NOTE: The numbering of the *Workers Compensation Act* has changed, effective April 6, 2020. See worksafebc.com/wca2019.

Safe Work Practices for Asbestos Laboratories

WorkSafeBC

About WorkSafeBC

At WorkSafeBC, we're dedicated to promoting safe and healthy workplaces across B.C. We partner with workers and employers to save lives and prevent injury, disease, and disability. When work-related injuries or diseases occur, we provide compensation and support injured workers in their recovery, rehabilitation, and safe return to work. We also provide no-fault insurance and work diligently to sustain our workers' compensation system for today and future generations. We're honoured to serve the workers and employers in our province.

Prevention Information Line

We provide information and assistance with health and safety issues in the workplace.

Call the information line 24 hours a day, 7 days a week to report unsafe working conditions, a serious incident, or a major chemical release. Your call can be made anonymously. We can provide assistance in almost any language.

If you have questions about workplace health and safety or the Occupational Health and Safety Regulation, call during our office hours (8:05 a.m. to 4:30 p.m.) to speak to a WorkSafeBC officer.

If you're in the Lower Mainland, call 604.276.3100. Elsewhere in Canada, call toll-free at 1.888.621.7233 (621.SAFE).

Safe Work Practices for Asbestos Laboratories

WorkSafeBC

Health and safety resources

All employers — no matter how big or small — are responsible for the health and safety of their workers. To help support your health and safety needs, a wide range of information and resources is available on worksafebc.com.

Many of our resources are available to order in hard copy from the WorkSafeBC Store at worksafebcstore.com. If you have any questions about placing an order online, please contact a customer service representative at 604.232.9704, or toll-free at 1.866.319.9704.

Copyright

ISBN 978-0-7726-6009-1

Contents

Introduction

Asbestos is a group of naturally occurring minerals used in many products because it adds strength, heat resistance, and chemical resistance. Asbestos is a hazardous material. If employers and workers don't take proper precautions for work around asbestos, workers may develop serious chronic health problems or even die of an asbestos-related disease. To prevent these health problems, WorkSafeBC has developed requirements detailed in the Occupational Health and Safety Regulation.

Who should read this manual?

This manual is intended for asbestos laboratories and laboratory analysts, including field analysts, who examine the following for the presence of asbestos:

- Building products
- Other materials (brake pads, clutch pads, furniture, etc.)
- Air samples

This manual is based primarily on Parts 5, 6, and 30 of the Regulation and is meant to give you a basic understanding of your health and safety requirements. For more information on your legal responsibilities for workplace health and safety and the ways that you can reduce the risk of workplace injury, illness, and disease, please also refer directly to the Regulation. You can find a searchable version of the Regulation and its accompanying OHS Guidelines at worksafebc.com/law-policy.

This manual addresses asbestos laboratory analytical methods that use polarized light and phase contrast microscopy. It doesn't address transmission electron microscopy or other methodologies used to identify asbestos.

The importance of the asbestos analysis laboratory

The asbestos analysis laboratory provides information on the type and percentage of asbestos (and other materials) present in bulk samples submitted for analysis. This is one of the most critical components of developing an inventory of asbestos-containing

materials and is an integral part of a risk assessment. Any misidentification or failure to detect asbestos could put workers at risk of exposure to asbestos or result in the unnecessary removal of non-asbestos materials.

Air samples may be collected during the removal of asbestos-containing materials for the purposes of monitoring worker exposure and final air clearance. If these samples aren't analyzed properly, potential worker exposures may be missed, or workers may continue to work in an environment for which they're not adequately protected.

ALARA

The ALARA principle governs worker exposure to asbestos — all exposures must be kept **a**s **l**ow **a**s **r**easonably **a**chievable. Although the Regulation specifies exposure limits and action levels, every employer must further reduce or eliminate worker exposure *if it can reasonably be done.* Improvements in technology, as well as new work practices and procedures, will help employers decrease worker exposures and move closer to the ultimate goal of zero exposure to asbestos.

Wording in this manual

In this manual, the word *must* means a requirement specified in the Regulation. The word *should* indicates that a particular action, although not specified in the Regulation, will improve safety in the workplace. Please note that the word *worker* includes supervisors, managers, laboratory analysts, and other workers.

Related manuals

A number of related manuals on safe practices are available, such as *Breathe Safer: How to Use Respirators Safely and Start a Respirator Program* and *Safe Work Practices for Handling Asbestos*. These manuals are available at worksafebc.com. For hard copies, visit worksafebcstore.com or call toll-free 1.866.319.9704.

General health and safety requirements for labs

Working in a laboratory usually involves working with various chemical, physical, and biological hazards. Because the hazards vary from lab to lab, employers must address the hazards specific to their workplaces by developing and implementing the following:

- Written safe work and emergency procedures
- Education and training programs for workers
- Workplace inspections (regular and special inspections of workplace equipment, methods, and practices)
- Investigation of workplace incidents (incident investigations and reports)
- First aid equipment and procedures
- Periodic management meetings to review health and safety activities
- Regular staff safety meetings or a joint health and safety committee where required
- Records and statistics

Safe work and emergency procedures

Employers must prepare written safe work and emergency procedures for hazardous operations in laboratories. Such procedures might include:

- Methods for working with hazardous chemicals (e.g., using dispersion staining liquids, solvents, or acids during asbestos analysis)
- Emergency measures for dealing with asbestos or chemical spills
- Methods required to minimize or eliminate a risk from physical hazards (e.g., musculoskeletal injuries resulting from long hours using the microscope)

Worker education and training

Employers must provide workers with the following:

- Adequate education in the hazards of the workplace
- Training and instruction on how to do their work safely

Defining laboratories

Part 30 of the Regulation lists general and substance-specific requirements that apply to laboratories, which are defined as "rooms, buildings or areas in buildings equipped with apparatus, equipment, chemicals or test animals and used for research, quality control, performance of tests, experiments or measurements, photographic development, or the preparation of drugs or other products in the natural sciences."

The written safe work procedures should be used as a primary source of information. Many laboratory workers may have advanced formal education, but they still need site-specific training on work methods involving particular hazards such as asbestos. The training must include proper handling and disposal of hazardous materials.

Supervisors are responsible for the adequate training and instruction of all workers under their direction and control. A supervisor is anyone who instructs, directs, and controls workers in the performance of their duties, even if this person doesn't hold the title of supervisor. An experienced laboratory worker who is training another worker is acting as a supervisor within the Regulation definition.

Workplace inspections

The purpose of a workplace inspection is to look for unsafe work conditions, practices, and procedures. Regular inspections of the entire workplace will help ensure that these issues don't develop over time.

Such inspections should be conducted by the joint health and safety committee or, if there is no committee, by at least one employer representative and one worker representative. Special inspections must be carried out after an incident or an equipment malfunction.

Checklists may help identify common safety concerns and ensure that these concerns are checked consistently. For example, a checklist might include sections on chemical labelling, housekeeping, and storage practices.

A workplace inspection may also include the following activities:

- Monitoring air velocity in fume hoods
- Annual testing and certification of fire extinguishers
- Inspecting laboratory equipment as recommended by manufacturers, or as required by the analytical methods used

All unsafe or harmful conditions must be corrected without undue delay. In an emergency, only workers trained and qualified to take corrective action may be exposed to the hazard. Every possible effort must be made to control the hazard while such corrective action is being taken.

Workers must not wait for the regular inspection to identify a workplace hazard. If they become aware of a health and safety problem at their workplace, they're required to report it to their

Resources

See Appendix A for a checklist that outlines the regulatory requirements for asbestos laboratories.

supervisor or employer. The person receiving the report must investigate the problem and ensure that any required corrective action is taken without delay. If the problem can't be solved in-house, contact a WorkSafeBC officer by calling the Prevention Information Line at 1.888.621.7233. Procedures for reporting unsafe conditions and for refusing to perform unsafe work are also described in detail in Part 3 of the Regulation.

Incident investigations

If a workplace incident results in an injury, or could have caused a serious injury, both employers and WorkSafeBC have certain responsibilities. Incident investigations help identify the cause and hazards, while finding ways to prevent similar incidents from happening in the future.

Two different investigations may take place after an incident occurs: one that the employer conducts and one that WorkSafeBC conducts.

Employer investigations

- Employers are responsible for conducting investigations related to incidents that happen in their workplaces and submitting employer incident investigation reports (EIIRs) to WorkSafeBC.
- Depending on the incident and how serious it is, employers may also need to immediately report the incident to WorkSafeBC.
- Employers are responsible for completing reports to represent the four stages of an investigation: preliminary investigation, interim corrective actions, full investigation, and full corrective actions.

For more information, visit the "Conducting an employer investigation" page on worksafebc.com.

WorkSafeBC investigations

- Following an incident or near miss (an incident that almost happened), a WorkSafeBC investigation may be conducted to identify the cause and explore other related factors.
- The investigation process is also used to determine if enforcement action, such as imposing an administrative penalty or proceeding to prosecution, is appropriate.
- Findings from WorkSafeBC investigation reports are posted online. These are intended to help employers and workers understand the factors that contribute to workplace incidents so similar incidents can be prevented in the future.

First aid equipment and services

Laboratory employers must provide equipment, supplies, facilities, first aid attendants, and services that are adequate and appropriate for the following:

- Promptly rendering first aid to workers if they suffer an injury at work
- Transporting injured workers to a place of medical treatment

The employer must conduct an assessment of the workplace to determine what first aid services are needed. Asbestos laboratories can generally be classified as having a low hazard rating. Table 1 summarizes the recommended minimum levels of first aid for laboratories that are within 20 minutes surface travel time to a hospital. See Part 3 of the Regulation and the associated guidelines for details.

Table 1: Minimum first aid requirements for a low-risk workplace, 20 minutes or less surface travel time to a hospital

Number of workers per shift	Supplies, equipment, and facility	First aid certificate required for attendant
1		
2–10	• Basic first aid kit	
11–50	• Level 1 first aid kit	Level 1 certificate
51–100	• Level 2 first aid kit • Dressing station	Level 2 certificate
101 or more	• Level 2 first aid kit • First aid room	Level 2 certificate

Joint health and safety committee

A joint health and safety committee is required for laboratories with 20 or more workers. The committee must have at least four regular members, representing both the workers and the employer. Their duties are specified in Part 3, Division 4 of the *Workers Compensation Act*.

