Section I

SAMPLING, MEASUREMENT METHODS, AND INSTRUMENTS

CHAPTER 1: PERSONAL SAMPLING FOR AIR CONTAMINATION

CHAPTER 2: SAMPLING FOR SURFACE CONTAMINATION

CHAPTER 3: TECHNICAL EQUIPMENT

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SECTION I: CHAPTER 1

PERSONAL SAMPLING FOR AIR CONTAMINANT

A. INTRODUCTION

Unnecessary air sampling wastes laboratory resources and produces delays in reporting results of necessary sampling. Evaluate the potential for employee overexposure by observing and screening samples before conducting any partial or full-shift air sampling.

Screening with portable monitors, gravimetric sampling, or detector tubes can be used to evaluate the following:

- exposures to substances with exceptionally high permissible exposure limits (PELs) in relatively dust-free atmospheres, e.g., ferric oxide and aluminum oxide;
- intermittent processes with substances without short-term exposure limits (STELs);
- engineering controls, work practices, or isolation of process; and
- the need for CSHO protection.

Substances that have ceiling exposure limits (there are validated direct reading sampling devices available specifically for these substances)

Take a sufficient number of samples to obtain a representative estimate of exposure. Contaminant concentrations vary seasonally, with weather, with production levels, and in a single location or job class.
If the employer has conducted air sampling and monitoring in the past, review the records.

Bulk samples are often required to assist the OR-OSHA lab in the proper analysis of field samples. (See Section I, Chapter 4, Sample Shipping and Handling.) Some contaminants in these categories are:

- silica,
- portland cement,
- asbestos,
- mineral oil and oil mist,
- chlorodiphenyl,
- hydrogenated terphenyls,
- chlorinated camphene,
- diisocyanates,
- polynuclear aromatic hydrocarbons,
- fugitive grain dust, and
- explosibility testing.

Bulk samples can also be taken and analyzed to support any Hazard Communication inspections (i.e., Material Safety Data Sheet determinations).

B. GENERAL SAMPLING PROCEDURES

Screen the sampling area with detector tubes, if appropriate. Determine the appropriate sampling technique (see Section C or the current version of the Chemical Information Table in Chapter 13, Appendix A of the OR-OSHA Field Operations Manual or at http://www.cbs.state.or.us/industrial/osha/lab/lab.htm on the Internet. Prepare and calibrate the equipment and obtain the appropriate sample media.

Select the employee to be sampled and discuss the purpose of the sampling. Inform the employee when and where the equipment will be removed. Stress the importance of not removing or tampering with the sampling equipment. Turn off or remove sampling pumps before an employee leaves a potentially contaminated area (such as when he/she goes to lunch or on a break).

Instruct the employee to notify the supervisor or the CSHO if the sampler requires temporary removal.

Place the sampling equipment on the employee so that it does not interfere with work performance.

Attach the collection device (filter cassette, charcoal tube, etc.) to the shirt collar or as close as practical to the nose and mouth of the employee, i.e., in a hemisphere forward of the shoulders with a radius of approximately 6 to 9 inches.

The inlet should always be in a downward vertical position to avoid gross contamination. Position the excess tubing so that it does not interfere with the work of the employee.

Turn on the pump and record the starting time.

Observe the pump operation for a short time after starting to make sure it is operating correctly.

Record the information required by the Air Sampling Data Form (OSHA 91A).

Check pump every two hours. More frequent checks may be necessary with heavy filter loading. Ensure that the sampler is still assembled properly and that the hose has not become pinched or detached from the cassette or the pump. For filters, observe for symmetrical deposition, fingerprints, or large particles, etc. Record the flow rate.

Periodically monitor the employee throughout the workday to ensure that sample integrity is maintained and cyclical activities and work practices are identified.

Take photographs (as appropriate) and detailed notes concerning visible airborne contaminants, work practices, potential interferences, movements, and other conditions to assist in determining appropriate engineering controls.
Prepare blank(s) during the sample period for each type of sample collected. (See Section I, Chapter 4, Sample Shipping and Handling.) One blank will suffice for up to 20 samples for any given analysis except asbestos, which requires a minimum of two field blanks. These blanks may include opened but unused charcoal tubes.

Turn off the pump and record the ending time.

Remove the collection device from the pump and seal it with an Occupational Health Sample seal, 440-1316 as soon as possible. The seal should be attached across sample inlet and outlet so that tampering is not possible. (See Figures I:1-1a and I:1-1b) or the sample or samples may be placed in a whirlpak. Turn down the end of the whirlpak and seal.

Prepare the samples for mailing to the OR-OSHA lab for analysis. (See Section I, Chapter 4.)

Recalibrate pumps after each day of sampling (before charging).

For unusual sampling conditions such as wide temperature and pressure differences from calibration conditions, call the OR-OSHA lab for technical support.

Note: Radio frequency electromagnetic fields can interfere with the proper operation of industrial hygiene instruments. This interference is called electromagnetic susceptibility (EMS). Determine if there is a potential for such interference. Likely sources of radio frequency interference are walkie-talkies, vehicles equipped with mobile radio transmitters, RF heat sealers, etc. If there is a potential for such interference, select sampling instruments that are properly rated for EMS to avoid faulty data or malfunction.

C. SAMPLING TECHNIQUES

DETECTOR TUBES

Each pump should be leak-tested before use.

Submit the detector tube pump to the OR-OSHA Lab yearly for calibration. (See Appendix I:1-1.)
TOTAL DUST AND METAL FUME

Collect total dust on a preweighed, 5.0 micron low-ash polyvinyl chloride or a 0.8 micron polyvinyl chloride filter at a flow rate of about 2 liters per minute (L/min), depending on the rate required to prevent overloading.

Collect metal fumes on a 0.8-micron mixed cellulose ester filter at a flow rate of approximately 1.5 L/min, not to exceed 2.0 L/min. Total particulates can be determined with metal fumes using a 0.8 micron polyvinyl chloride filter.

Take care to avoid overloading the filter, as evidenced by any loose particulate.

Calibrate personal sampling pumps before and after each day of sampling, using a bubble meter method (electronic or mechanical) as described in Section E.

RESPIRABLE DUST

Collect respirable dust using a clean cyclone equipped with a preweighed 5.0 micron low-ash polyvinyl chloride filter at a flow rate of 1.7 ± 0.2 L/min. See Figure I:1-2.

Collect silica only as a respirable dust. A bulk sample should be submitted to the OR-OSHA Lab.

All filters used shall be preweighed and postweighed.

CALIBRATION PROCEDURES

@ Perform the calibration at the pressure and temperature where the sampling is to be conducted.

@ For respirable dust sampling using a cyclone or inhalable dust sampler set up the calibration apparatus as shown in Figure I:1-9.

@ Place the inhalable dust sampler or cyclone assembly in a 1-liter jar. The jar is provided with a special cover.

@ Connect the tubing from the electronic bubble meter to the inlet of the jar.

@ Connect the tubing from the outlet of the cyclone holder assembly or from the filter cassette to the outlet of the jar and then to the sampling pump.

@ Calibrate the pump. Readings must be within 5% of each other.

CYCLONE CLEANING

@ Unscrew the grit pot from the cyclone. Empty the grit pot by turning it upside down and tapping it gently on a solid surface.

@ Clean the cyclone thoroughly and gently after each use in warm soapy water. Rinse thoroughly in clean water, shake off excess water, and set aside to dry before reassembly. Never insert anything into the cyclone during cleaning. See Figure I:1-2.

@ Inspect the cyclone parts for signs of wear or damage such as scoring, rifling, or a loose coupler. Replace the units or parts if they appear damaged.

@ Submit the cyclones to the lab yearly for leak testing.

@ Detailed instructions on leak testing are available from the OR-OSHA Lab.

INHALABLE DUST

Collect inhalable dust using an IOM inhalable sampler with a preweighed 25 mm 0.8 micron PVC polyvinyl chloride filter at a flow rate of ~2.0 L/min. See Figure I:1-2a. For calibration see the preceding Calibration Procedures section.

Figure I:1-2. The cyclone (chamber) of the cyclone assembly is sensitive to scratches.
WELDING FUME SAMPLING

Collect welding fumes inside the welding helmet using a 25 mm 0.8 micron polyvinyl chloride filter at ~ 1 to 3 L/min. The cassette should be placed in the same horizontal plane and within ~ 2 inches (50 mm) of the mouth of the welder. The WELDFUME sampler can be attached to the helmet harness or around the neck of the welder to assist in securing the cassette in this area. See Figure I:1-2b.

SOLID SORBENT TUBES

Organic vapors and gases may be collected on activated charcoal, silica gel, or other adsorption tubes using low-flow pumps.

Immediately before sampling, break off the ends of the flame-sealed tube so as to provide an opening approximately half the internal diameter of the tube. Wear eye protection when breaking ends and use the Drager tube breaker #6400010. Use tube holders, if available, to minimize the hazards of broken glass. Do not use the charging inlet or the exhaust outlet of the pump to break the ends of the tubes.

Use the smaller section of the tube as a back-up and position it near the sampling pump. The tube shall be held or attached in an approximately vertical position with the inlet down during sampling.

Draw the air to be sampled directly into the inlet of the tube. This air is not to be passed through any hose or tubing before entering the tube.

Cap the tube with the supplied plastic caps immediately after sampling and seal with an OSHA-21 form as soon as possible. (See Figures I:1-4a and b.) The tube may placed in a whirlpak and sealed. Do not ship with bulk material.

Tubes may be furnished by the OR-OSHA lab with either caps or flame-sealed glass ends. If using the capped version, simply uncap during the sampling period and recap at the end of the sampling period.

For organic vapors and gases, low-flow pumps are required. Refer to the Chemical Information Manual for flow rates recommended for specific chemicals.

With sorbent tubes, flow rates may have to be lowered or smaller air volumes (half the maximum) used when there is high humidity (above 90%) in the sampling area or relatively high concentrations of other organic vapors are present.
Incorrectly sealed “C” - Tube. End caps can be removed and sample integrity jeopardized without disturbing the seal.

**CALIBRATION PROCEDURES**

Set up the calibration apparatus as shown in Figure 1:1-8 replacing the cassette with the solid sorbent tube to be used in the sampling (e.g., charcoal, silica gel, etc.). If a sampling protocol requires the use of two charcoal tubes, the calibration train must include two charcoal tubes. The air flow must be in the direction of the arrow on the tube.

Calibrate the pump.

**MIDGET IMPINGERS AND BUBBLERS**

**METHOD**

Take care in preparing bubblers and impingers to see that frits or tips are not damaged and that joints can be securely tightened.

If the impingers come empty add the specified amount of reagent supplied by the OR-OSHA Lab to the bubbler or impinger flask either in the office or at the sampling location. If flasks containing the reagent are transported, caps must be placed on the bubbler or impinger stem and side arm.

To prevent overflow, do not add over 10 ml of liquid to the midget impingers or bubblers.

Collect contaminants in an impinger or bubbler at a maximum flow rate of 1.0 L/min.

The impinger or bubbler is attached to the employee’s clothing using an impinger or bubbler holster. It is very important that the impinger or bubbler does not tilt and cause the reagent to flow down the side arm to the hose and into the pump. Watch the reagent level to see that it does not fall below ~ 5 milliliters. If it does remove the impinger and replace it with another.

