide

Specimen slides between 0.9 mm and 1.2 mm in thickness are recommended for the CHS/CHT microscopes. If the thickness of a slide exceeds this range, illumination may sometimes be impaired.

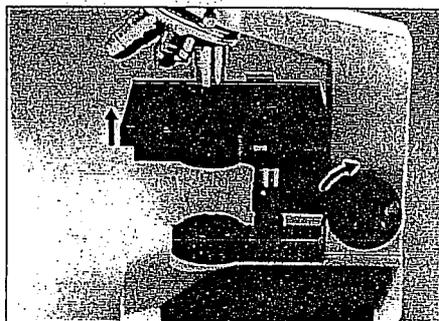


Fig. 16

3 Focus

- 1) Swing in the 10X objective.
- 2) Bring the specimen into focus by means of the coarse and fine adjustment knobs.
 - ★ Rotate the focus adjustment knobs clockwise (in the direction of the arrow in Fig. 16), and you can raise the stage (or the specimen approaches the objective).

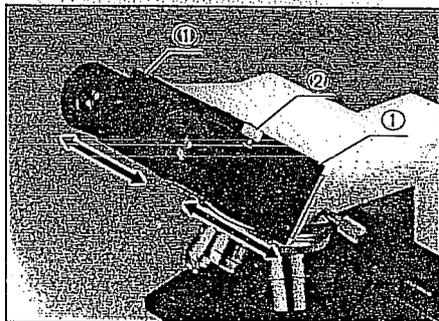


Fig. 17

4 Interpupillary distance adjustment

- 1) Looking through the binocular tube, move the knurled dovetail slides ① in the directions of the arrows until a perfect binocular vision is obtained. (Fig. 17)
- 2) If you memorize your interpupillary distance setting on the scale ② provided between the dovetail slides ①, it is convenient to obtain a proper setting next time. (Fig. 17)

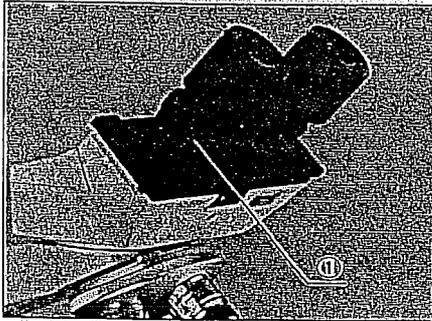


Fig. 18

5 Diopter adjustment

- 1) Look at the image through the right eyepiece with your right eye, and focus on the specimen with the focus adjustment knobs.
- 2) Next, looking at the image through the left eyepiece with your left eye, rotate the diopter adjustment ring ① to focus on the specimen without using the focus adjustment knobs. (Fig. 18)

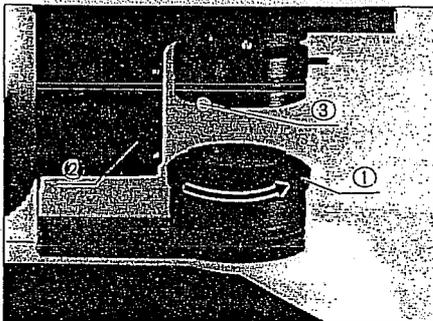


Fig. 19

6 Centration of the field iris diaphragm CH2-FS (optional)

- 1) Rotate the diaphragm ring ① counterclockwise to stop down the iris diaphragm to the minimum. (Fig. 19)
- 2) Rotate the condenser height adjustment knob ② in either direction until the image of the field diaphragm is visible sharply in the field of view. (Fig. 19)
- 3) Bring the image of the field diaphragm into the center of the field by means of the two attachment lens centering screws ③. (Figs. 19, 20)

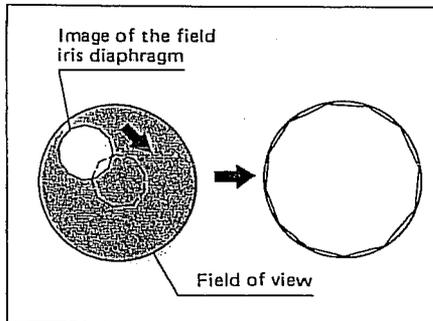


Fig. 20

- 4) Open the diaphragm until the small ring of the diaphragm inscribes the field of view. If the polygonal ring is not concentric with the field of view, repeat the centering procedure mentioned above. (Fig. 20)
- 5) After centration is complete, re-open the diaphragm until it becomes a larger polygonal ring around (or circumscribes) the circular edge of the field.

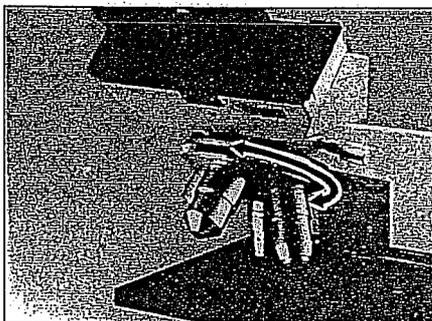


Fig. 21

7 Objective change

- 1) Swing in the objective to use. (Fig. 21)
- 2) Be certain to click the nosepiece in position.

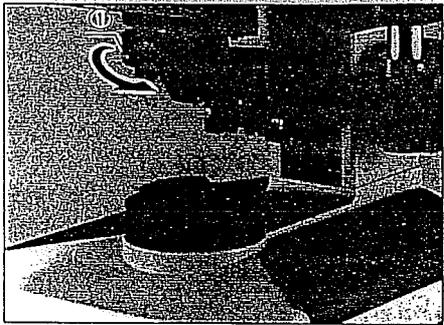


Fig. 22

8 Adjustment of the aperture iris diaphragm

The opening of the aperture iris diaphragm built in the condenser can be adjusted to match with the numerical aperture of the objective in use, in order to achieve optimum objective performance as depth of focus, image contrast and resolution.

- 1) Turning the diaphragm lever ① counterclockwise reduces the diaphragm opening. (Fig. 22)

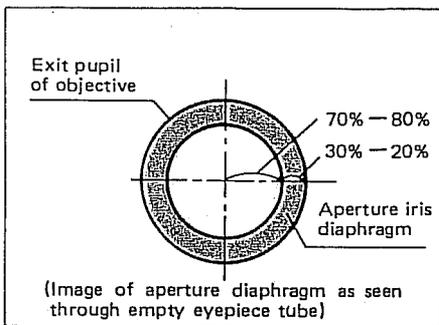


Fig. 23

- 2) Remove the eyepiece, and looking at the exit pupil of the objective through the empty eyepiece tube, adjust the opening of the diaphragm. Generally, it is preferable to stop down the aperture diaphragm to 70% to 80% of the objective N.A. (Fig. 23)
If the specimen is lightly stained, or almost colorless and transparent, further reduce the diaphragm opening to increase contrast for better image observation. Be careful, however, if the diaphragm is stopped down too much, the resolution will be deteriorated.

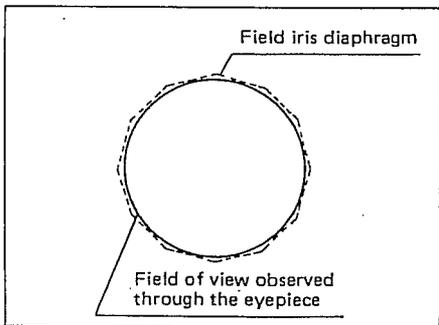


Fig. 24

9 Adjustment of the field iris diaphragm (for CH2-FS only)

- 1) The field iris diaphragm controls the diameter of the ray bundle impinging on the specimen and therefore, by stopping down the field diaphragm until it is slightly larger than the field of view, it can reduce stray light, which in turn increases image definition and contrast. (Fig. 24)
- 2) Turning the field diaphragm ring ① (Fig. 19) counterclockwise reduces the diaphragm opening, or reverse the ring to increase the opening.