For labs with more than 9 but fewer than 20 workers, a worker health and safety representative is required. The representative has the same duties and functions as a joint committee.

For more information, visit the "Joint health & safety committees" page on worksafebc.com.

General records

Laboratories must maintain adequate records and statistics, including first aid records, reports of inspections, and incident investigations. This information must be available to the joint health and safety committee, to a WorkSafeBC officer, and to the laboratory workers themselves.

Asbestos analysis

Standard operating procedures manual

All laboratories should have a standard operating procedures (SOP) manual that describes how the laboratory operates, analyzes samples, and reports results. Many of the elements within this manual are mandated by both the U.S. National Institute for Occupational Safety and Health (NIOSH) and Environmental Protection Agency (EPA) analytical methods. These elements may also be required by any accreditation programs that the laboratory belongs to.

The SOP manual typically includes the following elements:

- **Laboratory characterization** — information about the type of laboratory and the services it provides.
- **Laboratory staff** — staff biographies, qualifications, and training and performance (quality control) records.
- **Standard operating procedures** — how the laboratory tracks and analyzes samples, reports results, maintains equipment, and disposes of waste. Examples include:
  - **Chain-of-custody and log-in procedures** — how samples are tracked from the time they're submitted to the lab until the analysis is complete. (See Appendix B for a sample chain-of-custody/log-in form.)
  - **Criteria for acceptance or rejection of samples for testing** — to determine if the sample size is adequate and the appropriate material has been collected (e.g., drywall mud rather than gypsum board — see Table 2).
  - **Sample analysis procedures**, including:
    - **Sampling methods** — air and bulk sampling analysis methods used by the laboratory.
    - **Equipment** — microscopes, fume hoods, and accessory equipment used to analyze air and bulk samples.
    - **Analytical procedures** — procedures used to identify asbestos or count asbestos fibres. These should include any deviations from the standard methods, along with a rationale for those changes. Procedures for preparing and analyzing difficult samples (e.g., floor tiles and mastics) should also be described.

- **Calibration procedures for laboratory equipment**, including:
  - **Microscopes** — how microscopes are set up and calibrated to ensure they are operating properly. This would include the removal and repair of defective microscopes.
  - **HEPA (high-efficiency particulate air) filter units and vacuums** — inspection and regular (annual) DOP/PAO testing to ensure the filters are working properly.
  - **Refractive index (RI) liquids** — testing of RI liquids to ensure they're not contaminated.
  - **Phase contrast test slide** — used to test the resolution of phase contrast microscopes.
- **Reporting of results:**
  - **Data sheets for individual bulk samples.** (See Appendix B for a sample data sheet.)
  - **Data sheets for air sampling results.** (See Appendix B for a sample spreadsheet.)
  - **Laboratory reports** — instructions for reporting the results of the analysis and sending documentation to clients.
  - **Disclaimers** — used to describe samples that aren't collected properly (e.g., the size of the sample is too small).
  - **Complaints from clients** — instruction on how to handle client complaints regarding analytical results.
- **Storage of samples** — how and where samples will be stored, and how long they will be kept in storage.
- **Waste disposal procedures** — how asbestos waste is handled, stored, and disposed of.
- **Safe work procedures for analysts** — including spill cleanup, waste disposal, and changing HEPA filters on fume hoods and vacuum cleaners.

- **Quality control program** — procedures used to ensure that laboratory equipment is operating and calibrated properly, analysts are trained and monitored, and the analytical results are reliable. A quality control program is a requirement of asbestos air and bulk sample analysis methods used in B.C. For more information on the elements required for a quality control program, see page 21.

Bulk sample analysis

The following methods are currently mandated for the purposes of bulk asbestos analyses by polarized light microscopy:

- NIOSH Method 9002, Asbestos (bulk) by PLM (Issue 2, dated August 15, 1994)
- NIOSH Method 9000, Asbestos, Chrysotile by XRD (Issue 2, dated August 15, 1994)
- EPA Test Method for the Determination of Asbestos in Bulk Building Materials (EPA/600/R-93/116, July 1993)
- EPA Research Method for Sampling and Analysis of Fibrous Amphibole in Vermiculite Attic Insulation (EPA/600/R-04/004, January 2004)

These methods describe the techniques used for the qualitative identification of asbestos and the semi-quantitative determination of asbestos in bulk samples. Each method includes sections outlining the following:

- The accuracy of the method (e.g., range, precision, limit of detection)
- Interferences (e.g., other fibres that look like asbestos)
- The equipment required (e.g., microscopes, slides, tools)
- Reagents (e.g., dispersion staining liquids)
- Ventilation (fume) hood requirements
- Sample preparation
- Calibration and quality control (mandatory provisions for intra-laboratory quality control systems, and recommendations for inter-laboratory quality control programs)
- Reporting of results (e.g., consideration of layers of materials, and estimation of asbestos percentages)

Copies of the analytical methods used in the laboratory must be available on site for reference.

Defining asbestos-containing material

Section 6.1 of the Regulation defines *asbestos-containing material* as follows:

(a) a manufactured article or other material, other than vermiculite insulation, that would be determined to contain at least 0.5% asbestos if tested in accordance with one of the following methods:

(i) Asbestos, Chrysotile by XRD, Method 9000 (Issue 2, dated August 15, 1994) in the NIOSH Manual of Analytical Methods, published by the United States National Institute for Occupational Safety and Health, Centre for Disease Control;

(ii) Asbestos (bulk) by PLM, Method 9002 (Issue 2, dated August 15, 1994) in the NIOSH Manual of Analytical Methods, published by the United States National Institute for Occupational Safety and Health, Centre for Disease Control;

(iii) Test Method for the Determination of Asbestos in Bulk Building Materials (EPA/600/R-93/116, dated July 1993) published by the United States Environmental Protection Agency;

(b) vermiculite insulation that would be determined to contain any asbestos if tested in accordance with the Research Method for Sampling and Analysis of Fibrous Amphibole in Vermiculite Attic Insulation (EPA/600/R-04/004, dated January 2004) published by the United States Environmental Protection Agency

Collecting bulk samples of materials suspected of containing asbestos

To confirm or discount the presence of asbestos, representative bulk samples must be collected by a qualified person. Multi-layered materials (such as multiple layers of old tile and linoleum flooring, or multiple layers in wall or ceiling materials) are commonly encountered. A sample should be collected from each suspect layer. The surveyor should identify each sample's location in the building with a unique sample number.

The sampling technique and the quantity of material sampled are two other important factors to consider. Sufficient quantities of material must be collected. Check the laboratory method for required sample quantities. For materials like vermiculite, ensure that the full depth of the material down to the bottom is sampled, and that the quantity collected meets the requirements of the analytical method that will be used. (For example, about 4 L [1 gal.] of vermiculite insulation is required for the EPA/600/R-04/004 method.)

Sample collection methods must minimize disturbance of the materials as well as minimize exposure to asbestos for the persons collecting the bulk samples. Use of protective clothing and a

properly fitted, approved respirator are required. Persons collecting the samples must have a written sample collection procedure as part of their asbestos exposure control plan. A respirator program is also required.

The number of representative bulk samples collected should be consistent with recognized industry standards and principles of good occupational hygiene practice. The following table provides guidance on the minimum number of bulk samples and the quantity of material that should be collected to identify asbestos-containing materials that might be present in a building.

Table 2: Bulk material sample collection guide

Type of material	Area of homogeneous material	Minimum number of bulk samples to be collected	Minimum recommended quantity per sample
Surfacing materials, including textured coatings, drywall mud, plasters, and stucco	Less than 90 m^2 (approx. 1,000 sq. ft.)	At least 3 samples of each type of surfacing material	50 cm^3 (3 cu. in.); for drywall mud, sample the mud only — don't include the drywall or tape (unless suspected as containing asbestos)
	Between 90 and 450 m^2 (approx. 5,000 sq. ft.)	At least 5 samples of each type of surfacing material	
	Greater than 450 m^2	At least 7 samples of each type of surfacing material	
Sprayed insulation and blown-in insulation, including sprayed fireproofing	Less than 90 m^2 (approx. 1,000 sq. ft.)	At least 3 samples	50 cm^3 (3 cu. in.)
	Between 90 and 450 m^2 (approx. 5,000 sq. ft.)	At least 5 samples	
	Greater than 450 m^2	At least 7 samples	
Loose vermiculite insulation (including vermiculite insulation within concrete masonry units or CMUs)	Less than 90 m^2 (approx. 1,000 sq. ft.)	At least 3 samples	4 L (1 gal.); collect from the top to the bottom of the application to get a representative sample
	Between 90 and 450 m^2 (approx. 5,000 sq. ft.)	At least 5 samples	
	Greater than 450 m^2	At least 7 samples	
Ceiling tiles	Less than 90 m^2 (approx. 1,000 sq. ft.)	At least 3 samples	5 cm × 5 cm (2 in. × 2 in.)
	Between 90 and 450 m^2 (approx. 5,000 sq. ft.)	At least 5 samples	
	Greater than 450 m^2	At least 7 samples	

Type of material	Area of homogeneous material	Minimum number of bulk samples to be collected	Minimum recommended quantity per sample
Flooring, including vinyl sheet flooring (and backing) and floor tiles	Any size	At least 1 sample per flooring type in each room (and 1 from each layer of flooring)	5 cm × 5 cm (2 in. × 2 in.)
Levelling compounds and mortars	Any size	At least 3 samples	50 cm^3 (3 cu. in.)
Asbestos ropes, gaskets, wires, etc.	Any size	At least 1 sample	5 linear cm (2 linear in.) or 5 cm × 5 cm (2 in. × 2 in.)
Mechanical insulation, including duct taping, pipe and elbow insulation, and boiler/tank or vessel insulation	Any size	At least 3 samples	50 cm^3 (3 cu. in.); all layers must be collected down to the pipe, tank, or vessel
Mastics and putties, including duct mastic (around penetrations) and window putty	Any size	At least 3 samples	15 cm^3 (1 cu. in.)
Roofing materials, including felting and shingles	Less than 90 m^2 (approx. 1,000 sq. ft.)	At least 1 sample (each layer of material must be sampled)	5 cm × 5 cm (2 in. × 2 in.); collect all layers, down to the sheathing
	Between 90 and 450 m^2 (approx. 5,000 sq. ft.)	At least 2 samples (each layer of material must be sampled)	
	Greater than 450 m^2	At least 3 samples (each layer of material must be sampled)	
Asbestos cement (transite) board and pipe	Any size	At least 1 sample	5 cm × 5 cm (2 in. × 2 in.)
Other sprayed materials	Any size	At least 1 sample per type of material	1 full, small zip-lock bag
Other non-friable products	Any size	At least 1 sample per type of material	5 cm × 5 cm (2 in. × 2 in.)