**NOTE:** Attach a trap in line to the pump, if possible.

After sampling, remove the glass stopper and stem from the impinger or bubbler flask. Cap the impinger with the cap supplied by the OR-OSHA Lab.

**CALIBRATION**

Set up the calibration apparatus as shown in Figure 1:1-8 and replace the cassette with the impinger or bubbler filled with the amount of liquid reagent specified in the sampling method. (Refer to the Chemical Information Manual.)

Connect the tubing from the electronic bubble meter to the inlet of the impinger or bubbler.

Connect the outlet of the impinger or bubbler to the tubing to the pump.

Calibrate the pump at a maximum flow rate of 1.0 L/min.

**MAILING**

Mail bulk samples and air samples separately to avoid cross-contamination. Pack the samples securely to avoid any rattle or shock damage (do not use expanded polystyrene packing). Use bubble sheeting as packing. Put identifying paperwork in every package. PRINT LEGIBLY ON ALL FORMS. See Section I, Chapter 4.
VAPOUR BADGES

Passive-diffusion sorbent badges, Figure I:1-6, are useful for screening and monitoring certain chemical exposures, especially vapors and gases. Few badges have been validated for use in compliance.

![Vapor badge with a clothing clip.](image)

**Figure I:1-6.** Vapor badge with a clothing clip.

Vapor badges are not currently used by OR-OSHA. The volume of air sampled cannot be as accurately documented as with sampling media which use pumps with calibrated flow rates so greater SAE occurs than with other methods.
D. SPECIAL SAMPLING PROCEDURES

ASBESTOS

Collect asbestos on a special 0.8 micrometer pore size, 25-mm diameter mixed cellulose ester filter with a back-up pad.

Use a fully conductive cassette with conductive extension cowl, Figure I:1-7.

Sample open face in worker's breathing zone.

Ensure that the bottom joint (between the extension and the conical black piece) of the cassette is sealed tightly with a shrink band or electrical tape. Point the open face of the cassette down to minimize contamination.

![Figure I:1-7. A standard asbestos cassette (25 mm) sealed properly with an OSHA-21 form.](image)

Use a flow rate in the range of 0.5 to 2.5 L/min. Calibrate pump before and after sampling. Calibration may be as in Figure I:1-9.

Sample for as long a time as possible without overloading (obscuring) the filter.

Instruct the employee to avoid knocking the cassette and to avoid using a compressed-air source that might dislodge the sample while sampling.

Submit 10% blanks, with a minimum in all cases of two blanks.

Where possible, collect and submit to the OR-OSHA lab a bulk sample of the material suspected to be in the air.

Mail bulk sample and air samples separately to avoid cross-contamination. Pack the samples securely to avoid any rattle or shock damage (do not use expanded polystyrene packing). Use bubble sheeting as packing. Put identifying paperwork in every package. Use the Field and Laboratory Analysis Report form. PRINT LEGIBLY ON ALL FORMS.

For exceptional sampling conditions or high flow rates, contact the OR-OSHA lab. More detailed instructions can be obtained from the OR-OSHA lab.

SAMPLING FOR WELDING FUMES

When sampling for welding fumes, the filter cassette must be placed inside the welding helmet to obtain an accurate measurement of the employee's exposure.

Welding fume samples are normally taken using 37-mm filters and cassettes; however, if these cassettes will not fit inside the helmet, 25-mm filters and cassettes can be used. See page I:1-5. Care must be taken not to overload the 25-mm cassette when sampling.

The OR-OSHA lab should be consulted in the case of technical difficulties.
E. EQUIPMENT PREPARATION AND CALIBRATION

**ALKALINE BATTERIES**

Replace alkaline batteries monthly. Keep fresh replacement batteries with the equipment.

**RECHARGEABLE NI-CAD BATTERIES**

Check the rechargeable Ni-Cad batteries before use. If possible check the pumps under load (e.g., turn pump on and check voltage at charging jack). This is only possible with the MSA Flowlite. The MSA Elf can be checked through the charging jack with the pump off. The DuPont P4LC has to be disassembled to check the battery. The Gillian can be check through the battery charger, but only after a discharge and charge cycle. The SKC Pocket Pump and AirChek 2000 have battery status indicators on the pump.

**TIME OF CALIBRATION**

Calibrate personal sampling pumps before and after each day of sampling, using the electronic bubble-meter method.

**ELECTRONIC FLOW CALIBRATORS**

These units are high-accuracy electronic bubble flow meters that provide instantaneous air-flow readings and cumulative averaging of multiple samples. These calibrators measure the flow rate of gases and present the results as volume per unit of time.

These calibrators should be used to calibrate all air-sampling pumps. Appendix I:1-2 provides more information on this piece of equipment.

**CALIBRATION**

When a sampling train requires an unusual combination of sampling media (e.g., glass fiber filter preceding impinger), the same media and devices should be in line during calibration.

**ELECTRONIC BUBBLE METER METHOD**

Allow the pump to run five minutes prior to voltage check and calibration.

If a cassette adaptor is used, care should be taken to ensure that it does not come in contact with the back-up pad.

**NOTE:** When calibrating with a bubble meter, cassette adaptors can cause moderate to severe pressure drop at high flow rates in the sampling train and affect the calibration result. If adaptors are used for sampling, they should also be used when calibrating.

**CAUTION:** Nylon adapters can restrict air flow due to plugging. Stainless-steel adapters are preferred.

Connect the collection device, tubing, pump, and calibration apparatus as shown in Figure I:1-8 for the cassette sampler and Figure I:1-9 for the cyclone sampler.

Visually inspect all Tygon tubing connections. Throw out old or very dirty tubing.

Wet the inside of the electronic flow cell with the soap solution supplied by pushing on the button several times.

Turn on the pump and adjust it to the appropriate flow rate.

Press the button on the electronic bubble meter. Visually capture a single bubble and electronically time the bubble. The accompanying printer will automatically record the calibration reading in liters per minute.

Repeat the step until two readings are within 5%.

**NOTE:** When calibrating a pump a minimum of three electronically timed measurements should be taken.
If necessary, adjust the pump while it is still running.

Repeat the procedures described above for all pumps to be used for sampling. The same cassette and filter may be used for calibrations involving the same sampling method.

**MANUAL BURET BUBBLE METER METHOD**

See Appendix I:1-3.

**Figure I:1-8.** For calibration, the cassette is attached to an electric bubble meter.

**Figure I:1-9.** The cyclone is calibrated by placing the cyclone in a 1 liter vessel attached to an electronic bubble meter.
F. FILTER MEDIA

The filter media is 37-mm diameter, 5.0 micron low-ash polyvinyl chloride or 0.8 micron polyvinyl chloride. The 5.0 micron PVC filters are used for silica (quartz) analysis, and any other appropriate substance requiring gravimetric analysis. The filters may be used without the cyclone attached for total dust analyses. The 0.8 micron PVC filters are used for metals or total particulates. Please indicate on the Field and Laboratory Analysis Report form all analysts of interest. The filter is mounted in a cassette unit shown in Figure I:1-11.

![Figure I:1-11. The Filter/cassette Unit](image)

These filters are shipped pre-weighed and assembled in the cassettes.

Be sure to follow all appropriate protocols for calibration, sampling and submission of samples. A blank should be included with every set of samples. **It is very important that the blank filter have the same date on it as the samples.** Visual observation of the airborne dust concentration around the worker may assist in determining how frequently to check the filter for overloading.
G. FILTER WEIGHING PROCEDURE

The step-by-step procedure for weighing filters follows:

@ There shall be no smoking or eating in the weighing area. All filters will be handled with tongs or tweezers. Do not handle the filters with bare hands.

@ Desiccate all filters at least 24 hours before weighing and sampling. Change desiccant before it completely changes color (i.e., before blue desiccant turns pink).

@ Zero the balance prior to use to each weight.

@ Immediately prior to placement on the balance, pass all filters over an ionization unit to remove static charges. (After 12 months of use, return the unit to the distributor for disposal.)

@ Weigh all filters at least twice.

@ If there is more than 0.005 mg difference in the two weighings, repeat the zero and calibration and reweigh.

@ If there is less than 0.005 mg difference in the two weighings, average the weights for the final weight.

@ Record all the appropriate weighing information (in ink) in the Weighing Log.

@ In reassembling the cassette assembly, remember to add the unweighed backup pad, Figure 1:1-12.

NOTE: At all times take care not to exert downward pressure on the weighing pan(s). Such action may damage the weighing mechanism.


APPENDIX I:1-1. DETECTOR TUBES AND PUMPS

PRINCIPLE AND DESCRIPTION

Detector tube pumps are portable equipment which, when used with a variety of commercially available detector tubes, are capable of measuring the concentrations of a wide variety of compounds in industrial atmospheres.

Operation consists of using the pump to draw a known volume of air through a detector tube designed to measure the concentration of the substance of interest. The concentration is determined by a colorimetric change of an indicator which is present in the tube contents.

Most detector tubes can be obtained locally.

APPLICATIONS AND LIMITATIONS

Detector tubes and pumps are screening instruments which may be used to measure more than 200 organic and inorganic gases and vapors or for leak detection. Some aerosols can also be measured.

Detector tubes of a given brand are to be used only with a pump of the same brand. The tubes are calibrated specifically for the same brand of pump and may give erroneous results if used with a pump of another brand.

A limitation of many detector tubes is the lack of specificity. Many indicators are not highly selective and can cross-react with other compounds. Manufacturers' manuals describe the effects of interfering contaminants.

Another important consideration is sampling time. Detector tubes give only an instantaneous interpretation of environmental hazards. This may be beneficial in potentially dangerous situations or when ceiling exposure determinations are sufficient. When long-term assessment of occupational environments is necessary, short-term measurements may not reflect time-weighted average levels of the hazardous substances present.

Detector tubes normally have a shelf life at 25°C of one to two years. Refrigeration during storage lengthens the shelf life. Outdated detector tubes (i.e., beyond the printed expiration date) should never be used. The OR-OSHA lab can sometimes use these outdated tubes for training purposes.

PERFORMANCE DATA

Specific manufacturers' models of detector tubes are listed in the Chemical Information Manual. The specific tubes listed are designed to cover a concentration range that is near the PEL. Concentration ranges are tube-dependent and can be anywhere from one-hundredth to several thousand ppm. The limits of detection depend on the particular detector tube.

Accuracy ranges vary with each detector tube.

The pump may be hand-held during operation (weight 8-11 ounces), or it may be an automatic type (weight about 4 pounds) that collects a sample using a preset number of pump strokes. A full pump stroke for either type of short-term pump has a volume of about 100 ml.

In most cases where only one pump stroke is required, sampling time is about one minute. Determinations for which more pump strokes are required take proportionately longer.

Maintenance: Contact the OR-OSHA Laboratory for maintenance.

LEAKAGE TEST

Each day prior to use, perform a pump leakage test by inserting an unopened detector tube into the pump and
attempt to draw in 100 ml of air. After a few minutes, check for pump leakage by examining pump compression for bellows-type pumps or return to resting position for piston-type pumps. Automatic pumps should be tested according to the manufacturer’s instructions.