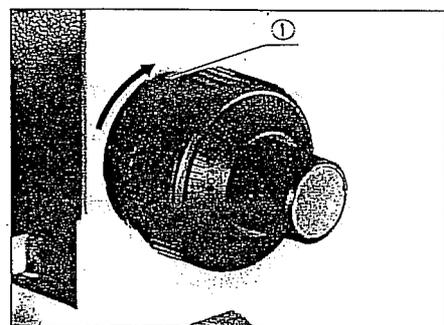


Fig. 25

10 Tension adjustment of the coarse adjustment knobs

- 1) A tension adjustment ring ① is provided next to the coarse adjustment knob. With this device the tension of the coarse adjustment is freely adjustable for either heavy or light movement, depending upon operator preference. (Fig. 25)
Applying the tip of a large screwdriver at a groove in the periphery of the tension adjustment ring ①, rotate the ring in the direction of the arrow to increase the tension, or reverse the ring to loosen.
- 2) However, do not loosen the tension adjustment ring too much, because this may cause the stage to drop or the fine adjustment knobs to slip.

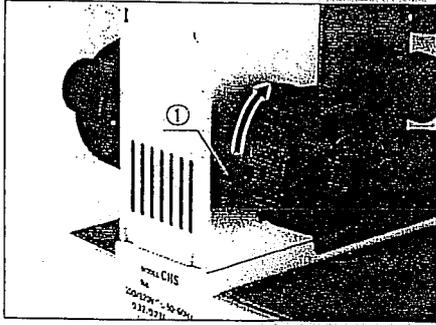


Fig. 26

11 Locking of the pre-focusing lever

This lever ① is provided to prevent possible contact between specimen and objective as well as to simplify coarse focusing. The lever is locked in the direction of the arrow in Fig. 26, after coarse focus has been accomplished. This is convenient for liquid application or change of specimens, too, since it prevents further upward travel of the stage by means of the coarse adjustment knobs, and provides a limiting stop if the stage is lowered and then raised again. The pre-focusing lever does not restrict fine focusing.

★ Unlock this lever when not in use.

12 Use of immersion objectives

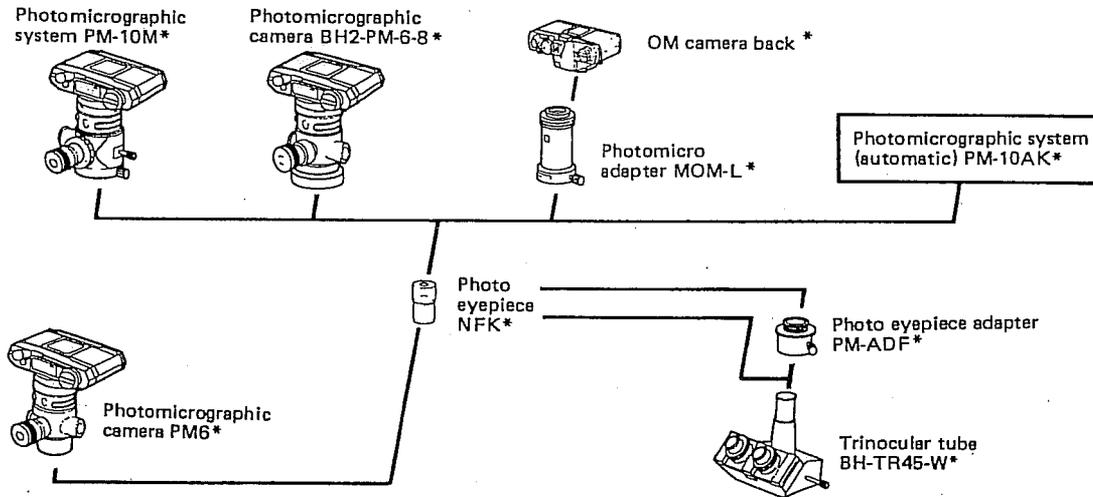
- 1) To utilize the full numerical aperture of an immersion objective (with inscription "oil"), the objective and specimen are immersed in an immersion oil in a following procedure:
- 2) Focus on the specimen with a low power objective.
- 3) Put a drop of immersion oil on the specimen slide and the front lens of the immersion objective.
- 4) Turn the nosepiece to bring the immersion objective into the light path, and focus with the fine adjustment knobs.

- ★ Use of the pre-focusing lever facilitates steps 2) through 4) above.
- ★ Care should be taken to prevent oil bubbles from forming in the oil film; if any, re-apply immersion oil, since these bubbles greatly deteriorate the lens performance.
- ★ Be careful not to stain other objectives with immersion oil, and after use, carefully wipe off the immersion oil on the objective, etc. completely.

6 PHOTOMICROGRAPHY

A trinocular tube BH-TR45-W, optionally available, is used for photomicrography with the CHS/CHT microscope in conjunction with Olympus photomicrographic equipment PM-10AK (automatic), PM-10M (manual), photomicrographic camera BH2-PM-6-8, OM camera backs, etc. Read the instruction manual of each equipment in use for explanation in detail.

6-1 System Diagram of Olympus Photomicrographic Equipment (optionally available)



*Optional accessories

6-2 Setup of the Photomicrographic Equipment

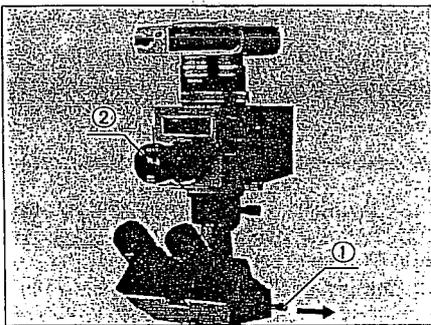


Fig. 27

1 Mounting the PM-10AK, PM-10M or PM-6-8 on the microscope

- 1) Each of these attachments can be mounted on the photo tube of the trinocular tube as photographed in Fig. 27. (Fig. 27 shows the PM-10AK on the trinocular tube.)
- 2) Use the photo eyepiece NFK3.3X or NFK5X.
- 3) Pull out the light path selector lever ① to deflect the light to the photo tube. (Fig. 27)
- 4) Looking through the focusing telescope ②, focus on the specimen. (Fig. 27)

★ In case of long time exposure, ambient light in the room will go through the eyepieces, and its image formed on the film plane may cause ghost or flare; to exclude this extraneous light, dim the room or cap the eyepieces during photographic procedure.

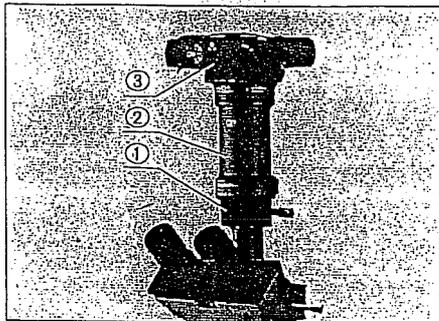


Fig. 28

2 Mounting the OM camera back

- 1) Mount the photo eyepiece adapter PM-ADF ① (into which a choice of NFK photo eyepiece is inserted), Photomicro adapter (MOM-L) ② and OM camera back ③ on the photo tube in this order. (Fig. 28)
- 2) The compatible photo eyepieces are NFK3.3X and NFK5X.
- 3) Bring the specimen into focus, looking through the viewfinder of the camera.
- 4) Photomicrographic magnification equals the objective magnification multiplied by the photo eyepiece magnification.

★ To take a good photomicrograph with a single lens reflex camera back, a shutter speed at 1/2 second or slower is recommended so as to reduce the mirror-lockup shock.

6-3 Color Temperature Regulation (for use of daylight color film)

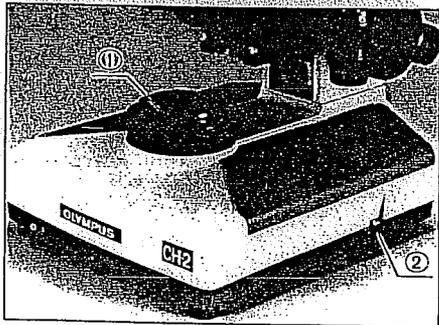


Fig. 29

1 Use of the light balancing filter 45LBD-2N (optionally available)

- 1) Remove the blue filter from the condenser.
- 2) Slip a 45LBD-2N filter into the filter mount ① at the light exit on the microscope base. (Fig. 29)
- 3) Turn the voltage control dial ② until the dial is aligned at the graduation "10" (maximum), and daylight color can be obtained. (For CHS only).