For more information on sample collection, refer to the publication *Safe Work Practices for Handling Asbestos* at worksafebc.com.

Equipment for bulk sampling analysis

The following is a list of the equipment and materials recommended for the accepted bulk analytical methods:

- Polarized light compound microscope capable of 100–400× magnification, with a 360-degree rotatable stage
- Compensator plate, ca. 550 nm retardation ("first order red" compensator)
- Eyepiece reticle (crosshair)
- Dispersion staining objective lens
- Stereo microscope capable of 10–45× magnification
- Light source for the stereo microscope
- Refractive index liquids for dispersion staining:
  - High-dispersion (HD) series 1.550, 1.605, and 1.620
  - Standard-dispersion series 1.670, 1.680, and 1.700
- Microscope slides and cover slips
- Tools to manipulate samples (e.g., tweezers, dissecting needles, spatulas, probes, and scalpels)
- Tools to grind non-friable samples (e.g., mortar and pestle)
- Sharps container for used slides or broken glassware
- Fume hood equipped with a HEPA filtration system
- Sealable plastic (zip-lock) bags and wet wipes (talc-free) to clean the interior of the fume hood between samples
- HEPA vacuum for emergency cleanups
- Sealed waste container, labelled for asbestos waste
- Asbestos reference samples
- In-house standard asbestos samples
- Additional equipment for specialized procedures:
  - Point-counting stage
  - Laboratory balance (sensitivity to 0.0001 gram) for conducting gravimetric analysis
  - Drying oven (capable of drying samples at 100°C)
  - Ducted muffle furnace (capable of temperatures of 300–500°C) for ashing samples
  - Ducted fume hood for organic solvents or acids
  - Laboratory glassware (beakers, test tubes, centrifuge tubes, etc.)
  - Filtration apparatus
  - Centrifuge
  - Ultrasonic bath
  - Hydrochloric acid (reagent-grade concentrated)
  - Other reagents (e.g., chemicals used to dissolve vinyl floor tiles)

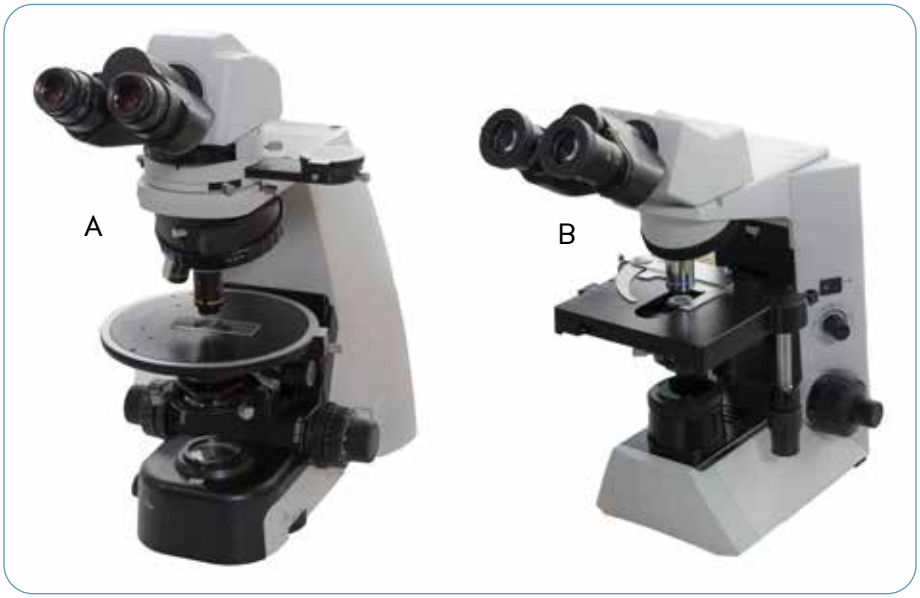

Figure 1: Microscopes used in asbestos analysis. (A) Polarized light microscope (PLM) used in asbestos identification. (B) Phase contrast microscope (PCM) used for asbestos fibre counting.

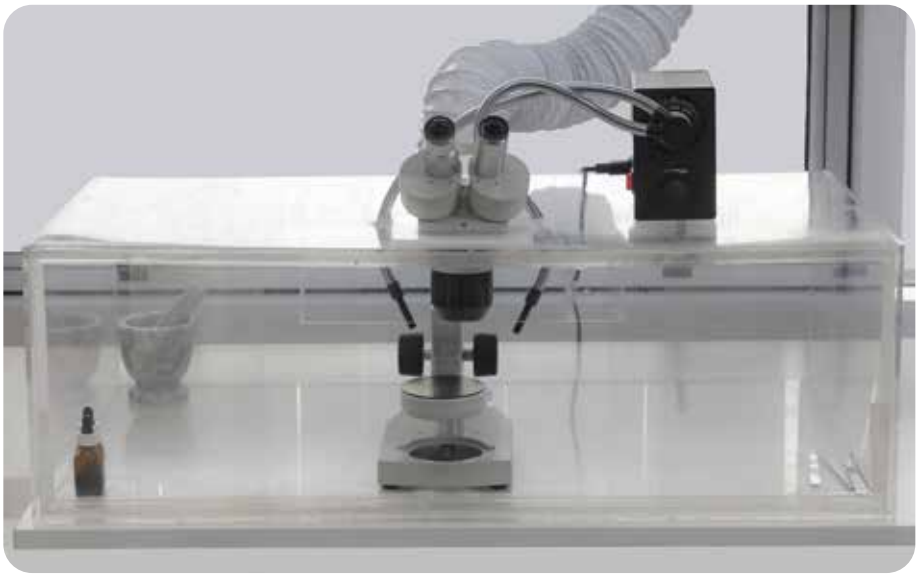

Figure 2: Stereo microscope and fume hood used in asbestos identification.

Analysis and reporting of results

To identify fibrous materials, measure the following properties using polarized light microscopy, and record these properties for each sample:

- Morphology
- Colour and pleochroism
- Indices of refraction (parallel and perpendicular), using dispersion staining or other means

- Birefringence
- Extinction characteristics
- Sign of elongation

Matrix materials (e.g., quartz, calcite, and gypsum) must also be identified, using optical properties where possible.

When reporting the analytical results, the following should be included for each sample:

- Unique lab sample number.
- Location information from the surveyor (field sample number, where the sample was collected, etc.).
- Material sampled (drywall mud, textured coating, floor tile, etc.). Where there is more than one layer, each layer should be listed separately.
- Type of asbestos present and the percentage. Percentages can be estimated using broad ranges (e.g., 10–20%, 30–40%, 50–60%). However, asbestos concentrations ranging from less than 0.5% to 10% should be estimated with greater accuracy. NIOSH Method 9002 includes a "percent estimate comparator" that illustrates estimates of 3%, 5%, and 10% asbestos in amosite and chrysotile carbonate mineral matrices.

  Percentages can also be estimated by comparison with calibrated standards. (For a list of organizations that provide asbestos reference materials and calibration standards, see page 24.) The point-counting technique described in EPA/600/R-93/116 allows an even more accurate percentage estimate at low concentrations. Point counting is recommended for drywall mud and textured coating materials that might contain asbestos in the 0.5–5% range or lower. If no asbestos fibres are observed in the sample (i.e., the sample is not asbestos-containing), the result can be reported as "none detected" or "ND." "Trace" or "<" can be used if asbestos fibres are identified but can't be quantified below the detection limit of the method used. The laboratory should state clearly what "trace" means with regard to the analytical results.
- Identity of other fibrous materials and matrix materials (if known), and percentages.
- Name or initials of the analyst.
- Comments ("Small sample size," "Sample doesn't match the description from the surveyor," etc.).

The lab report should include a copy of the chain-of-custody form and other important information, such as the dates the samples were received and analyzed, as well as the analytical method(s) used.

Any accreditations held by the laboratory (e.g., NVLAP, AIHA, or CALA; see page 23) should also be listed on the report. (See page 56 for a sample lab report template.) Reports can be kept in electronic format.

All laboratory samples should be retained until analysis for quality control is performed.

Figure 3: Analyst preparing a sample for asbestos identification.

How to quantify asbestos percentages below 0.5%

The NIOSH Method 9002, Asbestos (bulk) by PLM, has a range of 1 to 100% asbestos, with a limit of detection of less than 1%. However, the EPA/600/R-93/116 method allows the quantitation of asbestos analytical results to below 1%.

Reporting of results and laboratory method used

If your lab is reporting asbestos results of 0.5% or less, then either the EPA/600/R-93/116 method or both the NIOSH and EPA methods should be quoted on the laboratory reports. WorkSafeBC defines an *asbestos-containing material* as containing at least 0.5% asbestos.

To quantify asbestos percentages below 0.5%, one of the following analytical procedures should be used:

- **Comparison to reference standards** — Sample standards containing varying amounts of asbestos at and below 1% by weight (e.g., 1%, 0.7%, 0.5%, 0.3%, and 0.1% asbestos) can be purchased or prepared in the laboratory. These samples should be mixtures of different types of asbestos (e.g., chrysotile or amosite) within a variety of matrix materials, such as gypsum, drywall mud, perlite, and calcium carbonate. (For a list of organizations that provide asbestos reference materials and calibration standards, see page 24.)
- **Point counting** — This technique provides a determination of the area percentage of asbestos in a sample. For each layer of the material to be counted, several slides are prepared. A reticle in the eyepiece of the microscope superimposes a grid of points over the field of view. A large number of these "points" are counted, any asbestos is identified, and a percentage is calculated. Either of the following point-counting techniques would be acceptable, but the 1,000-point count is preferred:
  - 400-point count plus gravimetric reduction (which has a limit of detection of 0.25% asbestos)
  - 1,000-point count (which has a limit of detection of 0.1% asbestos)

  A 200-point count wouldn't be acceptable because its limit of detection is only 0.5%. Using this method, a result of less than 0.5% would still be considered asbestos-containing in B.C. Confidence intervals should be included or be available upon request. For example, a result of 0.3% asbestos with 95% confidence limits of ±0.3% may be considered asbestos-containing due to analytical variation (0.3% + 0.3% = 0.6%).