In the event of leakage which cannot be repaired in the field, send the pump to the OR-OSHA Lab for repair.

Record that the leakage test was made on the Direct-Reading Data Form (OSHA-93).

CALIBRATION TEST (Laboratory)

Calibrate the detector tube pump for proper volume measurement at least yearly.

Simply connect the pump directly to the bubble meter with a detector tube in-line. Use a detector tube and pump from the same manufacturer.

Wet the inside of the 100 ml bubble meter with soap solution.

For volume calibration, experiment to get the soap bubble even with the zero (0) ml mark of the buret.

For piston-type pumps, pull the pump handle all the way out (full pump stroke) and note where the soap bubble stops; for bellows-type pumps, compress the bellows fully; for automatic pumps, program the pump to take a full pump stroke. For either type pump, the bubble should stop between the 95 ml and 105 ml marks. Allow 4 minutes for the pump to draw the full amount of air (This time interval varies with the type of detector tube being used in-line with the calibration setup).

Also check the volume for 50 ml (one-half pump stroke) and 25 ml (one-quarter pump stroke) if pertinent. As in Section 1 above, + 5% error is permissible. If error is greater than + 5%, the pump is need of repair and recalibration.

Record the calibration information required on the Calibration Log (OSHA-93).

It may be necessary to clean or replace the rubber bung or tube holder if a large number of tubes have been taken with any pump.

ADDITIONAL INFORMATION

DRAEGER, MODEL 31 (BELLOWS)

When checking the pump for leaks with an unopened tube, the bellows should not be completely expanded after 10 minutes.

MINE SAFETY APPLIANCES, SAMPLAIR PUMP, MODEL A, PART NO. 46399 (PISTON)

The pump contains a flow-rate control orifice protected by a plastic filter which periodically needs to be cleaned or replaced. To check the flow rate, the pump is connected to a buret and the piston is withdrawn to the 100-ml position with no tube in the tube holder. After 24-26 seconds, 80 ml of air should be admitted to the pump. Every 6 months the piston should be relubricated with the oil provided.

SENSIDYNE-GASTEC, MODEL 800, PART NO. 7010657-1 (PISTON)

When checking the pump for leaks with an unopened tube, the pump handle should be pulled back to the 100-ml mark and locked. After 1 minutes, the handle should be released carefully. It should return to a point < 6mm from zero or resting position. Periodic relubrication of the pump head, the piston gasket, and the piston check valve is needed and is use-dependent.

SPECIAL CONSIDERATIONS

Detector tubes should be refrigerated when not in use to prolong shelf life.

Detector tubes should not be used when cold. They should be kept at room temperature or in a shirt pocket for one hour prior to use.

Lubrication of the piston pump may be required if volume error is greater than 5%.
APPENDIX 1:1-2. ELECTRONIC FLOW CALIBRATORS

DESCRIPTION

These units are high-accuracy electronic bubble flowmeters that provide instantaneous airflow readings and a cumulative averaging of multiple samples. These calibrators measure the flow rate of gases and report volume per unit of time.

The timer is capable of detecting a soap film at 80-microsecond intervals. This speed allows under steady flow conditions an accuracy of ± 0.5% of any display reading. Repeatability is ± 0.5% of any display.

The range with different cells is from 1 ml/min to 30 L/min.

Battery power will last 8 hours with continuous use. Charge for 16 hours. Can be operated from A/C charger.

MAINTENANCE OF CALIBRATOR

CLEANING BEFORE USE

Remove the flow cell and gently flush with tap water. The acrylic flow cell can be easily scratched. Wipe with cloth only. Do not allow the center tube, where the sensors detect soap film, to be scratched or get dirty. NEVER clean with ACETONE. Use only soap and warm water. When cleaning prior to storage, allow flow cell to air dry. If stubborn residue persists, it is possible to remove the bottom plate. Squirt a few drops of soap into the slot between base and flow cell to ease removal.

LEAK TESTING (Laboratory)

The system should be leak checked at 6” H2O by connecting a manometer to the outlet boss and evacuate the inlet to 6” H2O. No leakage should be observed.

VERIFICATION OF CALIBRATION (Laboratory)

The calibrator is factory calibrated using a standard traceable to National Institute of Standards and Technology, formerly called the National Bureau of Standards, (NBS). Attempts to verify calibrator against a glass one liter burette should be conducted at 1000 ml/min. for maximum accuracy. The calibrator is linear throughout the entire range.

SHIPPING AND HANDLING

When transporting, especially by air, it is important that one side of the seal tube which connects the inlet and outlet boss, be removed for equalizing internal pressure within the calibrator.

Do not transport unit with soap solution or storage tubing in place.

PRECAUTIONS AND WARNINGS

Avoid the use of chemical solvents on flow cell, calibrator case and faceplate. Generally, soap and water will remove any dirt.

Never pressurize the flow cell at any time with more than 25 inches of water pressure.

Do not charge batteries for longer than 16 hours.

Do not leave A/C adapter plugged into calibrator when not in use as this could damage the battery supply.

Black close fitting covers help to reduce evaporation of soap in the flow cell when not in use.

Do not store flow cell for a period of one week or longer with soap. Clean and store dry.

The Calibrator Soap is a precisely concentrated and sterilized solution formulated to provide a clean, frictionless soap film bubble over the wide, dynamic range of the calibrator. The sterile nature of the soap is important in the prevention of residue build-up in the flow cell center tube, which could cause inaccurate readings. The use of any other soap is not recommended.
When a sampling train requires an unusual combination of sampling media (e.g., glass fiber filter preceding impinger), the same media/devices should be in line during calibration. Calibrate personal sampling pumps before and after each day of sampling.

**BUBBLE METER METHOD**

1. Allow the pump to run 5 minutes prior to voltage check and calibration.

2. Assemble the polystyrene cassette filter holder using the appropriate filter for the sampling method. If a cassette adaptor is used, care should be taken to ensure that it does not come in contact with the back-up pad.

   **NOTE:** When calibrating with a bubble meter, the use of cassette adaptors can cause moderate to severe pressure drop in the sampling train, which will affect the calibration result. If adaptors are used for sampling, then they should be used when calibrating.

3. Connect the collection device, tubing, pump and calibration apparatus as shown in Figures I:1-12 and I:1-13.

4. A visual inspection should be made of all Tygon tubing connections.

5. Wet the inside of a 1-liter buret with a soap solution.

6. Turn on the pump and adjust the pump rotameter to the appropriate flow rate setting.

7. Momentarily submerge the opening of the buret in order to capture a film of soap.

8. Draw two or three bubbles up the buret in order to ensure that the bubbles will complete their run.

9. Visually capture a single bubble and time the bubble from 0 to 1000 ml for high flow pumps or 0 to 100 ml for low flow pumps.

10. The timing accuracy must be within +1 second of the time corresponding to the desired flow rate.

   If the time is not within the range of accuracy, adjust the flow rate and repeat steps 9 and 10 until the correct flow rate is achieved. Perform steps 9 and 10 at least twice, in any event.

While the pump is still running, mark the pump or record on the OSHA-91 the position of the center of the float in the pump rotameter as a reference.

Repeat the procedures described above for all pumps to be used for sampling. The same cassette and filter may be used for all calibrations involving the same sampling method.
**Figure 1:1-12.** Calibration setup for personal sampling with filter cassette.

**Figure 1:1-13.** Calibration of cyclone respirable-dust sampler using a bubble meter.
## APPENDIX I:1-4. SHELF LIFE OF SAMPLING MEDIA

**PROVIDED BY OR-OSHA Lab**

<table>
<thead>
<tr>
<th>Sampling medium</th>
<th>Shelf Life</th>
<th>Comments</th>
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<tbody>
<tr>
<td>Sodium hydroxide (all normalities)</td>
<td>6 months</td>
<td>Same for all concentrations of all solutions.</td>
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<tr>
<td>Hydrochloric acid</td>
<td>1 year</td>
<td></td>
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<tr>
<td>Sulfuric acid</td>
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<tr>
<td>Methanol in water</td>
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<tr>
<td>Nitrogen oxides collection tubes</td>
<td></td>
<td>Should be stored in a refrigerator.</td>
</tr>
<tr>
<td>Sampler for ozone (Nitrite-treated filter collection device)</td>
<td>28 days</td>
<td>Prepared on request*</td>
</tr>
<tr>
<td>MAMA reagent in toluene and MAMA treated filter sampler for diisocyanates</td>
<td>2 weeks</td>
<td>Prepared on request*, Should be stored in refrigerator.</td>
</tr>
<tr>
<td>(MDI, HDI, TDI, etc.)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Please notify OR-OSHA Lab of need two days in advance to allow for preparation time.
APPENDIX I:1-5. SAMPLING FOR SPECIAL ANALYSES

CRYSTALINE SILICA SAMPLES ANALYZED BY X-RAY DIFFRACTION (XRD)

AIR SAMPLES

Respirable dust samples for quartz, cristobalite, and tridymite are analyzed by X-ray diffraction (XRD). XRD is the preferred analytical method due to its sensitivity, minimum requirements for sample preparation and ability to identify polymorphs (different crystalline forms) of free silica.

The analysis of crystalline free silica by XRD requires that the particle size distribution of the samples be matched as closely as possible to the standards. This is best accomplished by collecting a respirable sample.

- Respirable dust samples are collected on a tared low ash PVC filter using a 10-mm nylon cyclone at a flow rate of 1.7 L/min +/- 0.2 L/min.

- A sample not collected in this manner is considered a total dust (or nonrespirable) sample. CSHOs are discouraged from submitting total dust samples since an accurate analysis cannot be provided by XRD for such samples.

- If the sample collected is nonrespirable, the laboratory must be advised. (Nonrespirable sampling is discouraged by the OR-OSHA lab)

Quartz (also cristobalite and tridymite) is initially identified by its major (primary) X-ray diffraction peak. A few substances also have peaks near the same location, and it is necessary to confirm quartz (also cristobalite or tridymite) using secondary and/or tertiary peaks. To assist the analyst in identifying interference, the CSHO should provide information concerning potential presence of other substances in the workplace. The following substances should be noted:

- Aluminum phosphate
- Feldspars (microcline, orthoclase, plagioclase)
- Graphite
- Iron carbide
- Lead sulfate
- Micas (biotite, muscovite)
- Montmorillonite
- Potash
- Sillimanite
- Silver chloride
- Talc
- Zircon (Zirconium silicate).

Note: Specific additional chemicals should be listed on the Field and Laboratory Analysis Report Form if they are suspected to be present.

- If heavy sample loading is noted during the sampling period, it is recommended that the filter cassette be changed to avoid collecting a sample with a weight greater than 5.0 milligrams.

Laboratory results for air samples are usually reported as follows:

- Percent Quartz (and/or Cristobalite). Applicable for a respirable sample in which the amount of quartz (or cristobalite) in the sample was confirmed.

- If the presence of quartz (or cristobalite) is suspected in this case, the Industrial Hygienist may want to sample for a longer period of time to increase the sample weights.
**BULK SAMPLES**

Bulk samples should be submitted for all silica analyses, if possible.