★ The 45LBD-2N filter cannot be used with the CHT microscope for color temperature regulation.

The optionally available color balancing filter 45LBD-2N is specially designed to obtain a better color rendition for daylight type color film than a blue filter.

2 Use of the blue filter 32,50-2

- 1) Engage the blue filter as used for observation in the condenser.
- 2) To obtain color temperature for daylight type film, set the voltage control dial ② at the graduation "9" for CHS, or at the graduation "10" for CHT.

★ If a photograph tends to overexposure, do not change the voltage control dial, but apply an optional N.D. filter (45mm dia.) to the filter mount at the light exit on the microscope base.

★ Since the blue filter tends to characteristically leave somewhat a yellowish tint, an optionally available 45LBD-2N is recommended for better improvement of color rendition in conjunction with the CHS microscope. However, the CHT microscope can be used only with the blue filter for color temperature compensation.



OPTICAL DATA

■ D Achromat

Objective	Type	D Achromat			
		4X	10X	40X	100X*
Eyepiece	Magnification	4X	10X	40X	100X*
	N.A.	0.10	0.25	0.65	1.30
	W.D. (mm)	18.23	7.18	0.63	0.20
	Focal length (mm)	30.03	16.90	4.58	1.66
	Resolving power (μ)**	3.4	1.3	0.52	0.26
cWHK10X (Field number 18)	Remarks	Spring-loaded			
	Total magnification	40X	100X	400X	1000X
	Focal depth (μ)	172.5	27.60	3.03	0.66
	Field of view (mm)	4.5	1.8	0.45	0.18

■ E D Achromat

Objective	Type	E D Achromat			
		4X	10X	40X	100X*
Eyepiece	Magnification	4X	10X	40X	100X*
	N.A.	0.10	0.25	0.65	1.25
	W.D. (mm)	29.00	6.30	0.53	0.20
	Focal length (mm)	31.05	16.45	4.59	1.90
	Resolving power (μ)**	3.4	1.3	0.52	0.26
cWHK10X (Field number 18)	Remarks	Spring-loaded			
	Total magnification	40X	100X	400X	1000X
	Focal depth (μ)	172.5	27.60	3.03	0.67
	Field of view (mm)	4.5	1.8	0.45	0.18

*Immersion objectives

**The resolving power is obtained with the fully opened aperture diaphragm.

Glossary:

- Working distance:** The distance from the specimen or cover glass to the nearest point of the objective.
- Numerical aperture:** The N.A. represents a performance number which could be compared to the relative aperture (f-number) of a camera lens. The quantity of light which the objective receives from the object increases with the square of the performance number.
- Resolving power:** The resolving power of a lens is measured by its ability to separate two points.
- Focal depth:** The distance between the upper and lower limits of sharpness in the image formed by an optical system. As you stop down the aperture iris diaphragm, the focal depth becomes deeper. The larger the N.A. of the objective the shallower the focal depth.
- Field number:** A number that represents the diameter in mm of the image of the field diaphragm that is formed by lens in front of it.
- Field-of-view diameter:** The actual size of the field of view in mm.
- Total magnification:** Equals the objective magnification multiplied by the eyepiece magnification.



8 TROUBLESHOOTING GUIDE

If you are unable to obtain full performance from your microscope because of your unfamiliarity, please consult with the table below as pointers for troubleshooting:

Trouble	Cause	Remedy
1. Optical system		
a) Field of view is cut off, or illuminated irregularly.	Nosepiece is not clicked into place.	Slightly rotate the nosepiece until it clicks into position. (p. 11)
	Condenser is not correctly mounted on the condenser holder.	Re-insert the condenser all the way without tilt. (p. 7)
	Field iris diaphragm is not centered.	Center it correctly. (p. 11)
	Field iris diaphragm is stopped down too much.	Open it properly. (p. 12)
	Dust or dirt on objective, eyepiece, condenser or light exit glass on microscope base	Clean each lens or glass.
b) Dust or dirt is visible in the field of view.	Dust on the light exit glass on the microscope base	Remove dust or dirt, or clean the specimen.
	Dust on the condenser top lens	
	Dirty specimen	
	Dust on eyepiece	
c) Excessive image contrast	Condenser is lowered too much.	Raise the condenser. (p. 7)
	Aperture iris diaphragm is stopped down excessively.	Open the diaphragm. (p. 12)
d) Resolution problems: <ul style="list-style-type: none"> • Image is not sharp. • Insufficient contrast. • Image details lack definition. 	Objective is not correctly engaged in the light path.	Slightly rotate the nosepiece until it clicks into position. (p. 11)
	Dirt on the objective front lens	Clean the objective.
	Immersion objective is used without immersion oil.	Apply immersion oil. (p. 13)
	Bubbles in the immersion oil	Remove bubbles. (p. 13)
	Olympus immersion oil is not used.	Use Olympus immersion oil.
	Dirty specimen	Clean the specimen, eyepiece or condenser lens.
	Dust on eyepiece or condenser top lens	
e) Field of view is partially out of focus.	Objective is not correctly positioned in the light path.	Slightly rotate the nosepiece until it clicks into position. (p. 11)
	Specimen is not correctly placed on the stage.	Replace it on the stage correctly and secure it with the specimen holder or stage clips. (p. 9)
f) Image is tinted yellowish.	Blue filter is not engaged.	Engage blue filter. (p. 8)

Trouble	Cause	Remedy
2. Focus adjustment mechanism		
a) Coarse adjustment knobs are too tight.	Tension adjustment ring is tightened too much.	Loosen the tension adjustment ring slightly. (p. 12)
	User is trying to raise the stage, passing over the upper focusing limit imposed by the engaged pre-focusing lever.	Unlock the pre-focusing lever. (p. 13)
b) Stage drops and the specimen goes out of focus.	Tension adjustment ring is too loose.	Tighten the ring properly. (p. 12)
c) Stage cannot be raised to the upper limit.	Pre-focusing lever is engaged in lower than focusing position.	Unlock the lever. (p. 13)
d) Stage cannot be lowered to the lower limit of the working range.	Substage is lowered too much.	Raise the substage.
e) Objective front lens touches the specimen.	Specimen is mounted on the stage upside down.	Reverse the specimen. (p. 9)
3. Binocular tube		
Incomplete binocular vision	Interpupillary distance is not correctly adjusted.	Correct the interpupillary distance. (p. 10)
	Diopter adjustment is incomplete.	Complete the diopter adjustment. (p. 11)
	Right and left eyepieces are not matched.	Use a pair of matched eyepieces.
	User is unaccustomed to binocular vision.	Prior to looking at the image of the specimen, try to look at the entire field of view, or look at a far away object before resuming microscopic observation.
4. Stage		
a) Image easily goes out of focus when you touch the stage.	Stage clamping knobs are not tightened.	Tighten clamping knobs with a coin securely. (p. 7)
b) Image blurs as you move the specimen.	Specimen is not correctly positioned on the stage.	Adjust specimen position. (p. 9)
5. Objective change		
Front lens of high power objective comes into contact with specimen when it is engaged after low power objective.	Specimen is mounted on the stage upside down.	Reverse the specimen. (p. 9)
	Cover glass is too thick.	Use a 0.17 mm-thick cover glass. (p. 10)



Trouble	Cause	Remedy
6. Electric system		
a) Illuminator is too bright with the voltage control dial even at the lowest position (closest to the operator).	Voltage selector switch is not matched with the line voltage.	Conform the switch to the line voltage. (p. 6)
	Line voltage is too high.	Adjust the line voltage with a variable voltage transformer.
	Bulb is not a standard one.	Use a standard bulb. (p. 6)
b) Output voltage for the illuminator cannot be controlled (too high or too low).	Voltage selector switch is not matched with the line voltage.	Conform the switch to the line voltage. (p. 6)
	Line voltage is too high (or too low).	Adjust the line voltage with a variable voltage transformer.
c) Light flickers and intensity is unstable.	Line voltage is unstable.	Use a voltage stabilizer.
	Filament of the bulb is likely to burn out.	Replace the defective bulb. (p. 6)
	Loose electric cords	Secure the connections. (p. 8)
d) Fuse burns out too often.	Fuse is not a standard one.	Use a standard fuse. (p. 9)
	Voltage selector switch is not matched with the line voltage.	Conform the switch to the line voltage. (p. 6)
e) Bulb does not light.	Fuse is gone.	Replace the fuse. (p. 9)
	Bulb is burned out.	Replace the bulb. (p. 6)
	Loose electric connections.	Secure the connections. (p. 8)
f) Reduced bulb life	Voltage selector switch is not matched with the line voltage.	Conform the selector switch to the line voltage. (p. 6)
	Bulb is not a standard one.	Use a standard bulb. (p. 6)
	Bulb was overvoltage too long.	Reduce bulb voltage. (p. 9)



OLYMPUS

OLYMPUS OPTICAL CO., LTD.