  Point counting doesn't apply to the EPA vermiculite method. Any Libby amphiboles detected using this method would identify the material as asbestos-containing. This would include actinolite and tremolite asbestos, as well as other asbestiform mineral types, such as richterite and winchite. In order to confirm a "no asbestos detected" result for a vermiculite sample, transmission electron microscopy (TEM) or scanning electron microscopy (SEM) must be used as described in the EPA vermiculite method.

Air sampling analysis

The method that is accepted by WorkSafeBC for the purpose of asbestos air sampling analysis is NIOSH Method 7400, Asbestos and Other Fibers by PCM (August 1994). This method is updated periodically, and the most recent version should be used.

This method describes the techniques used for the quantitative determination of asbestos fibres in air samples. It includes sections outlining the following:

- The accuracy of the method (e.g., range, precision, limit of detection)
- The equipment required (e.g., microscopes, slides, tools)
- The reagents to use (e.g., acetone and glycerol triacetate)
- Sample preparation
- Calibration and quality control (mandatory provisions for intra- and inter-laboratory quality control procedures)
- Reporting of results

A copy of the analytical method used in the laboratory must be available on site for reference.

In the Regulation

Section 6.12 of the Regulation requires that during high-risk work activities, air monitoring must be conducted:

- Outside of the containment
- Within the clean room
- On workers inside the contaminated areas (occupational sampling during the course of the work)
- Within the containment after the work has been completed (clearance air sampling)

Results of the analysis of all air samples taken during a high-risk work activity must be made available to the workers involved within 24 hours of completing the collection of the samples.

Equipment for air sampling analysis

The following is a partial list of the equipment and materials recommended for the NIOSH 7400 air sampling analysis method:

- Positive phase contrast compound microscope capable of 400× magnification
- Phase contrast objective lens (40–45× magnification)
- Phase telescope for ocular phase-ring centering

- Walton-Beckett graticule (100 µm field of view) type G-22
- Phase contrast test slide
- Stage micrometer (0.01-mm divisions)
- Acetone vaporization unit
- Acetone (reagent grade) and glycerol triacetate (triacetin — reagent grade)
- Microscope slides and cover slips
- Tools to manipulate samples (scalpels, tweezers, etc.)
- Micropipettes or syringes (5 µL and 100 to 500 µL)
- Sharps container for used slides and pipettes
- In-house reference slides

Analysis and reporting of results

Fibres should be counted as follows using phase contrast microscopy (refer to NIOSH Method 7400 for a complete description):

- Count only fibres within the area of the graticule that are longer than 5 µm with a length-to-width ratio greater than 3:1.
- For fibres that cross the boundary of the graticule field, count as one-half fibre any fibre with only one end lying within the graticule area. (Do not count any fibre that crosses the boundary more than once.)
- Count bundles of fibres as one fibre, unless individual fibres can be identified by observing both ends of a fibre.
- Count enough graticule fields to yield 100 fibres. Count a minimum of 20 fields, and stop at 100 fields, regardless of the count.
- Fibre counts must be recorded for each field on a paper or electronic data sheet.

When the analytical results are reported, the following should be included for each sample:

- Unique lab sample number
- Date the sample was collected and the date it was analyzed
- Type of air sample (e.g., ambient, occupational, blank)
- Flow rate of the pump (litres per minute)
- Total sampling time (minutes)
- Volume of air collected (litres)
- Number of fibres counted and number of fields counted (e.g., 25 fibres in 100 fields)
- Fibre density (fibres/mm^2)
- Fibre concentration (fibres/cm^3 or fibres/mL)
- Name or initials of the analyst
- Whether or not the occupational exposure limit was exceeded

The lab report should include a copy of the chain-of-custody form and refer to the analytical method used. Any accreditations held by the laboratory (e.g., AIHA or CALA; see page 23) should also be listed on the lab report.

All laboratory samples should be retained until analysis for quality control is performed.

Analyst qualifications and training

In the Regulation

Section 30.2 of the Regulation states, "Operators of laboratory equipment must be adequately instructed and trained in the safe use of laboratory equipment and the precautions to be taken when the equipment is used."

It's critical that laboratory analysts be properly qualified and trained to perform their work, as is expected of other workers who handle asbestos.

Asbestos identification analysts should have, at a minimum, a bachelor's degree in the sciences (e.g., biology, chemistry, physics). They should also have credit for an internationally recognized 40-hour course of instruction in the microscopical identification of asbestos. Courses accepted by WorkSafeBC would include those presented by the McCrone Research Institute (mccroneinstitute.org) and MICA — Microscopy Instruction, Consultation and Analysis (micascope.com).

Asbestos fibre counting analysts should have credit for a NIOSH 582 course (Sampling and Evaluating Airborne Asbestos Dust). The American Industrial Hygiene Association (AIHA) maintains a list of AIHA-approved NIOSH 582 equivalency courses and providers at aiha-assets.sfo2.digitaloceanspaces.com/AIHA/registry/aar/NIOSH582_Weblist.pdf.

If an employer chooses to implement an in-house training program for air sampling analysis, this training must be supported by an instruction manual and performance criteria (exercises and exams). Training should include at least 30 hours of contact and analytical time by a qualified instructor. The instructor should have taken a NIOSH 582 equivalent course from an approved vendor within the previous three years.

If a laboratory can't demonstrate that its analysts have the proper training and qualifications, WorkSafeBC officers won't accept the laboratory results.

Quality control program

A quality control program is required for all asbestos laboratories to document analytical uncertainty and ensure confidence in the analytical results. The methods for asbestos identification and fibre

counting that are mandated or accepted by WorkSafeBC require the implementation of a quality control program. Elements of this program may include the following:

- **Quality control manual** — documents the quality control (QC) program and includes monthly summaries of the analysis of internal and external QC samples.
- **Records of calibration and maintenance of equipment.**
- **Contamination control** — procedures for properly disposing of sample containers, cleaning enclosures, testing RI (refractive index) liquids, screening microscope slides and cover slips, cleaning microscopes, and using laboratory blanks.
- **Quality control analyses**:
  - **Intra-laboratory quality control program** — describes and includes the reanalysis of samples previously analyzed by the laboratory.
  - **Inter-laboratory quality control program** — sample exchange programs with two other laboratories, and analysis of samples obtained through a recognized third-party proficiency analytical testing (PAT) agency (see page 23). (Sets of PAT samples are typically dispatched three or four times a year.)

Quality control officer

A quality control officer should be appointed to oversee the program. An officer's duties would include the following:

- Obtaining and/or creating sets of reference slides (for fibre counting) and asbestos reference standards (for asbestos identification)
- Overseeing blind recounts on a minimum of 10% of both the fibre counting and bulk samples that were analyzed
- Identifying any sample custody errors (lost samples, mixed-up samples, etc.)
- Checking chemicals (e.g., refractive index liquids) for contamination
- Analyzing blank filters for the presence of asbestos contamination
- Performing proficiency checks on analysts (which could include the use of statistics and control charts)
- Maintaining quality control manuals for both asbestos identification and fibre counting (including sample custody procedures, microscope resolution and calibration checks, equipment maintenance records, results from blank samples, records of analyst proficiency, etc.)

The quality control program manual or procedures and the latest set of calibration and proficiency testing results must be available for inspection by a WorkSafeBC officer.

Proficiency analytical testing programs

Laboratories that offer asbestos identification and/or fibre counting services should also participate in external proficiency analytical testing (PAT) programs. Unlike accreditation programs (see below), these testing programs only provide samples with known concentrations of asbestos or asbestos fibres for quality control purposes.

The American Industrial Hygiene Association offers the following PAT programs for both asbestos fibre counting and asbestos identification:

- Industrial Hygiene Proficiency Analytical Testing (IHPAT) Program (aihapat.org/Programs/IHPAT/Pages/default.aspx)
- Bulk Asbestos Proficiency Analytical Testing (BAPAT) Program (aihapat.org/programs/bulk-asbestos-proficiency-analytical-testing-bapat-program)
- Asbestos Analysts Registry — designed to recognize individual fibre counting analysts outside of established laboratories (aiharegistries.org/asbestos-analysts-registry)

Quality control program education and training

MICA — Microscopy Instruction, Consultation and Analysis (micascope.com) — offers an Advanced Asbestos QA/QC (quality assurance/quality control) course. This course is designed to assist with laboratory accreditation and covers the following topics:

- Microscope alignment and effective use
- Refractive index liquid calibration protocols
- Measurement and recording of all required optical data
- Analysis of non-routine samples and identification of rare fibres
- Contamination control
- Development of in-house training programs
- Statistical tracking of performance data

Accreditation programs

National Voluntary Laboratory Accreditation Program (NVLAP)

The NVLAP Asbestos Fiber Analysis program provides assurance that participating laboratories can competently analyze asbestos samples using polarized light microscopy. NVLAP provides an

unbiased third-party evaluation of laboratory performance. Participating laboratories periodically receive a series of bulk proficiency samples, and are evaluated on their qualitative and semi-quantitative analyses (including a determination of the optical properties of asbestos types present). Proficiency test results are coupled with results of NVLAP-conducted on-site assessments, every two years, to determine a laboratory's accreditation status. Information on NVLAP is available at nist.gov/nvlap/about-nvlap.

Industrial Hygiene Laboratory Accreditation Program (IHLAP)

The American Industrial Hygiene Association (AIHA) offers bulk asbestos identification and fibre counting accreditation as part of their IHLAP program. AIHA personnel carry out site visits to laboratories to assess specific analysts as well as the facility. Participation in the AIHA proficiency analytical testing programs is a prerequisite to qualify for IHLAP accreditation Information on IHLAP is available at aihaaccreditedlabs.org /LabAccreditationPrograms/IHLAP/Pages/default.aspx.

Canadian Association for Laboratory Accreditation (CALA)

CALA delivers laboratory accreditation for asbestos fibre counting and bulk identification (cala.ca). The association also operates two other programs that help laboratories meet international accreditation requirements: the Proficiency Testing Program and the Training Service. The granting and maintenance of accreditation is based on satisfactory participation in the site assessment program and in proficiency testing (where such testing is offered as part of the accreditation program).