They have the following purposes:

- To confirm the presence of quartz or cristobalite in respirable samples, or to assess the presence of other substances that may interfere in the analysis of respirable samples.
- To determine the approximate percentage of quartz (or cristobalite) in the bulk sample.
- To support Hazard Communication inspections.

A bulk sample should be representative of the airborne free silica content of the work environment sampled.

The laboratory's order of preference for bulk samples for an evaluation of personal exposure is:

- A high-volume respirable area sample.
- A high-volume area sample.
- A representative settled-dust (rafter) sample. (This is the most practical option. In certain operations it may be very difficult to collect enough material using high-volume sampling to be used as a bulk sample.)
- A bulk sample of the raw material used in the manufacturing process (most practical if used for Hazard Communication inspections).

The type of bulk sample submitted to the laboratory should be stated on the Field and Laboratory Analysis Report form and cross-referenced to the appropriate air samples.

A reported bulk sample analysis for quartz (also cristobalite or tridymite) will be semiquantitative because:

- Error associated with bulk sampling;
- The XRD analysis procedure requires a thin layer deposition for an accurate analysis; and
- The error for bulk samples analyzed by XRD is unknown because the particle size of nonrespirable bulk samples varies from sample to sample.

**SAMPLE CALCULATIONS FOR CRYSTALLINE SILICA EXPOSURES**

Where the employee is exposed to combinations of silica dust (i.e., quartz, cristobalite, and tridymite), the synergistic effects of the mixture will be considered.

For the PEL calculation specified in 29 CFR 1910.1000, Table Z-3, the percent silica will be determined by doubling the percentage of cristobalite and/or tridymite and adding it to the percentage of quartz, according to the following formula. The PEL mixture pertains to the respirable fraction.

\[
PEL = \frac{10 \text{ mg/m}^3}{\text{% quartz} + 2(\text{% cristobalite}) + 2(\text{% tridymite}) + 2}
\]
Two consecutive samples from the same employee taken for a combined exposure to silica dusts have the following results:

<table>
<thead>
<tr>
<th>Sample</th>
<th>Sampling period (min)</th>
<th>Total volume (L)</th>
<th>Respirable weight (mg)</th>
<th>Respirable concentration (mg/m³)</th>
<th>Laboratory results (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>238</td>
<td>405</td>
<td>0.855</td>
<td>2.1</td>
<td>5.2 quartz 2.3 cristobalite ND tridymite</td>
</tr>
<tr>
<td>B</td>
<td>192</td>
<td>326</td>
<td>0.619</td>
<td>1.9</td>
<td>4.8 quartz 1.7 cristobalite ND tridymite</td>
</tr>
<tr>
<td>Total</td>
<td>430</td>
<td>731</td>
<td>1.474</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Key:
ND Not detectable.

Calculation of the TWA from the sampling and analytical data:

Step 1. Calculate the percentage of quartz, cristobalite, and tridymite in the respirable particulate collected.

Quartz: \(5.2 \times 0.855/1.474 + 4.8 \times 0.619/1.474 = 3.0 + 2.0 = 5.0\%\)
Cristobalite: \(2.3 \times 0.855/1.474 + 1.7 \times 0.619/1.474 = 1.3 + 0.7 = 2.0\%\)

Step 2. Calculate the PEL for the mixture.

\[
PEL_{\text{mix}} = \frac{10 \text{ mg/m}^3}{\% \text{ quartz} + 2(\% \text{ cristobalite}) + 2(\% \text{ tridymite}) + 2}
\]

\[
= 10/[5.0 + 2(2.0) + 2(0) + 2] = 10/11.0 = 0.91 \text{ mg/m}^3
\]

Step 3. Calculate the employee’s exposure.

\[
\text{Exposure} = \frac{\text{Sample wt. A} + \text{Sample wt. B}}{\text{Total volume}} = (0.855 + 0.619)/0.731 = 2.0 \text{ mg/m}^3
\]

Step 4. Adjust (where necessary) for less than 8-hour sampling period.

\[
\text{TWA} = (2.0 \text{ mg/m}^3)[(430 \text{ min})/(480 \text{ min})] = 1.8 \text{ mg/m}^3
\]

Step 5. Calculate the severity of the exposure.

\[
(1.8 \text{ mg/m}^3)/(0.91 \text{ mg/m}^3) = 2.0
\]

This example does not include calculation using the SAE. Please contact the OR-OSHA lab for further information.
APPENDIX I:1-6. SAMPLING AND ANALYTICAL ERRORS (SAEs)

DEFINITION OF SAEs

When an employee is sampled and the results analyzed, the measured exposure will rarely be the same as the true exposure. This variation is due to sampling and analytical errors, or SAEs. The total error depends on the combined effects of the contributing errors inherent in sampling, analysis, and pump flow.

DEFINITION OF CONFIDENCE LIMITS

Error factors determined by statistical methods shall be incorporated into the sample results to obtain the lowest value that the true exposure could be (with a given degree of confidence) and also the highest value the true exposure could be (also with some degree of confidence).

The lower value is called the lower confidence limit (LCL), and the upper value is the upper confidence limit (UCL). These confidence limits are termed one-sided since the only concern is with being confident that the true exposure is on one side of the PEL.

DETERMINING SAEs

SAEs that provide a 95% confidence limit have been developed and are listed on each OR-OSHA Laboratory Report (most current SAEs). If there is no SAE listed in the Report for a specific substance, call the OR-OSHA Lab. If using detector tubes or direct-reading instruments, use the SAEs provided by the manufacturer.

ENVIRONMENTAL VARIABLES

Environmental variables generally far exceed sampling and analytical errors. Samples taken on a given day are used by OSHA to determine compliance with PELs. However, where samples are taken over a period of time (as is the practice of some employers), the CSHO should review the long-term pattern and compare it with the results. When OSHA's samples fit the long-term pattern, it helps to support the compliance determination. When OSHA's results differ substantially from the historical pattern, the CSHO should investigate the cause of this difference and perhaps conduct additional sampling.

CONFIDENCE LIMITS

One-sided confidence limits can be used to classify the measured exposure into one of three categories.

@ If the measured results do not exceed the standard and the UCL also does not exceed the standard, we can be 95% confident that the employer is in compliance. (See Equation I:1-6E.)

@ If the measured exposure exceeds the PEL and the LCL of that exposure also exceeds the PEL, we can be 95% confident that the employer is in noncompliance, and a violation is established. (See Equation I:1-6F.)

@ If the measured exposure does not exceed the PEL, but the UCL of that exposure does exceed the PEL, we cannot be 95% confident that the employer is in compliance. (See Equation I:1-6E.) Likewise, if the measured exposure exceeds the PEL, but the LCL of that exposure is below the PEL, we cannot be 95% confident that the employer is in noncompliance. (See Equation I:1-6F.) In both of these cases, the measured exposure can be termed a "possible overexposure."
A violation is not established if the measured exposure is in the "possible overexposure" region. It should be noted that the closer the LCL comes to exceeding the PEL, the more probable it becomes that the employer is in noncompliance.

If measured results are in this region, the CSHO should consider further sampling, taking into consideration the seriousness of the hazard, pending citations, and how close the LCL is to exceeding the PEL.

If further sampling is not conducted, or if additional measured exposures still fall into the "possible overexposure" region, the CSHO should carefully explain to the employer and employee representative in the closing conference that the exposed employee(s) may be overexposed but that there was insufficient data to document noncompliance. The employer should be encouraged to voluntarily reduce the exposure and/or to conduct further sampling to assure that exposures are not in excess of the standard.

**SAMPLING METHODS**

The LCL and UCL are calculated differently depending upon the type of sampling method used. Sampling methods can be classified into one of three categories:

- **Full-period, Continuous Single Sampling.** Full-period, continuous single sampling is defined as sampling over the entire sample period with only one sample. The sampling may be for a full-shift sample or for a short period ceiling determination.

- **Full-period, Consecutive Sampling.** Full-period, consecutive sampling is defined as sampling using multiple consecutive samples of equal or unequal time duration which, if combined, equal the total duration of the sample period. An example would be taking four 2-hour charcoal tube samples. There are several advantages to this type of sampling:
  - If a single sample is lost during the sampling period due to pump failure, gross contamination, etc., at least some data will have been collected to evaluate the exposure.
  - The use of multiple samples will result in slightly lower sampling and analytical errors.
  - Collection of several samples allows conclusions to be reached concerning the manner in which differing segments of the work day affect overall exposure.

- **Grab Sampling.** Grab sampling is defined as collecting a number of short-term samples at various times during the sample period which, when combined, provide an estimate of exposure over the total period. Common examples include the use of detector tubes or direct-reading instrumentation (with intermittent readings).

**CALCULATIONS**

If the initial and final calibration flow rates are different, a volume calculated using the highest flow rate should be reported to the laboratory. If compliance is not established using the lowest flow rate, further sampling should be considered.

Generally, sampling is conducted at approximately the same temperature and pressure as calibration, in which case no correction for temperature and pressure is required.
and the sample volume reported to the laboratory is the volume actually measured. Where sampling is conducted at a substantially different temperature or pressure than calibration, an adjustment to the measured air volume may be required depending on the sampling pump used, in order to obtain the actual air volume sampled.

The actual volume of air sampled at the sampling site is reported, and used in all calculations.

- For particulates, the laboratory reports mg/m³ of contaminant using the actual volume of air collected at the sampling site. The value in mg/m³ can be compared directly to OSHA Toxic and Hazardous Substances Standards (e.g., 29 CFR 1910.1000).

- The laboratory normally does not measure concentrations of gases and vapors directly in parts per million (ppm). Rather, most analytical techniques determine the total weight of contaminant in collection medium. Using the air volume provided by the CSHO, the lab calculates concentration in mg/m³ and converts this to ppm at 25°C and 760 mm Hg using Equation I:1-6A. This result is to be compared with the PEL without adjustment for temperature and pressure at the sampling site.

\[
\text{ppm}(\text{NTP}) = \frac{\text{mg/m}^3(24.45)}{\text{Mwt}}
\]

Where:
- 24.45 = molar volume at 25°C (298 K) and 760 mm Hg
- Mwt = molecular weight
- NTP = Normal Temperature and Pressure at 25°C and 760 mm Hg

- If it is necessary to know the actual concentration in ppm at the sampling site, it can be derived from the laboratory results reported in ppm at NTP by using the following equation:

\[
\text{ppm}(\text{PT}) = \frac{\text{ppm}(\text{NTP}) (760)}{(P)(T)(298)}
\]

where:
- P = sampling site pressure (mm of Hg)
- T = sampling site temperature (°K)
- 298 = temperature in degrees Kelvin (273 + 25)

NOTE: When a laboratory result is reported as mg/m³ contaminant, concentrations expressed as ppm (PT) cannot be compared directly to the standards table without converting to NTP.

NOTE: Barometric pressure can be obtained by calling the local weather station or airport, request the unadjusted barometric pressure. If these sources are not available then a rule of thumb is: for every 1000 feet of elevation, the barometric pressure decreases by 1 inch of Hg.
CALCULATION METHOD FOR A FULL-PERIOD, CONTINUOUS SINGLE SAMPLE

Obtain the full-period sampling result (value X), the PEL and the SAE. The SAE can be obtained from the Laboratory Analysis Report.