San-Ei Building, 22-2, Nishi Shinjuku 1-chome, Shinjuku-ku, Tokyo, Japan

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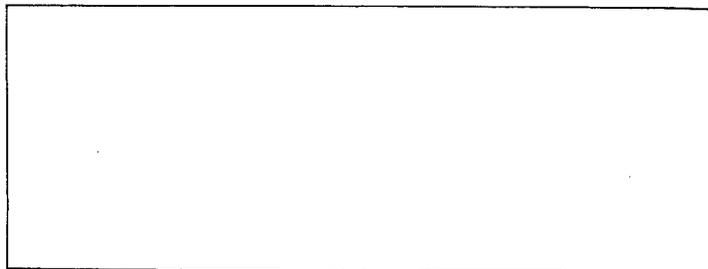
Postfach 104908, Wendénstrasse 14-16, 2000 Hamburg 1, Germany

OLYMPUS CORPORATION

4 Nevada Drive, Lake Success, N.Y. 11042-1179, U.S.A.

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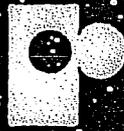
2-8 Honduras Street, London EC1Y0TX, United Kingdom



The design of the product is under constant review and whilst every effort is made to keep this manual up to date, the right is reserved to change specifications and equipment at any time without prior notice.

APPENDIX D

HOW TO USE YOUR TEST SLIDE



THE OPTOMETRICS GROUP
 incorporating
 OPTOMETRICS (USA) INC.
 OPTOMETRICS (UK) LTD.
 OPTOPTICS LTD

Description

The Standard Test Slides consist of identical epoxy replicas of a master slide produced and certified by the National Physical Laboratory, (NPL), Teddington, United Kingdom. A copy of the N.P.L. Certificate, for the master, is shown as Appendix 1.

The Test objects are seven blocks, each containing twenty ridges, in a resin of refractive index 1.58, mounted on a standard glass microscope slide (76 x 25 x 1.2mm).

The replica is covered by another resin of refractive index 1.485, and a glass cover slip 0.17mm thick.

In the coarsest block (Block 1) all the ridges are about 1.1 μm wide, and in the finest block, they are all about 0.25 μm wide. The ridges have a V-shape profile and have a height to width ratio of about 0.1. The blocks are separated by gaps 20 micrometers wide.

A set of 4 deep marker ridges is placed on either side of the array and a further two sets of 2 marker ridges spaced at an interval of 120 micrometres intersect the array at right angles.

The zone of the test objects to be used is delineated by the rectangle bounded by these marker ridges. This zone can easily be located by scanning the slide at about X100 magnification.

This is illustrated in Figures I and II. The widths of the ridges within each block and the calculated phase change (in degrees) associated with the maximum path difference in the light rays passing through the test objects are in Table I.

HSE/NPL Test Slide for Phase Contrast Microscopy

Epoxy Resin
 Replica + Cover Slip



Fig. 1. Test Slide
 (76 x 25mm)

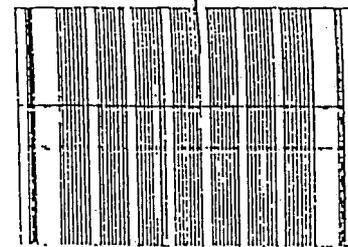


Fig. II. Enlarged Field of view
 20 lines per set (65mm high)

Table I

Block No.	Ridge Width (Micrometres)	Maximum Calculated Phase Change (in degrees) for light rays (wavelength = 530 nanometres) passing through test objects.
1	1.08	6.6
2	0.77	4.7
3	0.64	3.9
4	0.53	3.2
5	0.44	2.7
6	0.36	2.2
7	0.25	1.5

Widths of Test Objects and Calculated Maximum Phase Change Induced in Light Rays passing through Test Objects of HSE/NPL Test Slide.

Phase contrast microscopy, which was discovered by F Zernike in 1932, is used to help the microscopist who has to observe sample preparations which give low contrast objects. The method enables the phase differences in a specimen to be converted to amplitude differences to give an image of good contrast. It requires the use of a phase plate in the objective back focal plane and a phase ring in the condenser system and is usually used with a particular form of illumination.

Method of Use of Test Slide

Finding the Test Ridges

Place the Test Slide on the Microscope stage with the aluminium label strip uppermost; the circular clear area contains the test object, but it may not be centrally located within the circular area.

The microscope should be set up for phase contrast microscopy. If difficulty is experienced in finding the groups of ridges the following procedure may be helpful. If the microscope has a X10 phase objective this should be brought into the viewing position and used in conjunction with the phase annulus which matches the X40 objective. This will imitate a "dark ground" system. On some microscopes it will be necessary to select a different phase annulus, eg that provided for use with 100 X objective, to obtain this effect.

Focus the system onto the main vertical marker ridges of the test slide. The first two or three groups of ridges should readily be

seen and the main marker ridges at the end where the groups of ridges are observed should be brought into focus. Change to the X40 phase objective and select, if necessary, the matching phase annulus. With parfocal objectives it should only be necessary to make a small focus adjustment to bring the main marker ridges back to sharp focus. The eyepiece separation must be correct (on some systems this will require the tube length to be adjusted). Each eyepiece must also be correctly set for the microscopist's use. Check that the illumination is centralised and ensure that the field iris is sharply focussed in the specimen plane. Check that the phase annuli are correctly aligned.

The microscope will now be correctly set up for viewing the test slide under the same conditions as used for asbestos fibre counting.

Checking the Limit of Visibility

Move the first group of ridges (Group 1) into the centre of the field of view. Bring the ridges into sharp focus and then move the slide so as to position the second group of ridges centrally in the field of view and refocus again. Most systems will actually have sufficient width of view to enable three groups of ridges to be seen at the same time, when one group is positioned centrally, although some will only see parts of the groups on either side of the central group.

The procedure of moving from group to group should be continued until the finest group visible is found. When carrying out the test, especially for the first time, the brightness control should be adjusted so as to give the best results. A group is defined as visible when all the ridges of the group can be seen for their whole lengths between the horizontal marker ridges. The finest visible group of ridges will not be seen easily, and it may take some time

and concentration to determine the limit. It may be necessary to scan the eyes up and down the ridges in order to see them, although it should not be necessary to refocus during this operation. It is unlikely that all the groups will be visible, even with this care, but the majority of observers with medium to good microscopes can see group 5. Judging the limit of visibility will obviously be most difficult when the operator and microscope are being tested for the first time. However, once the limit of visibility has been established, and the operator is familiar with the appearance of the slide when the system is correctly set up, it should become easier for the system to be checked on a regular basis.

The Phase Contrast Test Slide was developed by the United Kingdom Health and Safety Executive in collaboration with the National Physical Laboratory. Its purpose was to provide a reproducible phase object to check microscope system performance prior to counting asbestos fibre samples.

The Slide is recommended by the Asbestos International Association in their Recommended Technical Method No. 1 (RTM1).

Reference Method for the Determination of Airborne Asbestos Fibre Concentrations at Workplaces by Light Microscopy. (Membrane Filter Method).