Standards Council of Canada (SCC)

The Standards Council of Canada offers internationally recognized accreditation programs for laboratories (scc.ca/en/accreditation /programs/laboratories). Requirements for SCC's Accreditation Program for testing and calibration laboratories are defined in *ISO/IEC 17025 – General Requirements for the Competence of Testing and Calibration Laboratories.*

Asbestos reference materials and calibration standards

National Institute for Standards and Technology (NIST)

The U.S. National Institute for Standards and Technology certifies and provides more than 1,300 Standard Reference Materials (SRMs), including asbestos standards. SRMs are used to perform

instrument calibrations as part of overall quality control programs (nist.gov/srm). The NIOSH and EPA methods both recommend using asbestos reference standards.

The McCrone Group

The McCrone Group sells reference sets featuring slide mounts of different fibre types, including many commonly encountered while identifying asbestos bulk samples. For more information, visit mccrone.com.

RTI International (Research Triangle Park, North Carolina)

RTI International has a repository of reference standards that includes 25 asbestos-containing building materials and other mineral fibres. These include asbestos percentages between 0.1 and 100%, in materials ranging from gypsum to vermiculite. For more information, visit rti.org/service-capability/proficiency-testing-and-reference-materials.

Making your asbestos laboratory safe

There are many types of laboratories, each with very different hazards. But many common control measures can be implemented to prevent incidents, injuries, and disease. The following processes can be used to address the health and safety hazards found in asbestos laboratories:

- Identify and assess hazards.
- Implement an exposure control plan.
- Use personal protective equipment.
- Prepare for emergencies.
- Dispose of wastes properly.

Identifying and assessing hazards

As an employer, you need to identify hazards and conduct a hazard assessment before any equipment, machinery, or work process is used or started. Potential hazards include exposure to chemicals, heat, noise, vibration, violence, and ergonomic problems. The hazard assessment should be done in consultation with a joint health and safety committee or, if there is no committee, a worker representative for health and safety issues.

Once hazards have been identified and assessed, you need to either eliminate or minimize exposure to the hazards by doing one or more of the following:

- Substituting with safer materials or equipment where feasible
- Using administrative controls (e.g., performing hazardous work away from other workers or after normal working hours)
- Using engineering controls (enclosing the hazardous process or material, providing local exhaust ventilation, etc.)

Personal protective equipment (e.g., respirators) is only used if other control measures can't provide adequate protection.

Implementing an exposure control plan

As an employer, you must develop and implement an exposure control plan (ECP) if a worker has or may have occupational exposure to asbestos. Strict adherence to the ALARA principle (see page 2),

as well as exposure limits and appropriate respiratory protection, are essential elements of exposure control plans. You must also ensure that a qualified person performs a formal risk assessment to determine which workers may be exposed to asbestos and to what extent. The requirements for exposure control plans are found in sections 5.54 and 6.3 of the Regulation.

An effective ECP for asbestos would include the following five elements:

1. **Statement of purpose and responsibilities** — The purpose of an asbestos exposure control plan is to prevent harmful exposure of workers (including laboratory analysts) to asbestos. Assignment of responsibilities for applying the ECP would depend on the scope of the work and the size of the workplace. For example, a small laboratory may only employ a supervisor and a second analyst. The supervisor would be responsible for administering the ECP, but the analyst's duties must still be listed. Larger sites may require that responsibilities for different aspects of the ECP be divided between several people.
2. **Risk identification and assessment** — A key step in developing an asbestos ECP is to identify the work activities that would put workers at risk of exposure. A risk assessment takes into account the following:
   - **Route of exposure** — For asbestos, the route of exposure is through the generation of airborne fibres.
   - **Identification of workers at risk of exposure** — This includes administrative workers who can receive asbestos samples and also maintenance staff who may clean the laboratory. Asbestos analysts are generally at a low risk of exposure, provided that proper engineering controls and work procedures are in place.
   - **Work methods or procedures that may result in exposure** — For example, working with very friable asbestos samples in a fume hood, cleaning up an asbestos spill, or replacing contaminated fume hood ducting would result in an elevated risk of exposure.

   Periodic air monitoring for asbestos should be conducted during typical work activities (e.g., analysis of friable samples, removal of asbestos waste, and changing the filter in a HEPA vacuum or filtration unit) to assess the potential for overexposure of analysts or other workers.

Persons who conduct risk assessments and develop safe work procedures must have education and training in the management and control of asbestos hazards. These individuals would include the following:

- A Certified Industrial Hygienist (CIH), Registered Occupational Hygienist (ROH), or Registered Occupational Hygiene Technologist (ROHT)
- A Certified Safety Professional (CSP), Canadian Registered Safety Professional (CRSP), or Professional Engineer, with experience specific to asbestos exposure and work procedures
- Persons with other combinations of education, training, and experience specific to asbestos exposure and work procedures

3. **Risk control** — Required controls may range from personal protective equipment (e.g., lab coat, disposable gloves, respirator, and eye protection) to more extensive measures that include engineering controls. For example, all asbestos identification analytical work should be done in a HEPA-filtered fume hood or cabinet, and any spills should be cleaned up using a HEPA vacuum.
4. **Education and training** — As an employer, you must ensure that workers are informed about the contents of the ECP. You must also provide workers with adequate education and training to work safely with and near materials that contain asbestos.

   You must inform all affected workers of the following:

   - The risk of exposure to asbestos
   - Safe work procedures to be followed
   - Use of personal protective equipment
   - How to seek first aid
   - How to report an exposure to airborne asbestos fibres
5. **Written procedures, hygiene/decontamination facilities, health monitoring, and record keeping** — Written safe work procedures and programs tell workers how to perform their duties safely. As an employer, you must ensure that all workers understand these procedures well enough to perform their duties competently.

   The requirements are as follows:

   - You must develop written work procedures for controlling the risk of exposure to asbestos (e.g., when disposing of asbestos waste, changing contaminated fume hood ducting, or cleaning up an asbestos spill). These procedures must be made readily available to workers.

- Facilities to permit proper handwashing are a basic expectation under all ECPs. Decontamination procedures will be needed when cleaning reusable personal protective equipment such as respirators and goggles.
- A record must be kept of all workers who are exposed to asbestos while on the job, and of worker education and training sessions on the hazards of exposure to asbestos.

You must review the exposure control plan at least annually, and update it as necessary, in consultation with the joint health and safety committee or the worker health and safety representative.

Using personal protective equipment

Lab coats

Lab coats should be worn in laboratories at all times as part of good general practice. To prevent contamination, protective clothing must not be stored with clean work clothes and personal clothing. As an employer, you must provide regular laundering or disposal of all required protective clothing.

When sending articles for laundering or dry cleaning, you must give the operator of the laundry or dry cleaning facility the following written information:

- The hazards of asbestos
- Any general precautionary measures to be followed when handling the materials

For example, lab coats from an asbestos laboratory should include the following label information:

DANGER!

MAY CONTAIN ASBESTOS DUST.
INHALATION HAZARD.
AVOID BREATHING THE DUST.

Foot protection

Footwear must be of a design, construction, and material appropriate to the protection required. Shoes with non-slip soles should be worn in laboratories. Open-toed shoes and sandals must not be worn by laboratory workers. Workers who need to stand for long periods while working need shoes that provide enough cushioning and support for their feet.

Respiratory protection

As an employer, you must provide appropriate respirators if workers are, or may be, exposed to concentrations of an air contaminant (e.g., asbestos) above the occupational exposure limit. For a list of exposure limits, see the Table of Exposure Limits for Chemical and Biological Substances in guideline G5.48-1 to Part 5 of the Regulation.

In general, asbestos laboratory workers shouldn't have to wear respiratory protection. Respirators may be required, however, during emergency response procedures such as cleanup of hazardous materials, or when changing contaminated ductwork and HEPA filters.

If laboratory workers are required to use a respirator, the laboratory must have a respirator program. The program must include training on the proper use, care, and cleaning of respirators, as well as regular fit testing. For more information on respiratory protection and respirator programs, see the publication *Breathe Safer* at worksafebc.com.

Preparing for emergencies

Laboratories must have written emergency procedures for accidental releases or spills of chemicals or other harmful substances. Workers must be trained in these procedures, which should be posted in work areas where such emergencies could occur. As an employer, you must conduct drills at least once a year to ensure that:

- Emergency exit routes and procedures are effective, and workers are aware of them.
- Workers and supervisors are familiar with their roles and responsibilities.

Written emergency procedures should include the following:

- Assignment of specific responsibilities to individuals and teams
- Instructions for immediate evacuation of workers
- Instructions for providing first aid to and transporting injured workers
- Appropriate emergency telephone numbers, including telephone numbers of nearby medical facilities so that they can be alerted when injured workers are on their way
- Instructions for safely cleaning up spills and properly disposing of the waste afterwards
- A list of agencies to notify in case of a major release of a toxic or hazardous substance, including WorkSafeBC and Emergency Management BC

- Re-entry procedures for maintenance and cleanup work
- Instructions for scheduling emergency drills and testing of emergency equipment
- Provisions for worker training (e.g., on the availability and use of personal protective equipment during an emergency, and how to extinguish small fires)

Spill cleanup

Accidental releases and spills of chemicals or other harmful substances (e.g., asbestos) must be controlled immediately. Workers who clean up spills of hazardous materials must be adequately instructed in safe procedures. The cleanup operation must be supervised by someone who is knowledgeable in the hazards involved and the precautions required. Any personal protective equipment that will be required during emergency cleanup or escape must be stored in a condition and location that make it immediately available.

Emergency washing facilities

Laboratories that handle or store corrosive chemicals or other chemicals harmful to the eyes or skin (e.g., dispersion staining liquids) must have appropriate emergency washing facilities. The facilities must be within either 6 or 30 metres of work areas, depending on the level of risk.

For low-risk workplaces (e.g., asbestos laboratories) where chemicals or other materials are used in a manner and quantity that present a risk of mild eye or skin irritation, any effective means of eye flushing (e.g., a portable eyewash station) may be used. For specific information on risk assessment and requirements for provision of emergency washing facilities, see Tables 5-2 and 5-3 in the Regulation.

All workers must know where the eyewash facilities are, and must be trained in their proper use. Each facility must have signs clearly identifying the location and providing clear instructions for proper use.

Eyewash facilities must be tested according to the manufacturer's instructions when first installed, and must be maintained in good working order. Records of maintenance work and testing should be kept.