Divide X by the PEL to determine Y, the standardized concentration. That is:

\[
Y = \frac{X}{\text{PEL}}
\]

Compute the UCL (95%) as follows:

\[
\text{UCL (95%)} = Y + \text{SAE}
\]

Compute the LCL (95%) as follows:

\[
\text{LCL}(95%) = Y - \text{SAE}
\]

Classify the exposure according to the following classification system:

@ If the UCL \(\leq 1\), a violation does not exist.

@ If LCL \(\leq 1\) and the UCL > 1, classify as possible overexposure.

@ If LCL > 1, a violation exists.

SAMPLE CALCULATION FOR FULL-PERIOD, CONTINUOUS SINGLE SAMPLE

A single fiberglass filter and personal pump were used to sample for carbaryl for a 7-hour period. The CSHO was able to document that the exposure during the remaining unsampled one-half hour of the 8-hour shift would equal the exposure measured during the 7-hour period. The laboratory reported 6.07 mg/m\(^3\). The SAE for this method is 0.23. The PEL is 5.0 mg/m\(^3\).

Step 1. Calculate the standardized concentration.

\[
Y = \frac{6.07}{5.0} = 1.21
\]

Step 2. Calculate confidence limits.

\[
\text{LCL} = 1.21 - 0.23 = 0.98
\]

Since the LCL does not exceed 1.0, noncompliance is not established. The UCL is calculated:

\[
\text{UCL} = 1.21 + 0.23 = 1.44
\]

Step 3. Classify the exposure.

Since the LCL < 1.0 and the UCL > 1.0, classify as possible overexposure.

CALCULATION METHOD FOR FULL-PERIOD CONSECUTIVE SAMPLING

The use of multiple consecutive samples will result in slightly lower sampling and analytical errors than the use of one continuous sample since the inherent errors tend to partially cancel each other. The mathematical calculations, however, are somewhat more complicated. If preferred, the CSHO may first determine if compliance or noncompliance can be established using the calculation method noted for a full-period, continuous, single-sample measurement. If results fall into the “possible overexposure” region using this method, a more exact calculation should be performed using equation I:1-6G.
Obtain $X_1, X_2, \ldots, X_n$, the $n$ consecutive concentrations on one workshift and their time durations, $T_1, T_2, \ldots, T_n$.

Also obtain the SAE in listed in the OSHA-91B sample report form

Compute the TWA exposure.

Divide the TWA exposure by the PEL to find $Y$, the standardized average (TWA/PEL).

Compute the UCL (95%) as follows:

$\text{UCL(95\%)} = Y + \text{SAE}$ (Equation I:1-6E)

Compute the LCL (95%) as follows:

$\text{LCL(95\%)} = Y - \text{SAE}$ (Equation I:1-6F)

Classify the exposure according to the following classification system:

- If $\text{UCL} \leq 1$, a violation does not exist.
- If $\text{LCL} < 1$, and the UCL > 1, classify as possible overexposure.
- If $\text{LCL} > 1$, a violation exists.

When the LCL < 1.0 and UCL > 1.0, the results are in the "possible overexposure" region and the CSHO must analyze the data using the more exact calculation for full-period consecutive sampling, as follows:

Equation I:1-6H

\[
\text{LCL} = Y - \frac{\text{SAE} \sqrt{\sum T_1^2 X_1^2 + T_2^2 X_2^2 \cdots + T_n^2 X_n^2}}{\text{PEL}(T_1 + T_2 + \cdots + T_n)}
\]

**SAMPLE CALCULATION FOR FULL-PERIOD CONSECUTIVE SAMPLING**

If two consecutive samples had been taken for carbaryl instead of one continuous sample, and the following results were obtained:

<table>
<thead>
<tr>
<th>-- Sample --</th>
<th>A</th>
<th>B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sampling rate (L/min)</td>
<td>2.0</td>
<td>2.0</td>
</tr>
<tr>
<td>Time (min)</td>
<td>240</td>
<td>210</td>
</tr>
<tr>
<td>Volume (L)</td>
<td>480</td>
<td>420</td>
</tr>
<tr>
<td>Weight (mg)</td>
<td>3.005</td>
<td>2.457</td>
</tr>
<tr>
<td>Concentration (mg/m³)</td>
<td>6.26</td>
<td>5.85</td>
</tr>
</tbody>
</table>

The SAE for carbaryl is 0.23

Step 1. Calculate the UCL and the LCL from the sampling and analytical results:

\[
\text{TWA} = \frac{(6.26 \text{ mg/m}³ \times 240 \text{ min}) + (5.85 \text{ mg/m}³ \times 210 \text{ min})}{450 \text{ min}}
\]

\[
\text{TWA} = 6.07 \text{ mg/m}³
\]

\[
Y = \frac{6.07 \text{ mg/m}³}{\text{PEL}} = \frac{6.07}{5} = 1.21
\]

Assuming a continuous sample: LCL = 1.21 - 0.23 = 0.98

\[
\text{UCL} = 1.21 + 0.23 = 1.44
\]

Step 2. Since the LCL < 1.0 and UCL > 1.0, the results are in the possible overexposure region, and the CSHO must analyze the data using the more exact calculation for full-period consecutive sampling as follows:

\[
\text{LCL} = 1.21 - \frac{0.23 \sqrt{(240 \text{ min})^2 (6.26 \text{ mg/m}³)^2 + (210 \text{ min})^2 (5.85 \text{ mg/m}³)^2}}{50 \text{ mg/m}³ (240 + 210 \text{ min})}
\]

\[
= 1.21 - 0.20 = 1.01
\]

Since the LCL > 1.0, a violation is established.
**GRAB SAMPLING**

If a series of grab samples (e.g., detector tubes) is used to determine compliance with either an 8-hour TWA limit or a ceiling limit, consult with the ARA for Technical Support regarding sampling strategy and the necessary statistical treatment of the results obtained.

**SAEs FOR EXPOSURE TO CHEMICAL MIXTURES**

Often an employee is simultaneously exposed to a variety of chemical substances in the workplace. Synergistic toxic effects on a target organ is common for such exposures in many construction and manufacturing processes. This type of exposure can also occur when impurities are present in single chemical operations. New permissible exposure limits for mixtures, such as the recent welding fume standard (5 mg/m³), address the complex problem of synergistic exposures and their health effects. In addition, 29 CFR 1910.1000 contains a computational approach to assess exposure to a mixture. This calculation should be used when components in the mixture pose a synergistic threat to worker health.

Whether using a single standard or the mixture calculation, the sampling and analytical error (SAE) of the individual constituents must be considered before arriving at a final compliance decision. These SAEs can be pooled and weighted to give a control limit for the synergistic mixture. To illustrate this control limit, the following example using the mixture calculation is shown:

The mixture calculation is expressed as:

\[
E_m = \frac{C_1}{L_1} + \frac{C_2}{L_2} + \ldots \frac{C_n}{L_n}
\]

Where:

- \( E_m \) = equivalent exposure for a mixture
- \( E_m \) should be \( \leq 1 \) for compliance
- \( C = \) concentration of a particular substance
- \( L = \) PEL

For example, to calculate exposure to three different but synergistic substances:

<table>
<thead>
<tr>
<th>Material</th>
<th>8-hr. exposure</th>
<th>8-hr TWA PEL (ppm)</th>
<th>SAE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Substance 1</td>
<td>500</td>
<td>1000</td>
<td>0.089</td>
</tr>
<tr>
<td>Substance 2</td>
<td>80</td>
<td>200</td>
<td>0.11</td>
</tr>
<tr>
<td>Substance 3</td>
<td>70</td>
<td>200</td>
<td>0.18</td>
</tr>
</tbody>
</table>

Using Equation I:1-6I:  \( E_m = \frac{500}{1000} + \frac{80}{200} + \frac{70}{200} = 1.25 \)

Since \( E_m > 1 \), an overexposure appears to have occurred; however, the SAE for each substance also needs to be considered:

@ Exposure ratio (for each substance) \( Y_n = \frac{C_n}{L_n} \)

@ Ratio to total exposure \( R_i = \frac{Y_i}{E_m}, \ldots R_n = \frac{Y_n}{E_m} \)

The SAEs (95% confidence) of the substance comprising the mixture can be pooled by:

\[
(RS)^2 = [(R_1)^2 (SAE_1)^2 + (R_2)^2 (SAE_2)^2 + \ldots (R_n)^2 (SAE_n)^2]
\]
The mixture Control Limit (CL) is equivalent to: 1 + RS_i

If E_m ≤ CL, then an overexposure has not been established at the 95% confidence level; further sampling may be necessary.

If E_m > 1 and E_m > CL, then an overexposure has occurred (95% confidence).

Using the mixture data above:

\[
\begin{align*}
Y_1 &= 500/1000 & Y_2 &= 80/200 & Y_3 &= 70/200 \\
Y_i &= 0.5 & Y_2 &= 0.4 & Y_3 &= 0.35 \\
R_i &= Y_i/E_m &= 0.4 & R_2 &= 0.32 & R_3 &= 0.28 \\
(RS)_i^2 &= (0.4)^2(0.089)^2 + (0.32)^2(0.11)^2 + (0.28)^2(0.18)^2 \\
RS_i &= [(RS)_i^2]^{1/2} &= 0.071 \\
CL &= 1 + RS_i &= 1.071 \\
E_m &= 1.25 \\
\end{align*}
\]

Therefore E_m > CL and an overexposure has occurred within 95% confidence limits. This calculation is also used when considering a standard such as the one for total welding fumes.
A. INTRODUCTION

Worksite analysis (i.e., hazard assessment) is a basic component of an effective safety and health program. A complete worksite analysis requires the assessment of surface contamination since workers may be exposed to these contaminants directly through dermal and ingestive routes (e.g., isocyanates, pesticides), and indirectly through inhalation of contaminants that become re-entrained in the air (e.g., asbestos, lead).

Dermal and ingestive routes of entry are much more significant than inhalation for a large number of chemicals. For example, a fifteen-minute exposure of the hands and forearms to liquid glycol ethers [2-methoxy-ethanol (ME) and 2-ethoxy-ethanol (EE)] will result in a dose to the body well in excess of the eight-hour inhalation dose at their recommended air exposure limits. (Biological monitoring for the urinary metabolites methoxyacetic acid and ethoxyacetic acid was used to estimate the absorption via skin and lung.) Unfortunately, many industrial hygienists are only familiar with air sampling and fail to evaluate significant exposures caused by surface contamination.

Wipe sampling is an important tool of worksite analysis for both identifying hazardous conditions, and in evaluating the effectiveness of personal protective equipment, housekeeping, and decontamination programs. As described below, wipe sampling is an important tool for assessing compliance with certain OSHA requirements even though there are few specific criteria for acceptable surface contamination amounts.

The terms wipe sampling, swipe sampling, and smear sampling are synonyms that describe the techniques used to assess surface contamination. Wipe sampling will be used in this chapter.