Daily use of a test slide is required in the method attached to the European Directive on Worker Protection against Asbestos (Official Journal on the European Communities, L263, 24 September 1983). The use of the HSE/NPL slide is also required in the method adopted by the Health and Safety Commission to determine compliance with UK asbestos control limits.

In day to day operations it should be remembered that after checking the system for test slide visibility the microscope will need to be correctly adjusted for viewing the membrane filter deposit; this should only require a slight refocusing of the field iris image.

Each slide has been examined by the Health and Safety Executive's (UK) Occupational Medicine and Hygiene Laboratory to ensure that group 5 is visible on their asbestos counting microscopes.

Anyone experiencing difficulty in using the test slide may contact the Health and Safety Executive, Microscopy Section, Occupational Medicine and Hygiene Laboratories, 403 Edgware Road, London NW2 6LN. Telephone No. 01-450-8911.

APPENDIX E

Appendix B

Alternative Work Practice



EAGLE ENVIRONMENTAL, INC.

SHIPPED JUL 14 2008

LETTER OF TRANSMITTAL

To: State of Connecticut DPH
410 Capitol Avenue, MS 5111K
P.O. Box 340408, Hartford
CT 06134

DATE:	7/10/08
JOB NO.	08-057-10
ATTENTION:	DPH AWP'S
RE:	Baltic Moll Sproague Ct

WE ARE SENDING YOU Attached Under separate cover via _____ the following items:

- Shop Drawings
 Prints
 Plans
 Samples
 Specifications
 Copy of Letter
 Change Order

COPIES	DATE	NO.	DESCRIPTION
			AWP Application

THESE ARE TRANSMITTED as checked below:

- For approval
 Approved as submitted
 Resubmit _____ copies for approval
 For your use
 Approved as noted
 Submit _____ copies for distribution
 As requested
 Returned for corrections
 Return _____ corrected prints
 For review and comment
 FOR BIDS DUE _____ PRINTS RETURNED AFTER LOAN TO US

REMARKS:

The vacant mill structure located at 27 Bushnell Road, Baltic Connecticut is currently being abated under a USEPA Brownfield's Grant. An asbestos inspection report has identified asbestos in the roofing felts and in the window glazing compound. The window glazing compound is located interior to the structure.

The structure is a four story granite building in substantial disrepair. The majority of the roof has collapsed into the upper floors and there are asbestos containing roofing felts in and around the structure. Many of the window sashes are broken as well and there is glazing compound on the ground and in the interior of the structure.

The upper floors, floors 2 through 4 are inaccessible from the interior of the structure because the floors are rotted around the interior perimeter of each of floors 2, 3 and 4. The ground floor is concrete.

The intent of this abatement program is to remove the window sashes and clean up the building felts and glazing compound lying around the exterior perimeter of the structure. Due to the unsafe conditions of the floors and the pre existing asbestos contamination inside the structure, we are requesting relief from establishing critical barriers at the masonry opening from which the window sashes will be removed from. Typically this would be considered a non disturbance activity but due to the deteriorated condition of the window sashes, the glazing compound is bound to become dislodged.

In lieu of the requirements of 19a-332a-5 (b), (c) (d), (e), and (h) of the State of Connecticut Standard for Asbestos Abatement, the designer request the use of work area preparation in accordance with 19a-332a-5 (a) and (f). Additionally a double layer of six (6) mil polyethylene sheeting will be used as a drop cloth to collect glazing debris that becomes dislodged.

Additionally the designer request exemption from 12a-332a-12 of the State of Connecticut Standard for Asbestos Abatement as there is no mechanism in place to clean the interior of the building. The designer request the use of a visual inspection on the exterior of the building only to document that the "no visible debris" criteria is met. A State of Connecticut licensed asbestos abatement project monitor will perform all visual inspections.

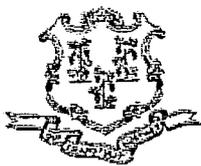
Access to the floors 2 through 4 will be restricted and signs posted identifying the asbestos hazard on the upper floors at the completion of the project.

All abatement work will be in compliance with the Environmental Protection Agency (EPA) 40 CFR 61, Subpart M – National Emission Standard for Hazardous Air Pollutants; Asbestos NESHAP Revision; Final Rule.

The estimated sash count is noted below.

LOCATION(S)	MATERIAL TYPE	QUANTITY
SOUTH	136 Sashes	4' x 3' Each
	108 Sashes	4' x 6' Each
	28 Sashes	4' x 5' Each
	3 Doors transom Windows	6' x 5' Each
EAST	4 Sashes	3' 4" x 3' 2" Each
	4 Sashes	3' 4" x 4' 6" Each
	30 Sashes	4' x 3' Each
	30 Sashes	4' x 6' Each
NORTH	148 Sashes	4' x 3' Each
	114 Sashes	4' x 6' Each
	34 Sashes	4' x 5' Each
	3 Sashes Above Door	2' x 3' Each

\\Eagle-server\public\2008 Files\2008 AWP\Paul Burgess\27 Bushnell Road>windowglazingcompound.doc



**State of Connecticut
DEPARTMENT OF PUBLIC HEALTH**

Application for Alternative Work Practices

State use only

Date: _____
 Check # _____
 Logged in: _____

Date Prepared:	06/10/08	Notification filed? if yes, date:	NO
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Please provide the following information as required by the Regulations of Connecticut State Agencies, Section 19a-332a-11.

1.	Name of Applicant: (Licensed Project Designer)	RAYMOND R FOLINO	Signature:				
	Address:	531 NORTH MAIN STREET BRISTOL, CONNECTICUT 06010					
	Telephone:	8605898257	License Number:	000022			
			Expiration Date:	10/31/08			
2.	Name of Facility Owner:	TOWN OF SPRAGUE					
	Address:	1 MAIN STREET BALTIC CONNECTICUT					
	Telephone	8605898257	Contact Person:	RAY FOLINO			
3.	Address of Facility:	27 BUSHNELL HOLLOW ROAD					
	City	BALTIC CONNECTICUT					
4.	Name of Asbestos Contractor:	NOT YET AWARDED	CT License Number:	N/A			
	Address:						
	City, State:						
	Telephone:	Contact:					
5.	Project start date (if known):						
6.	Nature of Asbestos Abatement:	Renovation <input checked="" type="checkbox"/>	Demolition: ()	Both ()			
7.	Type of Asbestos Abatement:	Removal <input checked="" type="checkbox"/>	Enclosure: ()	Encapsulation ()			
8.	Type of Asbestos Material pertaining to AWP:	INTERIOR WINDOW GLAZING COMPOUND		Square feet (Sq.Ft.)			
	(use additional attachment if			Linear feet (LF)			
9.	Description of facility	Size:	80,000	Age:	90	Use:	VACANT MILL STRUCTURE

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10. Section (s) and Subsections of the Standards for Asbestos Abatement regulation for which alternative work practice(s) is/ proposed:

19a-332- 5 (a), (b), (c), (d), (e) and (h)

11. Description of Alternative Work Practice(s): Please attach additional documentation if necessary

SEE ATTACHMENT

For Department of Public Health Use Only:

Approved	Set Aside	Denied

Reviewed by: _____

Date: _____

ATTACHMENT A – PHOTO DOCUMENTATION



Photo #1:	EAST FACADE
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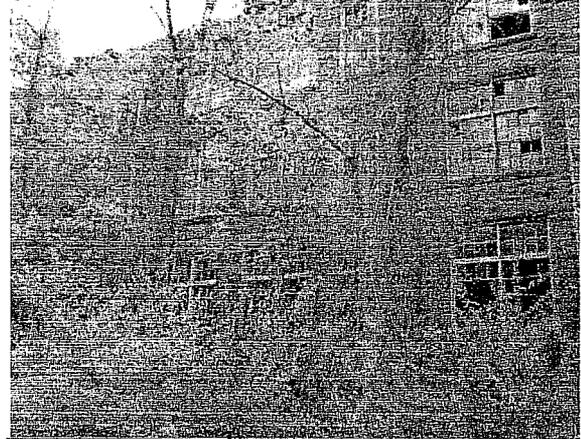