Fire protection

Laboratories must be equipped with portable fire extinguishers that are immediately accessible wherever flammable materials are used or stored. Workers who may be required to use the fire extinguishers must be trained in how to use them. Firefighting equipment must be maintained according to the manufacturers' instructions.

Table 3: Fire classes and types of extinguishers

Class	Source	Examples	Extinguisher type	Extinguisher characteristics
A	Ordinary combustibles	Wood, paper, cloth	Water, A-B-C dry chemical	Water is dangerous when used in many laboratory situations.
B	Liquid fuels	Solvents, oil, gasoline	Carbon dioxide, A-B-C dry chemical	Carbon dioxide dissipates so quickly that hot fuel may reignite; A-B-C dry chemical is the most versatile but leaves a residue that must be cleaned.
C	Electrical	Fuse boxes, motors	Carbon dioxide, A-B-C dry chemical	Carbon dioxide dissipates so quickly that hot fuel may reignite; A-B-C dry chemical is the most versatile but leaves a residue that must be cleaned.
D	Combustible metals	Sodium, potassium, phosphorus	Class D dry chemical	Class D dry chemical is designed for metal fires only.
K	Cooking media	Oils, lards, fats	Class K wet chemical	Class K wet chemical is designed for commercial kitchens and reduces the fire's temperature while extinguishing the flames by reacting with cooking oils.

A fire safety plan must be in place. Contact the local fire department for the specific requirements. Fire exits and exit routes must be clearly marked and kept free of obstructions at all times. All workers must be properly trained in the fire prevention and emergency evacuation procedures of their workplace.

As an employer, you must notify the local fire department if your laboratory uses or stores hazardous materials that may endanger firefighters. The fire department needs to know the nature and location of the hazardous materials and how to handle them safely. As part of the fire safety plan, there should be a list of any chemicals stored on site. In facilities with sprinklers, water-reactive chemicals should be protected from exposure to water.

Disposing of wastes

Laboratories must have proper waste disposal procedures to prevent injury to laboratory workers and to those who handle laboratory waste.

Asbestos waste

Asbestos waste should be double-bagged and placed in a clearly marked container with an asbestos hazard label. Waste shouldn't be allowed to accumulate in asbestos fume hoods or in the laboratory. Asbestos waste must be properly disposed of in compliance with the federal *Transportation of Dangerous Goods Act* and provincial environmental regulations. **Do not dispose of asbestos waste as regular garbage.**

Glass and sharps

Damaged or broken glassware can cause serious cuts and can spread infection. Broken glass, metal, or other sharp objects (e.g., glass microscope slides and cover slips) that can cut or puncture the skin must be disposed of separately from other laboratory waste, in leak-proof, puncture-resistant containers. These containers must be identified and labelled, and should be located near the area where the waste is generated. Sharps contaminated with asbestos must be disposed of as asbestos waste.

Do not overfill sharps containers. Containers should have a maximum fill line clearly marked.

Fume hoods

An important exposure control measure used in many laboratories is the ventilated work enclosure commonly called a fume hood. Fume hoods protect workers from hazardous exposure to airborne contaminants (such as asbestos) by capturing fumes, dusts, vapours, and gases generated inside the hood and discharging them safely. Because of the large amounts of air that pass through an operating fume hood, the fume hood is also an important part of the laboratory's general ventilation system.

Many fume hoods in asbestos laboratories are the conventional type in which air velocity is affected by the height of a vertically travelling sash or the lateral positioning of two or three horizontal sashes. Other asbestos fume hoods may have a fixed opening.

Airflow monitoring

Air velocities across the operational face of a fume hood must be measured and recorded at least once a year. Air velocities must also be measured if the system doesn't seem to be working well, and after any repairs or maintenance that could have affected the airflow. For example, as fan belts age, they may loosen and slip, resulting in a loss of airflow.

Note

It may be necessary to temporarily lower the airflow in an asbestos fume hood to prevent friable samples from being sucked off the microscope stage and into the exhaust ducting.

Air velocities can be measured with direct-reading air velocity meters such as a hot-wire anemometer. To determine the average and minimum fume hood air velocity, it's usually enough to measure the velocity at about nine points in a grid pattern across the operational face.

Fume hoods in asbestos laboratories should provide average air velocities over the operational face of between 0.4 and 0.6 metres per second (80 and 120 feet per minute). Part 30 of the Regulation specifies flow rates for fume hoods.

Cross drafts created by personnel traffic, air supply inlets, portable fans, or the opening and closing of doors or windows can disrupt the airflow across the operational face. Fume hoods must be located so as to prevent or minimize these and other disruptive forces. Smoke testing (e.g., using air current tubes) should be carried out to visually assess the uniformity of air currents entering the fume hood.

Defining laboratory fume hoods

Section 30.7.1 of the Regulation states that a *laboratory fume hood* "means an enclosed and mechanically ventilated workspace located in a laboratory, that is designed to

"(a) draw air into the workspace and to prevent or minimize the escape of airborne contaminants out of the workspace, and

"(b) allow a worker to conduct physical, chemical and biological manipulations inside the workspace."

Design and construction requirements

Fume hoods must be constructed of materials compatible with their use. Asbestos fume hoods can be built using Plexiglas.

Location of controls

The controls for operating a fume hood or filtration system must be located outside the fume hood and must be immediately accessible to the laboratory worker.

Exhaust

Fume hood local exhaust ventilation systems must discharge to the atmosphere in such a way that the discharged air won't be recirculated into the laboratory or other work areas. However, under Part 5 (Table 5-1) of the Regulation, recirculation of discharged air is permitted without written approval from WorkSafeBC for "asbestos fibre or other particulate, except a biological contaminant, provided that it is exhausted from a portable vacuum cleaner or bench-top containment unit, fitted with an effective HEPA filter." At least once per year, the efficiency of the HEPA filter should be tested using a suitable indicator chemical, such as dioctyl phthalate (DOP) or polyalphaolefin (PAO) aerosols.

Any other laboratory equipment or instrumentation that may emit harmful airborne quantities of a substance must be equipped with effective local exhaust ventilation. Some analytical equipment (such as gas chromatographs) and some process equipment (such as muffle furnaces and reaction vessels) may require this control measure.

Understanding WHMIS

References

For more information on WHMIS, see the publications *WHMIS 2015: At Work* and *WHMIS 2015: The Basics* at worksafebc.com.

The Workplace Hazardous Materials Information System (WHMIS) legislation ensures that workers are provided with adequate health and safety information. Products covered under WHMIS legislation are called hazardous products, and fall into two hazard groups:

- **Physical hazards**, based on the physical or chemical properties of the product (e.g., products that are flammable, reactive, or corrosive to metals)
- **Health hazards**, based on the ability of the product to cause a health effect, such as:
  - Eye irritation
  - Respiratory sensitization (may cause allergy or asthma symptoms, or breathing difficulties)
  - Carcinogenicity (may cause cancer)

The physical and health hazard groups are split up into a number of classes. Some of the classes are divided even further into categories. The classes are depicted by pictograms (symbols surrounded by red, diamond-shaped borders; see Table 4) that identify their specific hazards.

After a hazardous product has been classified, the following three WHMIS elements are used to communicate health and safety information to workers:

- WHMIS labels (supplier labels and workplace labels)
- Safety data sheets (SDSs)
- Worker education and training programs

The two main sources of health and safety information are supplier labels and SDSs. In general, suppliers are responsible for the following:

- Obtaining or preparing up-to-date supplier labels and SDSs for all hazardous products they sell or produce
- Providing these labels and SDSs to purchasers of hazardous products intended for use in a workplace

If employers import or produce a hazardous product, even if it's for their own use, they're considered to be the supplier of the hazardous product. For example, when a laboratory imports a specialty chemical that's also a hazardous product, the laboratory may become a supplier under WHMIS. This means the laboratory would have to provide an up-to-date SDS and attach a supplier label.

Labels

All hazardous products other than those that are exempt must be labelled according to WHMIS requirements. Two types of labels are required under WHMIS:

- Supplier labels, provided by the supplier of the hazardous product
- Workplace labels, provided by the employer for use in the workplace

Supplier labels

Supplier labels include information about the following:

- The identity of the hazardous product
- The nature and severity of the hazard
- The precautionary measures workers should take in case of exposure to the product or improper handling or storage
- Contact information for the manufacturer or importer of the product

A supplier label isn't meant to provide complete health and safety information about a product.

Workplace labels

In most cases, a workplace label is required if a hazardous product is made and used or decanted in the laboratory, or if a supplier label is lost or unreadable.

Workplace labels must include the following:

- The product's identity
- Safe handling information
- A reference to the availability of a safety data sheet

Labels must be replaced if they become illegible.

Safety data sheets (SDSs)

A safety data sheet is a document provided by suppliers for each hazardous product they manufacture, import, or sell. It contains detailed, product-specific hazard, precautionary, and emergency information that workers need to read, understand, and use. The SDS supplements the information provided on supplier labels.

Employers must ensure that they have an SDS for each hazardous product used, handled, or stored in the laboratory. An SDS, a hazardous waste profile sheet, or an equivalent data sheet must

be prepared for hazardous waste containing a hazardous product. Employers who produce a hazardous product for use in the laboratory must develop an SDS for that product.

In most cases, employers must obtain an up-to-date SDS when an SDS is 3 years old. Chemicals are constantly being studied, and new information can affect the health and safety information on an SDS.

SDSs must be readily available at the workplace as a reference for workers and for the joint health and safety committee or worker health and safety representative.

For more information on SDSs, refer to the publication *WHMIS 2015: At Work* at worksafebc.com.

Worker education and training

Employers are responsible for providing worker education and training. WHMIS education must include the following:

- How WHMIS works
- The major hazards of the hazardous products in use in the workplace
- The rights and responsibilities of employers and workers
- The information required on labels and SDSs, and the significance of the information

Workers must be trained in how to read and understand supplier labels and SDSs. All workers who work with or may be exposed to hazardous products must have site- and job-specific training for all such products.

Employers must develop training programs based on written safe work procedures for using, storing, handling, and disposing of hazardous products, as well as on detailed emergency procedures. Such programs must include all hazardous products used, handled, or stored, including those exempt from WHMIS that don't require supplier labels and safety data sheets.

Maintenance and cleaning staff who may be exposed to spills and other accidental releases of hazardous products must also be given the training.