Wipe sampling is most often used to determine the presence of asbestos, lead and other metals, aromatic amines, and PCBs.
Surfaces that may come into contact with food or other materials that are ingested or placed in the mouth (e.g., chewing tobacco, gum, cigarettes) may be wipe sampled (including hands and fingers) to detect contamination.

Contaminated smoking materials may allow toxic materials or their combustion products to enter the body via the lungs (e.g., lead, mercury). Wiping of surfaces that smoking materials may touch (e.g., hands, fingers) may be useful in evaluating this possible route of exposure.

Accumulated toxic materials can become suspended in air and may contribute to airborne exposures (e.g., asbestos, lead, or beryllium). Bulk and wipe samples may help assess this possibility.

**Sampling of Personal Protective Equipment**

Effectiveness of personal protective gear (e.g., gloves, aprons, respirators) may sometimes be evaluated by wipe sampling the inner surfaces of the protective gear (and protected skin).

Effectiveness of decontamination of surfaces and protective gear (e.g., respirators) can sometimes be evaluated by wipe sampling.

When accompanied by close observation of the operation in question, wipe sampling can help identify sources of contamination and poor work practices.

**Evaluation of Sampling Results**

- False negative results, i.e., when surface contamination is not detected by a wipe sample, are possible.
- The CSHO must use professional judgment on a case by case basis when evaluating the significance of positive wipe-sampling results.
- When evaluating results, consider the toxicity and the contribution of skin absorption and/or gastrointestinal absorption to the total dose. Additional factors are the ambient-air concentrations, skin irritation, etc.

The Chemical Information Manual or OCIS (the OSHA Computerized Information System on the Internet) lists substances that have a potential for ingestion toxicity, skin absorption, and/or a hazardous effect on skin. This information may be found under the "Health" notation. Additional toxicological information concerning chronic skin absorption, dermatitis, etc. should be used in determining if the resulting exposure presents a potential employee hazard (see Bibliography).

**The use of Surface Contamination Sampling in Evaluating Safety and Health Programs**

29 CFR 1910.132 requires employers to "assess the workplace to determine if hazards are present, or are likely to be present, which necessitate the use of personal protective equipment (PPE)." To this purpose, wipe sampling can be useful in categorizing work areas for certain types of controls, such as PPE and/or special cleaning and decontamination. It is also useful in assessing the effectiveness of these controls, including proper work practices. Examples are provided below for three generalized work areas: controlled areas that require the use of PPE, controlled areas that require the use of special cleaning and/or decontamination, and non-controlled work areas that require neither PPE or special cleaning.

**Controlled Work Areas Requiring PPE**

These are areas where it has been determined (e.g., from an employer's hazard assessment) that PPE is necessary to prevent dermal exposures to a surface contaminant in spite of an aggressive, yet feasible cleaning regimen. Many production areas and specific job tasks fall into this category.

Wipe sampling can be used in assessing the effectiveness of the PPE program. Many elements of PPE programs are intended to prevent contamination to certain locations, such as the use of gloves to prevent contamination to the skin of the hands. Surface contamination found in those "protected" locations usually indicates a problem with the program. For example, the presence of surface contamination inside a glove is normally the result of either PPE failure (e.g., the contaminate soaked through the glove material or a tear in the glove), and/or an improper work practice for using the PPE, such as the worker inserting a contaminated hand inside the glove. Additional sampling and observation can be used to determine the specific source of the program failure and possible abatement (e.g., changing gloves more often, checking for tears before donning, cleaning hands before donning, etc.). Sampling after abatement measures are implemented can be used...
to show the effectiveness of the abatement.

It is important to recognize that this sampling is not attempting to assess the health risk resulting from the contamination inside the glove. Rather, it is to identify failures in the PPE program. Therefore, the criteria for concluding that contamination exists does not need to be quantitative. Criteria and reproducible procedures should be selected that provide confidence that contamination has not been adequately controlled (i.e., contaminant levels are above background). The use of wipe pads that change color upon contact with the contaminant is ideal both in locating contamination and as a visual tool in training workers on the consequences of poor work practices.

Controlled Work Areas Requiring Special Cleaning

Wipe sampling in these areas can show that a feasible and practical regimen of special cleaning and/or decontamination precludes the need for PPE or additional cleaning. The cleaning of lunch room tables, and the decontamination of equipment before being removed from a restricted area are examples of this category. Other examples include cleaning surfaces to reduce accumulation of toxic materials (e.g., asbestos, lead, beryllium) that may become re-suspended in air and thus contribute to airborne exposures.

Wipe sampling is used in these areas as a quality control test of the specialized cleaning (or decontamination) regimen. Therefore, samples are taken to assess contamination levels of those surfaces for which the special cleaning is required. Samples found in excess of an acceptable, task-specific, surface contamination limit (see below) indicate a failure in the cleaning or decontamination program. More aggressive training and supervision of the cleaning procedures and/or scheduling may need to be implemented.

Again, it is important to recognize that this sampling is not attempting to assess the health risk resulting from the contamination. Rather, it is to ensure that the cleaning and decontamination regimen is being effectively implemented. Establishing an acceptable contamination limit will depend on the purpose of the cleaning, and what is feasible for the procedures utilized. For example, periodic vacuuming of floor surfaces in a lead production area may be used to reduce the amount of lead dust available for re-entrainment, but significant lead contamination of the floor would still be expected. An acceptable surface contamination limit for this type of cleaning would be set much higher than a limit used to evaluate cleaning of tables in the break room.

A few surface contamination concentration guidelines have been published, but typically concentration limits must be established by an employer for a specific task. The limits should be based on sufficient initial sampling to determine a"normal" range of contamination that can be expected after utilizing prescribed cleaning procedures. It would be appropriate to include documentation for the limits and their purpose, in the worksite Safety and Health Program.

Non-Controlled Work Areas

These are work areas for which no special cleaning or PPE are required by the Safety and Health Program. Examples of this category are office areas that are physically separated from the production areas. These areas are often "assumed" to have no significant contamination. Wipe sampling is useful in demonstrating the lack of contamination. If samples do show contamination, further investigation would be needed to determine the cause. Consistent positive results would require a re-assessment of whether the area requires controls.

As with sampling to evaluate PPE programs described above, procedures and criteria for sampling non-controlled areas need to provide confidence that contamination has not occurred (i.e., surface concentrations are not above background). Again, the use of wipe pads which change color upon contact with the contaminant is ideal. The "direct reading" capability makes it possible to quickly screen an entire work area (and a single pad may be used for multiple locations within the area).

Sample those locations within the non-controlled area that accumulate dust (e.g., tops of filing cabinets), and surfaces that have potential for contamination from production areas (e.g., paper work brought in from the production areas).

Additional surfaces to consider for sampling include those that may come into contact with food and other materials that are ingested or placed in the mouth (e.g., chewing tobacco, gum, cigarettes).
Contaminated smoking materials may allow toxic materials or their combustion products (e.g., lead, mercury) to enter the body via the lungs. Wiping of surfaces that smoking materials may touch, including the hands, may be useful in evaluating this possible route of exposure.

© Evaluation of Sampling Results

The investigator must use professional judgment on a case-by-case basis when evaluating the significance of wipe-sampling results. As described above, acceptable surface contamination amounts will vary widely for the same toxic agent depending on the purpose and location of the sample. Any concentration above background is sufficient to identify a problem with the PPE program for some sample locations.

When evaluating results, consider the toxicity and the contribution of skin absorption and/or gastrointestinal absorption to the total dose. Additional factors are the ambient-air concentrations, skin irritation, etc.

The OSHA Technical Links Internet site includes Chemical Sampling Information which lists substances that have a potential for ingestion toxicity, skin absorption, and/or a hazardous effect on skin. This information may be found under the “Health” notation. Additional toxicological information concerning chronic skin absorption, dermatitis, etc. should be used in determining if the resulting exposure presents a potential employee hazard (see Bibliography and other references in Technical Links).

B. GENERAL TECHNIQUE FOR WIPE SAMPLING

FILTER MEDIA AND SOLVENTS

Consult the OR-OSHA Lab, the Chemical Information Manual or OCIS (the OSHA Computerized Information System).
System on the Internet), for appropriate filter media and solvents. Dry wipes may be used. Solvents are not always necessary but may enhance removal.

Direct skin wipes should not be taken when high skin absorption of a substance is expected. Under no conditions should any solvent other than distilled water be used on skin, personal protective gear that comes into direct contact with the skin, or surfaces that come into contact with food or tobacco products.

Techniques and media for collection of wipe samples from surfaces vary with the agent and purpose of the sample. It is recommended that the OR-OSHA Lab be consulted when selecting a sampling procedure for a specific chemical or contaminant.

Classic wipe sampling techniques involve wiping a surface with a filter, which is then submitted to the OR-OSHA Lab for chemical analysis.

Generally, two types of filters are recommended for taking wipe samples:

- Glass fiber filters (GFF) (37 mm) are usually used for materials that are analyzed by high-performance liquid chromatography (HPLC), and often for substances analyzed by gas chromatography (GC). The OCIS or the Chemical Information Manual specifies when GFFs are to be used.

- Paper filters are generally used for metals. For convenience, the Whatman smear tab (or its equivalent) or polyvinyl chloride filters for substance that are unstable on paper-type filters are commonly used. (See the OCIS Chemical Sampling Information on specific sampling and analytical methods for details.)

- Polyvinyl chloride filters are available for substances which are unstable on paper-type filters.

- Squares of a gauze material, available from the OR-OSHA Lab upon request, may be used for many organic substances, and have the advantage of being more durable than filter media, especially when wiping rough surfaces. They may be used dry, or wetted with water or solvent to enhance collection efficiency.

- Charcoal-impregnated pads may be useful for collection of volatile solvents from surfaces. They work by trapping the solvent on activated charcoal, similar to air sampling charcoal tubes.

- In certain specialized cases, such as isocyanates and aromatic amines, highly reactive and unstable compounds must be collected on a filter medium that has been treated with a derivatizing reagent. These are available from the OR-OSHA Lab.

For a limited number of chemicals, direct-reading colorimetric wipe sampling procedures are available for qualitative or semi-quantitative detection of surface contaminants. These can be used for acids and bases, isocyanates, aromatic amines, organic solvents (not solvent specific), lead, platinum salts, explosives and hydrazine. Contact the OR-OSHA Lab for more information.

For a variety of pesticides and certain other toxic chemicals, immunoassay kits can provide qualitative or semi-quantitative information on-site, and within about an hour. Some wet chemistry is required. Contact the OR-OSHA Lab for more information.
Preloading a group of vials with appropriate filters is a convenient method. (The Whatman smear tabs should be inserted with the tab end out.) Always wear clean plastic gloves when handling filters. Gloves should be disposable and should not be powdered.

**Sampling Skin for Contamination**

Techniques and media for wipe sampling of skin contamination vary with the agent and purpose of the sample. It is recommended that the OR-OSHA Lab be consulted when selecting a sampling procedure for a specific chemical or contaminant.

There are concerns related to direct wipe sampling of the skin, including the possibility of promoting skin absorption with the use of certain solvents. Contact the OR-OSHA Lab prior to taking wipe samples directly on the skin to receive agent specific procedures and precautions. Where feasible, biological monitoring is often the most effective means of assessing overall absorption of a contaminant, including through the skin.