Photo #2:	PARTIAL NORTH FAÇADE – EAST END
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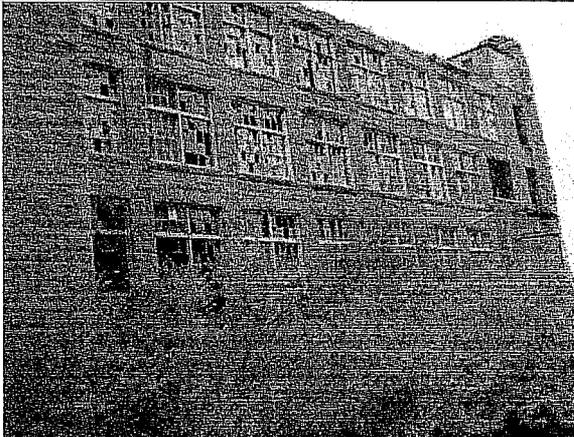


Photo #3:	PARTIAL NORTH FAÇADE–WEST END
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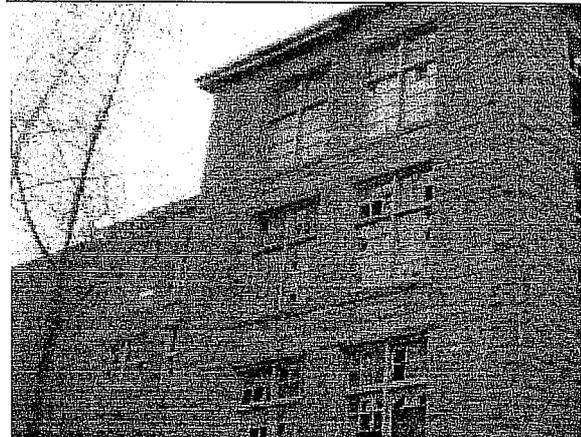


Photo #4:	PARTIAL NORTH FAÇADE-TOWER
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Photo #5:	WEST FACADE
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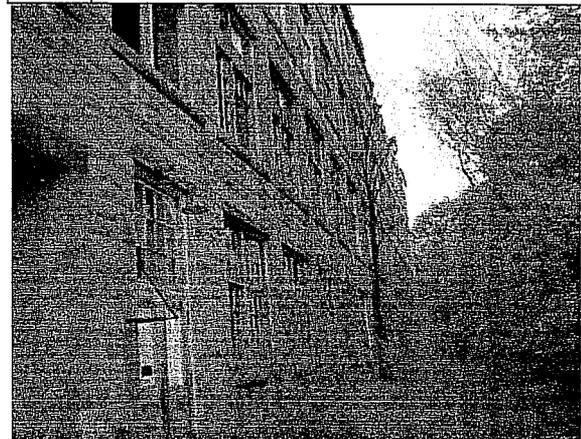


Photo #6:	SOUTH FACADE
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ATTACHMENT A – PHOTO DOCUMENTATION



Photo #7:	ASBESTOS CONTAINING ROOFING MATERIALS IN DEBRIS FIELD
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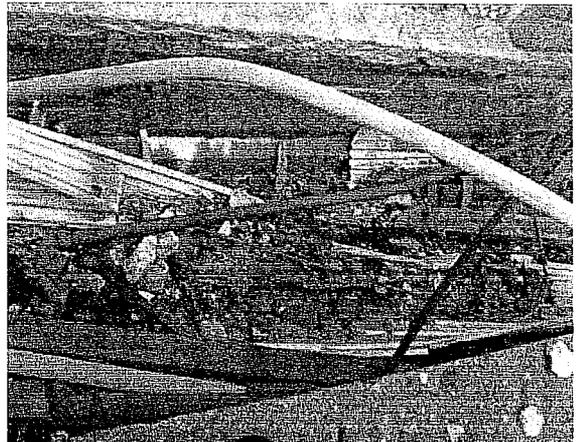


Photo #8:	ASBESTOS CONTAINING ROOFING MATERIALS IN DEBRIS FIELD
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Photo #9:	OVERGROWTH IN DEBRIS FIELD-NORTH FACADE
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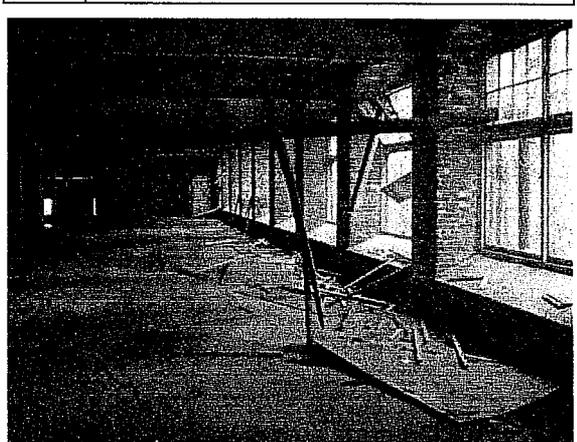
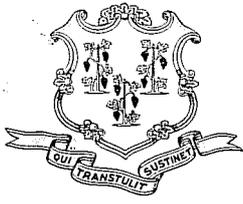


Photo #10:	FIRST FLOOR INTERIOR
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STATE OF CONNECTICUT

DEPARTMENT OF PUBLIC HEALTH

July 29, 2008

RECEIVED

JUL 31 2008

EAGLE ENVIRONMENTAL, INC.

Mr. Raymond Folino
Eagle Environmental, Inc.
531 North Main Street
Bristol, CT 06010

Re: Application for Approval of Alternative Work Practice 27 Bushnell Road, Baltic (Sprague), CT

Dear Mr. Folino:

This letter is in response to an application from you, received July 16, 2008, as revised July 28, 2008, requesting approval of an alternative work practice for the abatement of asbestos-containing window glazing compound and roofing felt at the referenced facility. The second through fourth floors of the facility have collapsed. The intent of the asbestos abatement at this facility is to remove the window sashes (including window glazing compound) from the building and also perform a decontamination of the grounds around the exterior perimeter of the facility. The estimated count of the window sashes is detailed in a table within the correspondence submitted with the application.

Based upon the information provided in the application describing the proposed alternative work practice to be used on this project, and a July 24, 2008, site inspection by the writer and Mr. William Stapleton, Jr., approval is granted by the Department of Public Health (DPH). This approval is based upon the understanding that the application requests a variance from the requirements of Subsections 19a-332a-5(b), (c), (d), (e), and (h), and Section 12 of the Standards for Asbestos Abatement regulation. This approval is granted with the following conditions:

1. A licensed Asbestos Abatement Contractor shall be retained to perform the asbestos abatement. The contractor must conform to the requirements of 40 CFR, Part 61, Subpart M, the asbestos National Emission Standards for Hazardous Air Pollutants (NESHAP), and all requirements of the Regulations of Connecticut State Agencies not specifically exempt from by this approval.
2. A licensed Project Monitor shall monitor all activities involving asbestos abatement on a full-time basis. The Project Monitor shall collect air samples at the down wind boundary of the regulated area on a daily basis to document airborne fiber concentrations. *The DPH shall be notified within twenty-four hours, if at any time during this abatement project, the fiber concentration exceeds 0.010 fibers per cubic centimeter.*
3. A worker decontamination system shall be established at the site, in accordance with the provisions of Section 19a-332a-6. All wastewater associated with the worker decontamination system shall be filtered in accordance with the provisions of Subsection 19a-332a-5(i).

In lieu of the requirements of Subsection 19a-332a-5(b), (c), (d), (e), and (h), and Section 12, a regulated area, as defined by barrier tape and appropriate signage, will be established around the facility prior to commencement of asbestos abatement work. A double layer of 6-mil polyethylene sheeting shall be placed on the ground beneath the window sash removal areas to serve as a drop cloth. All asbestos-containing materials shall be adequately wetted prior to their disturbance. All non-discrete waste that cannot be identified as asbestos-free shall be disposed of as asbestos-containing waste. All asbestos waste shall be placed into leak tight containers. After the waste is removed from the work area, the Project Monitor shall inspect the work area to ensure that no visible debris is present. Any suspect debris located in the work area shall be collected, double-bagged and disposed of as asbestos waste.