For more information on WHMIS education and training for workers, refer to the publication *WHMIS 2015: At Work* at worksafebc.com.

Chemical handling and storage

Storage facilities

The first step in organizing chemical stocks in laboratories and storerooms is to establish an inventory. All containers should be labelled with a purchase date and, where applicable, an expiry date. Chemical stocks should be reviewed at least once a year. Chemicals that have expired or deteriorated must be disposed of safely.

Laboratories should have separate storage facilities for chemicals. Working quantities (small containers of chemicals used daily or frequently) can be stored in cupboards or low shelving (below eye level) equipped with either sliding doors or lips that will prevent containers from falling off the shelves. Containers of chemicals stored in labs should be the smallest size practicable. (Under the Regulation, *practicable* means "that which is reasonably capable of being done.") Don't store extra containers of the same chemical in the lab unless they are being used daily.

Don't store chemicals in a fume hood unless the fume hood is used exclusively for this purpose and is labelled as a storage area only. Don't store chemicals other than dilute reagents in work areas such as open workbenches or shelving on the workbenches.

Special storage requirements

Chemical storage facilities may require special cabinets and modified shelving, depending on the chemicals being stored. Table 4 (see next page) summarizes the laboratory use and storage recommendations for specific categories of chemicals.

Table 4: Chemical storage recommendations

Category	Laboratory use	Storage recommendations
Toxic chemicals 	• Use only single, small, daily-use-sized containers.	• Store according to manufacturer's recommendations, away from incompatible chemicals.
Flammable gases, aerosols, liquids, and solids 	• The maximum quantity allowed in open lab areas is a one-workshift supply. • Daily working quantities should be kept to a minimum. • Use only single, small, daily-use-sized containers. • Use safety cans or approved containers whenever practical.	• Storage cabinets must be conspicuously labelled to indicate that they contain flammable liquids, and that open flames must be kept away. • Use safety cans or approved containers. • No combustible material is permitted in storage rooms. • Don't store in or adjacent to exits, elevators, or routes that provide access to exits. • Consult the BC Fire Code and your local fire department for specific details.
Highly reactive chemicals 	• Keep only the amount needed for the workday. • If explosions or implosions may result from laboratory work, provide adequate shielding for equipment used in such work. • Workers must wear personal protective equipment.	• Store in a cool, dry area away from normal work areas and protected from shock, vibration, incompatible chemicals, elevated temperatures, and rapid temperature changes.
Oxidizing agents 	• Use only single, small, daily-use-sized containers.	• Store in a fire-resistant, cool, and well-ventilated area. • Store according to manufacturer's recommendations, away from incompatible chemicals.

Category	Laboratory use	Storage recommendations
Corrosive chemicals 	• Use only single, small, daily-use-sized containers.	• Store in cool, dry, well-ventilated areas on corrosion-resistant material. • Segregate acids and bases.
Water-sensitive chemicals 	• Use only single, small, daily-use-sized containers.	• Store in cool, dry areas designed to prevent accidental contact with water and other incompatible substances. • Storage construction should be fire-resistant. • Protect chemicals from water from sprinkler systems.
Gases under pressure 	• Keep in the lab only the number of cylinders in daily use. • Label cylinders with the rated pressure and type of gas. • Keep all compressed gas cylinders upright and fully secured against falling. • Keep valve caps on all cylinders not in use. • Before using cylinders, check all fittings and regulators for defects, leaks, oil, and grease. • Use acetylene cylinders in an upright position only. If such cylinders have been stored or transported horizontally, let them stand upright for at least one hour before use.	• Store compressed gas cylinders in a well-ventilated area, segregated from flammable and corrosive materials. • Separate flammable gases from oxidizing gases with non-combustible partitions. • Protect cylinders from ignition sources, direct contact with the ground, and excessive variations in temperature. • Keep all compressed gas cylinders upright and fully secured against falling. • If pressure testing is required, indicate on the cylinder when it was pressure tested. • Label empty cylinders and store them separately from other cylinders.

Incompatible chemicals

It's not good practice to simply store chemicals on shelves in alphabetical order by name. Each chemical must be evaluated to determine where and how it should be stored. Manufacturers' recommendations should be followed. As a general rule, flammable chemicals, toxic chemicals, highly reactive chemicals, oxidizing agents, corrosive chemicals, water-sensitive chemicals, and gases under pressure should be segregated from each other. They must be stored in such a way that they won't mix with each other if a container leaks or breaks.

Cleaning up chemical spills

Cleanup of chemical spills must be supervised by workers who are knowledgeable about the hazards involved, and who've been trained in safe cleanup procedures. Before attempting to clean up a particular spill, workers must consult the safety data sheet for information on specific spill cleanup procedures and the personal protective equipment that's required.

Workers must be aware of all hazards associated with the chemical or chemicals that require cleanup. For example, when cleaning up flammable solvents, use an absorbent material that controls flammable vapours as well as the flammable liquid. Commercial spill kits are available for cleaning up hazardous chemicals such as flammable liquids, acids, bases, cyanide, mercury, and hydrofluoric acid.

Handling chemicals

Containers

Containers must be compatible with and resistant to their contents. For example, hydrofluoric acid must not be stored in glass containers, and tetrahydrofuran-chlorinated solvent mixtures must not be stored in stainless steel safety cans.

Inspect chemical stocks regularly. Dispose of damaged containers or those that have deteriorated. Keep containers securely closed, although some — for example, those containing lithium aluminum hydride, formic acid, nitric acid, or chromic acid — may need to be vented periodically to prevent a potentially explosive buildup of gases.

It's good practice to label containers with the purchase date of the chemical and the date when the container was opened. Apply the same labelling practices to containers holding chemicals that have been transferred from their original containers.

In general, keep containers sealed or covered when not in use.

Transporting chemicals

Containers of dangerous chemicals must be transported through the laboratory in a safe manner, so that there is no risk of damage to the containers. Use carrying cases of rubber or plastic to transport corrosive materials (such as acids and bases) in laboratory and storage areas. If a bottle breaks, these cases help contain the spill.

Labelling

Employers must comply with WHMIS requirements regarding both supplier and workplace labels. Labels must be replaced if they become illegible or damaged. Illegible labels can create first aid, handling, and disposal problems.

Physical hazards

Factors other than chemical hazards cause a significant proportion of injuries suffered by laboratory workers. These factors include the following:

- The physical requirements of a job, coupled with the workplace environment, that increase the risk of musculoskeletal injuries
- Sharps

Musculoskeletal injury (MSI)

Like most workers, laboratory workers are at risk for MSI, which can result in sprains, strains, and inflammation of soft tissues such as muscles, tendons, and ligaments. Employers must identify and assess the factors in the laboratory that may expose workers to this risk. They must then eliminate or minimize the risk using engineering or administrative controls.

Risk factors to consider for MSI include the following:

- **Physical demands of the work being performed**, such as the force needed, the amount of repetitive motion, the duration of such tasks, the workers' postures, and exposure to local contact stresses
- **Layout and conditions of the workplace or workstation**, such as how far workers are required to reach, the height of the work surface compared with that of the worker, seating conditions, and floor surface conditions
- **Characteristics of the objects workers handle**, such as size, shape, weight distribution, and types of handles and grips
- **Environmental conditions**, such as lighting and exposure to cold and vibration
- **Organization of the work**, such as work-recovery cycles, the amount of variability in the tasks, and the rate at which workers are required to work

Control measures may include mechanical aids, work procedures, and appropriate use of personal protective equipment. Workers must be educated in the signs and symptoms of MSI, and trained in the use of the control measures. The following tips will help reduce the risk of MSI in laboratory workers:

- Use an ergonomically designed workstation (height-adjustable chair and workbench, good back and elbow support, etc.).

- Ensure that lighting is proper for the task being performed, and that glare is avoided.
- Use appropriate personal protective equipment if necessary (e.g., gloves that improve your grip if you have to grasp slippery objects).
- Keep your head aligned with your spine.
- Avoid slouching or bending forward or to the side.
- Design tasks so that they encourage you to change positions frequently.
- Place materials at a comfortable working level, at or slightly below elbow height.
- Organize the work area so that materials and actions are within easy reach.
- Avoid handling heavy or unbalanced objects while sitting down.
- Avoid sitting for more than 30 minutes at a time.
- Use rest periods to relax or move around.

Working safely with microscopes

- Sit back in the chair instead of perching on it.
- Adjust the chair so that your feet rest comfortably — flat on the floor or on a footrest.
- Adjust the seat to put even pressure along the backs of your thighs.
- Adjust the back of the chair to keep your back in an upright position.
- Adjust the chair's tilt control to ensure that the chair supports your lumbar (lower back) region, or use a lumbar cushion if necessary.
- Ensure that the microscope eyepieces are in line with, or extend over, the front edge of the workbench.
- For comfort, set the vertical position of the eyepieces a little high. This will force you to keep your head upright and prevent strain on your neck.
- If necessary, raise the chair so you can see into the eyepieces. (You may need a footrest to keep your feet in the correct position.)
- Gaze slightly downward into the eyepieces instead of tilting your head down and looking straight ahead. Keep your back vertical and your head and neck upright.
- Ensure that there is no clutter around your legs.
- If the workbench is suitable for microscopy, your thighs shouldn't touch its undersurface.

- The most comfortable position for your hands is to hold them as if you were shaking hands. Your forearms should rest on the workbench to avoid the static loading problems that result if you hold your arms above the bench for long periods.
- To reduce eye strain, adjust the eyepieces for your interpupillary distance, and adjust each eyepiece individually so that the image in each is sharp.
- Make sure the eyepieces are clean.
- Make sure to correct any personal vision problems. Microscopy often makes vision problems (such as astigmatism, nearsightedness or far-sightedness, and poor eye coordination) more obvious.
- Reduce glare and reflection, both in your surroundings and in the microscope image. Reposition your workstation, use blinds, and remove highly reflective surfaces. Adjust the transformer or use filters to ensure an appropriate level of light and contrast in the microscope.
- Take regular breaks, and periodically focus your eyes on a distant object.
- To reduce the risk of repetitive strain injuries, take a 2- to 3-minute break every 30–40 minutes when working at the microscope. Try to rotate work activities to reduce the amount of time you spend at the microscope.
- During your work breaks, do simple stretching exercises.