Before any skin wipe is taken, explain why you want the sample and ask the employee about possible skin allergies to the chemicals in the sampling medium or wetting solution. Employees may elect not to allow sampling of their skin.

As an alternative to direct skin sampling, an indirect measurement of skin contamination (as well as PPE failure) can be assessed by wipe sampling surfaces that workers can touch (e.g., table tops, handles, control knobs, inside surfaces of protective equipment).

Classic wipe sampling techniques as described earlier, employing glass fiber filters, mixed cellulose ester filters or smear tabs, or gauze squares, charcoal impregnated pads, may be used for sampling contaminants on the skin. If it is deemed desirable to moisten the collecting medium to improve collection efficiency, procedures will normally utilize distilled or de-ionized water, or a 50% solution of isopropyl alcohol in water.

Hand washes may be appropriate in some cases. Twenty ml of distilled or de-ionized water, or a dilute solution of mild soap may be added to a zip-style sandwich bag. The hand to be sampled is inserted, and the bag held tightly closed around the wrist. After a few seconds of agitation, the hand is carefully removed, and the wash solution is poured back into a scintillation vial for shipment to the laboratory.

For a limited number of chemicals, direct-reading colorimetric wipe sampling procedures are available for qualitative or semi-quantitative detection of contaminants. These can be used for acids and bases, isocyanates, aromatic amines, organic solvents (not solvent-specific), platinum salts, and hydrazine. The technique differs from that used for surface wipes. Contact the OR-OSHA Lab for more information.

The same technology employed in the colorimetric wipe sampling procedures described above has been applied to a band-aid-type format. These can be applied to the hands inside gloves to demonstrate glove permeability or breakthrough. They can serve as an excellent tool in employee training.

**PROCEDURE**

Follow these procedures when taking wipe samples:

@ Preloading a group of vials with appropriate filters is a convenient method to carry the sample media to the worksite. (The smear tabs should be inserted with the tab end out.) Clean plastic gloves should be worn when handling the filters. The gloves should not be powdered.

@ If multiple samples are to be taken at the worksite, prepare a rough sketch of the area(s) or room(s) to be wipe sampled.

@ Use a new set of clean, impervious gloves for each sample to avoid contamination of the filter by the hand (and the possibility of false positives) and prevent contact with the substance.

@ Withdraw the filter from the vial. If a damp wipe sample is desired, moisten the filter with distilled water or other solvent as recommended in the Chemical Information Manual.

@ Depending on the purpose of the sample, it may be useful to determine the concentration of contamination (e.g., in micrograms of agent per area). For these samples, it is necessary to record the area of the surface wiped (e.g., 100 cm2). This would normally not be necessary for samples taken to simply show the presence of the contaminant.
Firm pressure should be applied when wiping.

Start at the outside edge and progress toward the center of the surface area by wiping in concentric squares of decreasing size.

Some substances should have solvent added to the vial as soon as the wipe sample is placed in the vial (e.g., benzidine). These substances are indicated with an "X" next to the solvent notation in the Technical Links Chemical Sampling Information File.

CAUTION

Skin, personal protective equipment, or surfaces that come into contact with food or tobacco products must be wiped either DRY or with distilled water, never with organic solvents. Skin wipes should not be done for materials with high skin absorption. It is recommended that hands and fingers be the only skin surfaces wiped. Before any skin wipe is taken, explain why you want the sample and ask the employee about possible skin allergies to the chemicals in the sampling filter or medium. If the employee refuses, do not force the issue.

Maximum pressure should be applied when wiping.

To ensure that all of the partitioned area is wiped, start at the outside edge and progress toward the center by wiping in concentric squares of decreasing size.

If the filter dries out during the wiping procedure, rewet the filter.

Without allowing the filter to come into contact with any other surface, fold the filter with the exposed side in, then fold it over again. Place the filter in a sample vial, cap and number it, and note the number at the sample location on the sketch. Include notes with the sketch giving any further description of the sample (e.g., "Fred Employee's respirator, inside;" "Lunch table").

At least one blank filter treated in the same fashion, but without wiping, should be submitted for each sampled area.

Submit the samples to the OR-OSHA Lab with a Field and Laboratory Analysis Report form.
C. SPECIAL TECHNIQUE FOR WIPE SAMPLING

ACIDS AND BASES

When examining surfaces for contamination with strong acids or bases, (e.g., hydrochloric acid, sodium hydroxide), pH paper moistened with water may be used. However, results should be viewed with caution due to potential interference.

DIRECT-READING INSTRUMENTS

For some types of surface contamination, direct-reading instruments may be used (e.g., mercury sniffer for mercury).

AROMATIC AMINES

Screening may determine the precise areas of carcinogenic aromatic amine contamination. This is an optional procedure. (See Appendix I.2-2.)

D. SPECIAL CONSIDERATIONS

Due to their volatility, most organic solvents are not suitable for wipes. Other substances are not stable enough as samples to be wipe sampled reliably. If necessary, judge surface contamination by other means, (e.g., by use of detector tubes, photoionization analyzers, or other similar instruments). Consult OCIS or the Chemical Information Manual.

Some substances should have solvent added to the vial as soon as the wipe sample is placed in the vial (e.g., benzidine). These substances are indicated with an "X" next to the solvent notation in the Chemical Information Manual or OCIS.

Do not take surface wipe samples on skin if:

- OSHA or ACGIH shows a "skin" notation and the substance has a skin LD50 of 200 mg/kg or less, or an acute oral LD50 of 500 mg/kg or less; or
- the substance is an irritant, causes dermatitis or contact sensitization, or is termed corrosive.
E. BIBLIOGRAPHY


APPENDIX I:2-1. TEMPLATES SAMPLES THAT COVER 100 SQUARE CENTIMETERS

DIAMETER OF THE CIRCLE IS 11.2 CM.

THE SIDES OF THE SQUARE ARE 10 CM.
APPENDIX I:2-2. FLUORESCENT SCREENING FOR CARCINOGENIC AROMATIC AMINES

As in the case of routine wipe sampling, wear clean, disposable, impervious gloves. Wipe an area of exactly 100 cm² with a sheet of filter paper moistened in the center with 5 drops of methanol.

After wiping the sample area, apply 3 drops of fluorescamine (a visualization reagent supplied by the OR-OSHA Lab upon request) to the contaminated area of the filter paper.

Place a drop of the visualization reagent on an area of the filter paper that has not come into contact with the surface. This marks a nonsample area or blank on the filter paper adjacent to the test area.

After a reaction time of 6 minutes, irradiate the filter paper with 366 nm ultraviolet light.

Compare the color development of the sample area with the nonsample or blank area. A positive reaction shows yellow discoloration that is darker than the yellow color of the fluorescamine blank.

A discoloration indicates surface contamination, possible aromatic amine carcinogen. Repeat a wipe sampling of the contaminated areas using the regular surface contamination procedure.

The following compounds are some of the suspected carcinogenic agents that can be detected by this screening procedure:

- 4,4'-methylene bis(2-chloroaniline)
- benzidine
- a-naphthylamine
- β-naphthylamine
- 4-aminobiphenyl

ALTERNATE SCREENING METHODS FOR AROMATIC AMINES

The OR-OSHA Lab is testing commercially available kits with wipe pads that contain an aromatic amine indicator. Preliminary evaluations show them to be an adequate screening tool. Their detection limit is approximately 5.0 mg/100 cm². These kits are more convenient than the fluorescent procedure outlined above, and they eliminate the added hazard of handling fluorescamine. Kits will be available for OSHA staff from OR-OSHA Lab.

The following compounds are among the suspected agents that can be detected through this screening procedure:

- methylene dianiline (MDA)
- 4,4'-methylene bis(2-chloroaniline)
- benzidine
- a-naphthylamine
- β-naphthylamine
- 4-aminobiphenyl
- o-toluidine
- aniline
- 2,4-toluenediamine
- 1,3-phenylenediamine
- napthylenediamine
- 2,4-xylidine
- o-chloroaniline
- 3,4-dichloroaniline
- p-nitroaniline.
SECTION I: CHAPTER 3

TECHNICAL EQUIPMENT

A. INTRODUCTION

The OR-OSHA Lab provides the overall management of technical equipment, including calibration and maintenance. Each person to whom technical equipment is assigned is responsible for ensuring that the equipment is properly maintained and calibrated according to Agency schedules.

This chapter discusses the types, calibration, maintenance, and operation of equipment commonly used by OSHA compliance personnel in the field. It is not a comprehensive discussion of all available equipment nor a review of technical equipment.

Mention of a specific product is not meant to imply approval or promotion by OSHA, but merely indicates past procurement policy.

Some technical equipment can be connected to a computer for calculations and print-outs. Consult the manufacturer's manual or call the OR-OSHA Lab.
B. CALIBRATION

The OR-OSHA Lab calibrates and repairs equipment and instruments, and it serves as a source of technical information on instruments and measurement technology.

SHIPPING INSTRUCTIONS

Equipment shall be packed and sent to OR-OSHA Lab when repairs are necessary or calibration is due. Send all parts of the instrument, not just those needing repairs. If the instrument needs repairs or any special attention, attach the Instrument Service Tag (see Figure I:3-1) to the instrument stating the associated problem as clearly as possible. Call OR-OSHA Lab, if there are any questions.

@ Equipment needing regular calibration by OR-OSHA Lab is listed in Appendix I:3-1. Schedules specific to each field office are issued monthly by the OR-OSHA Lab.

– List repairs needed and special instructions on the Instrument Service Tag. Include your name.

– Place the equipment in a clean plastic bag. Packing material should be polystyrene foam, polyurethane foam, or crumpled newspaper. Do not use vermiculite, wood-chips, or other fibrous or powdery material that may create fine dust, and clog the instrument(s).

– Do not send in equipment which has been contaminated. All contaminated equipment should be decontaminated on-site after use. If equipment must be sent in to the OR-OSHA Lab after it has been decontaminated, indicate such, including what the equipment was contaminated with. This information should be clearly shown on the Instrument Service Tag.

– After consultation with the OR-OSHA Lab, equipment contaminated with toxic chemicals must be double-wrapped in plastic bags, and each bag sealed separately with tape or twisted wire. A tag must be attached to the outside bag with the words:

POSTAL REGULATIONS

Packages to be shipped by the postal service cannot exceed 100 inches in length plus girth or 40 pounds in weight. All markings (old registration, certification, addresses, etc.) must be removed from reused shipping containers or covered so that only new markings are visible.

SPECIAL INSTRUCTIONS

Instruments requiring repair or special instructions must be tagged with the symptoms of the malfunction and/or the special instruction written on the tag. The special instructions in Appendix I:3-2 may apply. All toxic materials must be marked and the carrier informed.

The OR-OSHA Lab may sometimes have specialized equipment such as ozone meters, portable gas chromatographs, and radon and bioaerosol monitors available for field use. Contact OR-OSHA Lab for further information.

Figure I:3-1. Instrument Service Tag
C. BATTERIES

ALKALINE BATTERIES

Replace frequently (once a month) or carry fresh replacements.