Phone: (860) 509-7367 Fax: (860) 509-7378

Telephone Device for the Deaf: (860) 509-7191

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Mr. Raymond Folino
July 29, 2008 – Page 2 of 2

It is the understanding of the DPH that the Southeast stairwell shall be cleaned (to the first landing) utilizing HEPA vacuums. The waste material shall be disposed of as mixed asbestos and lead hazardous waste. Warning signs shall be posted on the entry doors of each floor.

Except as noted in this letter, all other work practices specified in the Standards for Asbestos Abatement regulation are mandatory. This approval is specific for the removal of asbestos-containing materials at the site identified in this application. This approval does not relieve the contractor or the facility owner from satisfying the requirements of any other, federal, state or municipal regulation.

Please contact this office should you wish to discuss this matter further.

Sincerely,



Jimmy Davila
Environmental Sanitarian 2
Asbestos Program
Environmental Health Section

Appendix C

Sampling Procedures for Airborne Fibers

SAMPLING PROCEDURES FOR AIRBORNE FIBERS

1.0 PURPOSE

Establish a standardized methodology for sampling an atmosphere for airborne fibers using air vacuum sampling pump and a filter membrane technique for appropriate sampling periods in representative sampling areas.

2.0 APPLICABLE DOCUMENTS

2.1 EPA 560/5-85-024, "Guidance for Controlling Asbestos-Containing Materials in Buildings".

EPA 600/4-85-049, "Measuring Airborne Asbestos Following an Abatement Action".

2.2 NIOSH Method P&CAM 239, "Asbestos Fibers in Air".

NIOSH Method 7400.

2.3 OSHA Standard 29 CFR 1926.58, "Asbestos Standard for the Construction Industry".

3.0 TERMINOLOGY

3.1 Definitions of descriptive terms used in this test method are as follows:

airborne - refers to material which can become and remain suspended in the air for more than a transient period of time.

aggressive sampling - a method of environmental sampling for airborne fibers in an attempt to determine worst case conditions for potential exposure to airborne fibers. This procedure is recommended for controlled conditions only, that is, conditions under which the dust clouds generated by this procedure will not be inhaled by unprotected workers or bystanders. Such a condition exists inside the sealed environment of the post-asbestos-abatement work area during final air clearance testing.

area (environmental) sampling - an air sample collected from a stationary point representing an area's atmosphere, such as a room.

ambient air - the surrounding air or atmosphere in a given area under normal conditions.

aspect ratio - the length of a fiber versus its width.

asbestos - a generic name given to a number of naturally occurring hydrated mineral silicates that possess a unique crystalline structure, are incombustible in air, and are separable into fibers. Asbestos includes the asbestiform varieties of chrysotile (serpentine), crocidolite (riebeckite), amosite (cummingtonite-grunerite), anthophyllite, and actinolite.

bubble meter - method of primary calibration using a graduate cylinder and visible soap bubble to determine pump flow rates. The bubble rise in the cylinder is timed and represents the rate of displacement of air with time.

bulk sampling - collection and analysis of materials which may contain asbestos. Can also be an analysis of collected dust for presence of asbestos.

calibration - method of checking, adjusting, and systematically standardizing the graduations of a quantitative measuring instrument, such as the flow rate of an air sampling pump with a flowmeter.

ceiling concentration - the maximum allowable level of toxic material that can be present at any given point in time. With asbestos work it is usually a fifteen minute sample taken inside containment during removal.

cowl - an electrostatically conductive plastic 55 mm tube which is used in place of the retaining ring in the three-piece filter cassette.

fiber - an elongated, filamentous particle having an aspect ratio 3:1 and 5 micrometer or greater in length (as defined by NIOSH).

field monitoring (aerosol monitoring) cassette (filter holder) - a three-piece plastic cylindrical device designed to contain a filter membrane and its cellulose support pad. The filter and pad are held in place in a recessed position in the cassette base plate by a pressure-fitted retaining ring. The cassette cover inserts into the upper portion of the retaining ring when the cassette is not in use. Small colored caps seal inlet and outlet ports in the cover section and base plate, respectively, when the cassette is not in use.

filter membrane - a device used to strain particles and fibers out of a passing air current, consisting of a sheath of thin, polymeric (polycarbonate or mixed cellulose ester) material backed by a cellulose support pad and held rigidly in place within a plastic holder (cassette). Standard filter diameters are 25 mm and 37 mm; pore size is usually 0.8 micrometers, except for the 0.4 micrometer pore size of the polycarbonate filters preferred for TEM analyses.

LUHR fitting - specialized adapter to mount an air sampling cassette onto a sampling pump's flexible tubing.

personal sample - an air sample collected in the breathing zone of a worker representing the worker's exposure during a typical work period.

sampling - the collecting of a representative portion of material which in content, quality, and character is typical of the whole of the rest of the material present.

sampling pump - a mechanical device for drawing air through an orifice at a preset or measurable rate for a predetermined or variable amount of time in a relatively consistent manner.

4.0 SUMMARY OF THE METHOD

- 4.1 Each sample is collected by drawing air, by means of an attached sampling pump, at a determined rate over a known length of time, through a standard membrane filter in an open-faced cassette, positioned in an obliquely downward direction so as to minimize the unintentioned accumulation of extraneous material.
- 4.2 Enough samples of sufficient volume are collected within each specific area and under such induced conditions as to insure the statistical validity of the subsequent microscopic analysis of the filters.

5.0 SIGNIFICANCE

- 5.1 This test method has wide applicability wherever the particulate or fiber concentration in an atmosphere is to be evaluated, but relates especially to the asbestos industry, where air sampling plays a pivotal role before, during, and after an asbestos abatement project:
 - Air sampling constitutes an important part in an Operations and Maintenance Program, to document either that asbestos-containing materials which are well enclosed in a containing matrix in good condition are not releasing asbestos fibers to the atmosphere, or that an area has an airborne asbestos fiber contamination requiring abatement.
 - Air sampling conducted outside a building provides a background airborne fiber assessment for those samples collected indoors.

- Within a building, while an asbestos abatement project is in progress, a comparison of the air outside an isolated work area is an effective tool to measure the adequacy of the containment barriers and to monitor the work practices and control techniques being used inside the work area to limit the release of asbestos fibers from the materials being abated.
- After an asbestos abatement project has been completed and a final visual inspection of the isolated work area has discovered neither unabated asbestos-containing materials nor debris, aggressive air sampling for area clearance purposes is conducted to document that the airborne fiber concentration inside the work area meets release criteria.

5.2 This method may involve hazardous materials, operations, and equipment. This standard does not purport to address all of the safety problems associated with its use. It is the responsibility of the user to consult and establish appropriate safety and health practice and to determine the applicability of regulatory limitations prior to use.

6.0 INTERFERENCES

6.1 Prime among interferences for outdoor air sampling are adverse weather conditions. High winds will generally increase airborne fiber amounts to abnormally high levels, and heavy rains will saturate the filter cassettes, even if positioned in an oblique deflection, to the point where the filter will no longer accumulate more material, and those particles already collected will be washed away.

6.2 Interferences inside buildings arise from conditions which overload the filters with irrelevant or excessive levels of material, either because aggressive sampling is being done in controlled area to evaluate a potential hazard or because work being done inside an isolated work area is not being performed with the proper control techniques for limiting the generation of airborne dust and debris.

7.0 APPARATUS

7.1 Sampling Train - a sampling pump connected by rubber or flexible plastic tubing to an LUHR fitting inserted in the base of a 25 mm or 37 mm filter cassette.

7.2 Filter Membrane - for PCM analyses: mixed cellulose ester, 0.8 micrometer pore size; for TEM analyses: polycarbonate, 0.4 micrometer pore size preferred; for personal samples: 25 mm filter cassettes; for area samples: 25 or 37 mm filter cassettes.

8.0 PROCEDURE

- 8.1 Calibrate the sampling pump together with the sampling train as it is to be used in the field, before and after each use. The Rotameter Calibration Form is to be used for entering information and documenting calibration.