Appendix A: Occupational Health and Safety Regulation checklist for asbestos laboratories

The following checklist outlines the parts and sections of the Occupational Health and Safety Regulation that apply to laboratories that analyze asbestos samples. The checklist is intended for laboratory managers and/or quality control officers to help their laboratories comply with the Regulation. WorkSafeBC occupational hygiene officers may also reference the checklist. The checklist should be completed at least annually as part of a laboratory's exposure control plan.

Regulatory requirements	Yes/No	Regulation section
Rights and responsibilities		
Are there regular meetings with workers to discuss matters of health and safety?	☐ Yes ☐ No	3.2
Has the employer conducted regular inspections of the workplace(s) for unsafe working conditions?	☐ Yes ☐ No	3.5
Is there provision for occupational first aid?	☐ Yes ☐ No	3.16
General conditions		
Are fire extinguishers present?	☐ Yes ☐ No	4.1, 30.5
Have workstations (e.g., microscope workstations) been evaluated to minimize the risk of musculoskeletal injuries (MSIs)?	☐ Yes ☐ No	4.47, 4.48, 4.49, 4.50, 4.51, 4.52
Chemical and biological substances		
Does the laboratory have a WHMIS program?	☐ Yes ☐ No	5.5
Have workers received WHMIS training?	☐ Yes ☐ No	5.6
Have workers been trained in the safe use, handling, storage, and disposal of hazardous products?	☐ Yes ☐ No	5.7
Have chemicals been labelled with workplace labels?	☐ Yes ☐ No	5.9, 5.10, 5.13
Are safety data sheets for hazardous products present and available to workers?	☐ Yes ☐ No	5.14
Has the employer conducted workplace monitoring for substances listed in the Table of Exposure Limits for Chemical and Biological Substances that workers might be exposed to (e.g., asbestos and laboratory reagents)?	☐ Yes ☐ No	5.53

Regulatory requirements	Yes/No	Regulation section
Does the employer have an exposure control plan for asbestos and other substances listed in the Table of Exposure Limits for Chemical and Biological Substances that workers might be exposed to? This would include engineering controls (see below), administrative controls, education and training, safe work procedures, personal protective equipment (see below), etc.	☐ Yes ☐ No	5.54
Are engineering controls (e.g., local exhaust ventilation) in use to reduce worker exposure to asbestos and other harmful substances?	☐ Yes ☐ No	5.55, 5.64
If the laboratory fume hoods are exhausted into the workplace, are they equipped with a HEPA filter (to filter the discharged air)?	☐ Yes ☐ No	5.70
Is the HEPA filter tested on an annual basis (to ensure that the filter is effective)?	☐ Yes ☐ No	5.70
Are emergency eyewash facilities or equipment present?	☐ Yes ☐ No	5.85
Substance specific requirements — asbestos		
Is the laboratory following analytical methods acceptable to WorkSafeBC?	☐ Yes ☐ No	6.1, 5.53(4)
Does the employer have an exposure control plan for asbestos?	☐ Yes ☐ No	6.3
Are there procedures or equipment in place (e.g., fume hoods) to control the release of asbestos fibres?	☐ Yes ☐ No	6.8
Have the workers received training in the hazards of asbestos?	☐ Yes ☐ No	6.11
Are asbestos waste containers properly labelled and sealed?	☐ Yes ☐ No	6.25
Personal protective clothing and equipment		
Is safety eyewear available and in use?	☐ Yes ☐ No	8.14(1)
Are workers wearing protective footwear (e.g., no open-toed shoes)?	☐ Yes ☐ No	8.22(1)
Are workers wearing respirators when exposed to asbestos (e.g., during the replacement of HEPA filters and/or contaminated ducting)?	☐ Yes ☐ No	8.32
Have the respirators been fit tested?	☐ Yes ☐ No	8.40
Laboratories		
Have the analysts been properly trained in the use of the laboratory equipment?	☐ Yes ☐ No	30.2
Is laboratory equipment (e.g., fume hoods and furnaces) equipped with an effective local exhaust ventilation system?	☐ Yes ☐ No	30.7
Is the airflow into the fume hoods within the range specified in the Regulation?	☐ Yes ☐ No	30.8
Is fume hood airflow monitoring conducted on an annual basis?	☐ Yes ☐ No	30.9

Regulatory requirements	Yes/No	Regulation section
If the fume hoods are connected to a common exhaust, has the ducting been designed in accordance with established engineering principles?	☐ Yes ☐ No	30.10(3)
Does the laboratory have written safe work procedures for the handling and disposal of hazardous chemicals?	☐ Yes ☐ No	30.14
Have workers received training in safe work procedures for the handling and disposal of hazardous chemicals?	☐ Yes ☐ No	30.17(5)
Does the laboratory have procedures in place for emergency spill cleanup?	☐ Yes ☐ No	30.18(1)
Does the laboratory have procedures and equipment in place for the safe handling and disposal of sharps (e.g., glass slides and cover slips)?	☐ Yes ☐ No	30.25

Appendix B: Laboratory forms and charts

Laboratory chain-of-custody/log form

Project number:	Project name:		
Company (or client) name & address:			
Email:	Phone:	Fax:	Contact:
Samples collected by:	Samples received by:		Date received:

Date collected	Date analyzed	Client sample number	Lab sample number	Sample description	Sample type	Analyzed by

Bulk sample analysis data sheet

Job #:	Job name:	Lab sample #:	Date:	Analyst:
Sample information:				

Description (phases/layers)	%	Asbestos type	%	Other		

Fibre morphology	Pleo/colour						CSDS colours		
	EW	NS	Bir	Sign	Ext ang	RI liquid	EW	NS	Fibre ID

Fibre identification chart

	Pleochroism/colour						CS dispersion staining colours	
Fibre type	**EW**	**NS**	**Bir**	**Sign**	**Ext ang**	**RI liquid**	**EW**	**NS**
Chrysotile	White	White	L/M	+	P	1.55	Magenta Blue	Blue Light blue
Heated chrysotile	Brown	Pink	L/M	+/−	P	1.55 1.58 1.605	Gold Blue Blue	Magenta Blue Blue
Amosite	White	White	M	+	P/O	1.68	Gold	Blue
Heated amosite	Red-brown	Orange	M	+	P/O	1.68 1.7	Red-brown Magenta	Orange Blue
Crocidolite	Blue	Grey-blue	M	−	P/O	1.68	Orange	Yellow
Heated crocidolite	Red-brown	Orange	M	+/−	P/O	1.68 1.7 1.71	Red-brown Light blue Pale blue	Orange Light blue Pale blue
Anthophyllite	White	White	M	+	P	1.605 1.61 1.63	Pale yellow Gold Blue	Gold/blue/magenta Blue-green Light blue
Actinolite	White	White	M	+	O	1.605 1.63	Yellow Magenta	Gold Blue
Tremolite	White	White	M	+	O	1.605 1.61 1.63	Yellow Yellow Blue/magenta	Blue/magenta Magenta Light blue
Wollastonite	White	White	M	+/−	O	1.605 1.63	Yellow Blue/purple	Gold Blue/green
Brucite (nemalite)	White	White	M	+/−	P/O	1.55 1.58 1.605	Gold Blue Pale blue	Yellow Blue Pale blue
Cellulose	White	White	M	+	U	1.55	Yellow	Blue

	Pleochroism/colour						CS dispersion staining colours	
Fibre type	**EW**	**NS**	**Bir**	**Sign**	**Ext ang**	**RI liquid**	**EW**	**NS**
Hair	White	White	L/M	+	P	1.55	Magenta	Blue
Mineral wool	White	White	I	NA	NA	1.55	Pale blue	Blue
Ceramic fibre	White	White	I	NA	NA	1.55	Yellow	Yellow
Polyolefin	White	White	M	+	P	1.55 1.605	Yellow/magenta Pale blue	Light blue Pale blue
Rayon	White	White	M	+	P	1.55	Magenta/blue	Blue/light blue
Polyester	White	White	H	+	P	1.55	White	Light blue
Dacron	White	White	H	+	P	1.55	White	Light blue
Nylon	White	White	H	+	P	1.55	Yellow	Light blue
Polyethylene	White	White	M	+	P	1.55	Yellow/magenta	Blue
Acetate	White	White	L	+	P	1.55 1.52	White Light blue	White Light blue
Acrylic	White	White	L	−	P	1.55 1.52	Light blue Blue	Light blue Blue-green
Modacrylic	White	White	L	+/−	P	1.55 1.52	Light blue Yellow	Light blue Gold
Kevlar	White	White	H	+	P	1.605	White	Yellow
Talc	White	White	M	+	P/O	1.55 1.588 1.605	Yellow Magenta/blue Blue	Yellow/blue/magenta Blue Light blue

Birefringence: L (low), M (medium), H (high), I (isotropic)
Sign of elongation: + (positive), − (negative)
Extinction angle: P (parallel), O (oblique), U (undulose)
NA: Not applicable

Sample reporting format for bulk analysis

Lab name and address:	Client name and address:	
	Email:	
	Phone:	
Project name:	Samples submitted by:	Date:

Lab sample #	Sample location/description	Material (layers)	Asbestos type	Other fibre types	Analyst
1	Kitchen linoleum flooring	• Red vinyl 50% • Grey fibrous backing 50%	• None detected • Chrysotile 35%	• Non-fibrous 100% • Cellulose 15%, non-fibrous 50%	GC
2	Kitchen drywall mud	• Beige cement 100%	• Chrysotile 1%	• Non-fibrous 99%	GC

Additional information that should be provided in the report

- Laboratory accreditation
- Samples analyzed in accordance with EPA/600/R-93/116 and/or NIOSH 9002
- Limit of detection and quantitation limit of the method(s)
- Issues with submitted samples (small size, drywall missing mud, etc.)
- Any instructions regarding the samples (recommended point counting, retention time, etc.)

Air sample collection and analysis data sheet

Project #:	Project name:	Analysis method:

Sample #	Date sampled	Date analyzed	Analyst	Sample type	Pump #	Initial flow rate (L/min)	Final flow rate (L/min)	Average flow rate (L/m)	Time (min)	Volume (L)	# of fibres	# of fields	Fibre density (fib/mm^2)	Fibre conc. (fib/mL)	Comments

Sample type: OCC (occupational), AMB (ambient), CR (clean room), AC (air clearance)

Notes

BK114 Printed in Canada R02/20