Use a primary standard, such as the soap bubble burette flow meter for calibration: a 1-liter burette for pumps with air flow rates up to 4 liters per minute; a 3-liter burette for pumps with air flow rates up to 12 liters per minute.

Perform consecutive calibrating runs until three successive trials agree within 5% precision; average these data points to obtain the flow rate used in subsequent calculations.

- 8.1.1 Attach flexible plastic tubing, of the same inner diameter in the sampling train, from the bubble burette to the inlet port of the closed-face filter cassette in the sampling train, as shown in Figure 1.
- 8.1.2 Turn on the sampling pump and allow the system to come to operational equilibrium, over a period of about three minutes and check for leaks in the sampling train.
- 8.1.3 Touch a reservoir of soap solution to the base of the burette; repeat this action until the bubble of soap film is drawn up the length of the graduated burette at a steady rate without bursting. Obtain a suitable soap bubble solution from any toy store.
- 8.1.4 Determine that the pressure drop across the filter, as measured by an in-line water manometer, does not exceed 13 inches of water.
- 8.1.5 Calculate the calibrated flow rate of the sampling train by dividing the time required for a soap bubble to travel through a known volume of the burette, in liters, by the elapsed travel time, in minutes.
- 8.1.6 Correct the flow rate for temperature and elevation variations if the field sampling conditions are significantly different from the laboratory conditions.
- 8.1.7 Note the reading on the pump's rotameter (to be used during sampling).
- 8.2 Personal Sampling - collect personal samples on worker engaged in activities suspected of generating excessive airborne concentrations of hazardous substances.

- 8.2.1 Label the filter cassette with a unique sample number, the date of sample collection, the pump identification number, the sampling start time (and the sampling stop time, at the conclusion of the sampling), the sampling pump flow rate, the worker's name, and the activity in progress.
- 8.2.2 Enter this data as well on a field data sheet which accompanies the sample(s) throughout the sampling collection period and subsequently throughout the analytical processing (chain of custody form).
- 8.2.3 Attach the battery-powered sampling pump to a belt at the worker's waist; extend the tubing to the downward deflected filter cassette clipped to the worker's clothing in the breathing zone.
- 8.2.4 Detach the cassette cover entirely from the retaining ring or cowl before starting the sampling pump.
- 8.2.5 Collect personal samples at the rate of 2.5 liters per minute; average the air fiber counts from two or more personal samples collected throughout a single work shift in one area and normalize the result to an eight-hour time base to generate a Time-Weighted Average (TWA) airborne fiber reading.
- 8.2.6 Check sampling pumps periodically (usually every 30 minutes) for proper operation and rotameter readings, referencing the reading obtained during calibration. A variation of $\pm 10\%$ or greater indicates a sampling train problem such as a break or overladen filter.
- 8.2.7 Collect the personal sample for as long a time as possible during the period of potential exposure to the airborne hazard, unless or until the filters become overladen, but for at least a period of time (usually 6-8 hours) sufficient to generate a minimal fiber density on the filter to provide satisfactory analytical precision:
- For PCM, the NIOSH Method P&CAM 239 requires a fiber density of 1 to 5 fibers per microscope field, or a minimum of 10 fibers detected in 100 fields, to insure an acceptable count precision.
 - For the NIOSH Method 7400, 5 fibers per 100 microscope fields are the minimum number of fibers to be detected to achieve a statistically valid filter analysis.
- 8.2.8 If filter overloading is a problem due to extraneous airborne material, collect several personal samples sequentially at the same time that a single sample is collected continuously; if the one long-term sample is overladen, the samples of shorter duration may be able to be analyzed successfully.

- 8.2.9 At the conclusion of the sampling period, turn the filter cassette upright, to prevent any accumulated particles from falling off the filter when the vacuum is released, turn off the sampling pump, and replace the cassette cover on the cassette retaining ring or cowl.
- 8.2.10 Record the sampling stop time and pump rotameter reading on the filter cassette label as well as on the sampling field data sheet (chain of custody form).
- 8.3 Area Sampling - Arrange the area sampling strategy to obtain a realistic representation of the airborne fiber and particulate content of the sample collection area. The number and location of the samplers, the volume of air sampled, and the conditions present in the sampling area while the samples are collected determine the statistical validity of the subsequent microscopic analyses.
- 8.3.1 In the process of evaluating an asbestos work area for successful abatement and acceptable air quality, once the abatement work itself has been completed, the more samples collected in the work area and the larger the air volume sampled, under aggressive sampling conditions, the greater the confidence level that a true picture of the area's airborne fiber concentration has been realized and the more rigorous the release criterion for the area sampled can be.
- 8.3.2 Collect area samples either with a personal sampling pump, at rates up to 4 liters per minute, or with an externally powered, high-volume pump, at rates up to 12 liters per minute. Regardless of whether the sample analyses ultimately are to be done by PCM or TEM, sample at least 3,000 liters of air with each sampler.

Deflect the filter cassette on each sampler obliquely downward, and place at nose level, where possible. Arrange at least five simultaneous sampling stations in each homogeneous work area, or one sampler per contiguous room, whichever number of area samplers is greater. Locate the samplers equidistant from one another and as far as possible from obstacles, building components, or other equipment.

- A greater volume of air sampled provides an accordingly lowered limit of reliable quantification for a PCM analysis and thereby allows for correspondingly lower airborne fiber readings to be required as a work area's release criterion.

- The single highest airborne fiber reading obtained by PCM analysis of clearance samples in a homogeneous area must be lower than the statistical limit of reliable quantification for the sample volume collected, in order for the area to pass the clearance criterion.
- Just as for the PCM analysis of personal samples, area sampling data validity is assumed only if at least 10 fibers can be detected in 100 fields on the microscope for the 37 mm filter cassettes (NIOSH Method P&CAM 239), or 5 fibers can be detected in 100 fields on the microscope for the 25 mm filter cassettes (NIOSH Method 7400).
- TEM area release criteria are based on the average reading of fiber counts from at least five area samplers inside a contiguous or homogeneous work area being lower than the average airborne fiber count from a comparable set of samples collected outside the building.

8.3.3 Locate the area samplers so that they draw air as freely as possible from all sides of the sampling stations.

- To create an atmosphere in a closed area as homogeneous as possible, insuring a representative sampling of the air, conduct the area sampling under aggressive conditions.
- Apply a turbulent air stream, with an electrically-powered leaf blower, to all surfaces in the sampling area, to induce fibers and particulate material to become airborne.
- Continue to agitate the area's atmosphere, to present a thoroughly mixed air content to the samplers throughout the duration of the air sampling, by locating 20-inch oscillating electric fans on 6-foot pedestals in the work area and directing their flow at the ceiling.
- Use the leaf blower to disturb the work area's exposed surfaces at the rate of at least 5 minutes per 1000 square feet of floor area.
- Position the oscillating fans equidistant from one another and area walls, and use them at the rate of one fan for every 10,000 cubic feet of area space.
- Conduct aggressive air sampling only in well isolated areas, to contain any airborne hazard so generated and avoid exposure of any unprotected bystanders.

Appendix D

Chain of Custody/Data Form



EAGLE ENVIRONMENTAL, INC.

Phase Contrast Microscopy Area Air Sampling Data Sheet

Project Name: _____ **Eagle Project No:** _____

Project Location: _____ **Sampling Date:** _____

Work Area Designation: _____ **Project Monitor Name:** _____

Microscope # _____ **Project Monitor License #:** _____

Sample #	Sample Location	Project Activity	Sample Time (Minutes)			Flow Rate (Liters/Minutes)		Average Flow Rate (Liters/Minute)	Total Volume (Liters)	Fiber Count (fib/field)	Concentration (Fibers/cc)
			On	Off	Min	Pre	Post				
	Duplicate Count										

Chain of Custody and Sample Receiving Log

Samples Analyzed By: _____ **Date:** _____ **Time:** _____ **AAR#** _____

Samples Collected By: _____ **Date:** _____ **Time:** _____

Samples Relinquished By: _____ **Date:** _____ **Time:** _____

Samples Received By: _____ **Date:** _____ **Time:** _____

Results Review By: _____ **Date:** _____ **Time:** _____