RECHARGEABLE NI-CAD BATTERIES

Check the batteries under load (e.g., turn pump on and check voltage at charging jack) before use. See manufacturers' instructions for locations to check voltage. Use 1.3-1.4 volts per Ni-Cad cell for an estimate of the fully charged voltage of a rechargeable battery pack.

It is undesirable to discharge a multicell Ni-Cad battery pack to voltage levels that are 70% or less of its rated voltage--doing this will drive a reverse current through some of the cells and can permanently damage them. When the voltage of the battery pack drops to 70% of its rated value, it is considered depleted and should be recharged.

Rechargeable Ni-Cad batteries should be charged only in accordance with manufacturer's instructions. Chargers are generally designed to charge batteries quickly (approximately 8 to 16 hours) at a high charge rate or slowly (trickle charge). A battery can be overcharged and ruined when a high charge rate is applied for too long a time. However, Ni-Cad batteries may be left on trickle charge indefinitely to maintain them at peak capacity. In this case, discharging for a period equal to the longest effective field service time may be necessary, because of short-term memory imprinting.

- Battery care is important in assuring uninterrupted sampling. A pump battery pack, for example, should be discharged to the recommended level before charging, at least once a month. If the pump is allowed to run down until the battery reaches the low battery Fault condition, the pump should be turned OFF soon after the Fault condition stops the pump. Leaving some pumps ON for a long time after this Fault condition can damage the battery pack. Also, avoid overcharging the battery pack.

Other Rechargeable Batteries

Other types of rechargeable batteries are being used in equipment such as lead-acid, nickel-metal hydride, etc. Make sure the manufacturer's instructions are followed concerning the handling and recharging of these types of batteries.

The Care and Feeding of Battery Packs

NiCad Battery Packs in General:

1) Do not overcharge. In general 16 hours is the maximum charge time.

2) Do not use NiCads when they are fully discharged.

3) Cycle at least once per month using the following sequence:
   a) Charge
   b) Discharge
   c) Charge

4) Do not store them in an uncharged state.

5) Charge fully before each use.

6) Charge them for at least twice as long as they were used (example: if the batteries are used for four hours charge them for eight hours)

Pump Specific Information

MSA Escort ELF:

1) Charge at least 14 to 16 hours. Continuous charging for longer periods will not reduce battery life as long as it is done at room temperature.

2) Use only Omega chargers from MSA.
DuPont P4LC

1) When the battery pack is on the pump the charger charges the battery at regular charge (the pump says "chrg" on its LCD) for 14 hours and then switches to trickle charge (the LCD says "tric"). If the charging cycle is interrupted during any portion of the 14 hours the cycle starts over on regular charge.

2) If the battery pack is charged separately from the pump the charger has to be manually switched from regular charge to trickle charge after 14 hours.

3) Do not overcharge. Continuous charging for more than 16 hours at the maximum charge rate will shorten the battery life, however the batteries can tolerate occasional weekend charging.

4) Use only Alpha-1 or Multichargers to charge the batteries.

5) New NiCad batteries should be run for three charge/discharge cycles.

D. ADVERSE CONDITIONS

ADVERSE TEMPERATURE EFFECTS

High ambient temperature, above 100°F and/or radiant heat (e.g., from nearby molten metal) can cause flow faults in air sampling pumps.

If these conditions are likely, contact the OR-OSHA lab for recommendations on which pump to use.

EXPLOSIVE ATMOSPHERES

Instruments shall not be used in atmospheres where the potential for explosion exists (see 29 CFR 1910.307) unless the instrument is intrinsically safe or certified by the Mine Safety and Health Administration (MSHA), Underwriter's Laboratory (UL), Factory Mutual (FM) or other testing laboratory recognized by OSHA for the type of atmosphere present.

When batteries are being replaced, use only the type of battery specified on the safety approval label.

Do not assume that an instrument is intrinsically safe. Verify by contacting the instrument's maker or the OR-OSHA Lab, if uncertain.

ATMOSPHERES CONTAINING CARCINOGENS

A plastic bag should be used to cover equipment when carcinogens are present.

Decontamination procedures for special environments are available through the Manager of the OR-OSHA Lab and should be followed after using equipment in carcinogenic environments.
E. DIRECT-READING INSTRUMENTS

MERCURY ANALYZER-GOLD FILM ANALYZER

DESCRIPTION AND APPLICATION
A gold-film analyzer draws a precise volume of air over a gold-film sensor. A microprocessor computes the concentration of mercury in milligrams per cubic meter and displays the results on the digital meter.

The meter is selective for mercury and eliminates interference from water vapor, sulfur dioxide, aromatic hydrocarbons, and particulates.

CALIBRATION
Calibration should be performed by the manufacturer or a laboratory with the special facilities to generate known concentrations of mercury vapor.

Instruments should be returned to the manufacturer or a calibration laboratory on a scheduled basis.

SPECIAL CONSIDERATIONS
In high concentrations of mercury vapor the gold film saturates quickly. It should not be used for concentrations expected to be over 1.5 milligrams per cubic meter. Hydrogen sulfide is an interferent.

MAINTENANCE
Mercury vapor instruments generally contain rechargeable battery packs, filter medium, pumps and valves which require periodic maintenance.

Except for routine charging of the battery pack, most periodic maintenance will be performed during the scheduled annual calibrations.

TOXIC GAS METERS

DESCRIPTION AND APPLICATION
This analyzer uses an electrochemical voltametric sensor or polarographic cell to provide continuous analyses and electronic recording.

In operation, sample gas is drawn through the sensor and absorbed on an electrocatalytic sensing electrode, after passing through a diffusion medium. An electrochemical reaction generates an electric current directly proportional to the gas concentration. The sample concentration is displayed directly in parts per million. Since the method of analysis is not absolute, prior calibration against a known standard is required. Exhaustive tests have shown the method to be linear; thus, calibration at a single concentration is sufficient.

Types-Sulfur dioxide, hydrogen cyanide, hydrogen chloride, hydrazine, carbon monoxide, hydrogen sulfide, nitrogen oxides, chlorine, ethylene oxide, formaldehyde. Can be combined with combustible gas and oxygen meters.

CALIBRATION
Calibrate the direct-reading gas monitor before and after each use in accordance with the manufacturer's instructions and with the appropriate calibration gas.

SPECIAL CONSIDERATIONS
Interference from other gases can be a problem. See manufacturer literature.

When calibrating under external pressure, the pump must be disconnected from the sensor to avoid sensor damage. If the span gas is directly fed into the instrument from a regulated pressurized cylinder, the flow rate should be set to match the normal sampling rate.

Due to the high reaction rate of the gas in the sensor, substantially lower flow rates result in lower readings. This high reaction rate makes rapid fall time possible simply by shutting off the pump. Calibration from a sample bag connected to the instrument is the preferred method.
PHOTOIONIZATION METERS

DESCRIPTION AND APPLICATIONS

Ionization is based upon making a gas conductive by the creation of electrically charged atoms, molecules, or electrons and the collection of these charged particles under the influence of an applied electric field.

The photoionization analyzer is a screening instrument used to measure a wide variety of organic and some inorganic compounds. It is also useful as a leak detector.

The limit of detection for most contaminants is approximately 1.0 ppm.

CALIBRATION

A rapid procedure for calibration can be done using the manufacturer’s instructions and isobutylene gas.

For precise analyses it is necessary to calibrate the instrument with the specific compound of interest. The calibration gas should be prepared in air.

SPECIAL CONSIDERATIONS

The specificity of the instrument depends on the sensitivity of the detector to the substance being measured, the number of interfering compounds present, and the concentration of the substance being measured relative to any interferences.

Some instruments are approved by Factory Mutual to meet the safety requirements of Class 1, Division 2, hazardous locations of the National Electrical Code.

MAINTENANCE

Keeping these instruments in top operating shape means charging the battery, cleaning the ultraviolet lamp window and light source, and replacing the dust filter.

The exterior of the instrument can be wiped clean with a damp cloth and mild detergent if necessary. Keep the cloth away from the sample inlet, however, and do not attempt to clean while the instrument is connected to line power.

INFRARED ANALYZERS

DESCRIPTION AND APPLICATIONS

The infrared analyzer has been used within OSHA as a screening tool for a number of gases and vapors (contact the OR-OSHA Lab) and is presently the recommended screening method for substances with no feasible sampling and an analytical method. See the Chemical Information Manual or OCIS for specific substances.

These analyzers are often factory-programmed to measure many gases and are also user-programmable to measure other gases.

A microprocessor automatically controls the spectrometer, averages the measurement signal, and calculates absorbance values. Analysis results can be displayed either in parts per million (ppm) or absorbance units (AU).

The variable path-length gas cell gives the analyzer the capability of measuring concentration levels from below 1 ppm up to percent levels.

Some typical screening applications are:

- anesthetic gases including, e.g., nitrous oxide, halothane, enflurane, penthrane, and isoflurane;

CALIBRATION

The analyzer should be calibrated before and after each use in accordance with the manufacturer’s instructions.

SPECIAL CONSIDERATIONS

The infrared analyzer may be only semispecific for sampling some gases and vapors because of interference by other chemicals with similar absorption wavelengths.

MAINTENANCE

No field maintenance of this device should be attempted except items specifically detailed in the instruction book such as filter replacements and battery charging.
MULTI-GAS METERS

DESCRIPTION AND APPLICATIONS

These meters use a platinum element as an oxidizing catalyst for combustibility testing. The platinum element is one leg of a Wheatstone bridge circuit. These meters measure gas concentration as a percentage of the lower explosive limit of the calibrated gas.

The oxygen meter displays the concentration of oxygen in percent by volume measured with a galvanic cell.

Other electrochemical sensors are available to measure carbon monoxide, hydrogen sulfide, and other toxic gases.

Some units have an audible alarm that warns of low oxygen levels or malfunction.

CALIBRATION

Before using the monitor each day, calibrate the instrument to a known concentration of the gas you are measuring. The unit's instruction manual provides additional details on calibration of sensors.

The monitor must be calibrated to the altitude at which it will be used. Changes in total atmospheric pressure from changes in altitude will influence the instrument's measurement of the air's oxygen content.

Special Considerations

Silicone compound vapors, leaded gasoline, and sulfur compounds will cause desensitization of the combustible sensor and produce erroneous (low) readings.

High relative humidity (90%-100%) causes hydroxylation, which reduces sensitivity and causes erratic behavior including inability to calibrate.

Oxygen deficiency or enrichment such as in steam or inert atmospheres will cause erroneous readings for combustible gases.

In drying ovens or unusually hot locations, solvent vapors with high boiling points may condense in the sampling lines and produce erroneous (low) readings.

High concentrations of chlorinated hydrocarbons such as trichloroethylene or acid gases such as sulfur dioxide will depress the meter reading in the presence of a high concentration of combustible gas.

High-molecular-weight alcohols can burn out the meter's filaments.

If the flash point is greater than the ambient temperature, an erroneous (low) concentration will be indicated. If the closed vessel is then heated by welding or cutting, the vapors will increase and the atmosphere may become explosive.

For gases and vapors other than those for which a device was calibrated, users should consult the manufacturer's instructions and correction curves.

MAINTENANCE

The instrument requires no short-term maintenance other than regular calibration and recharging of batteries.

Use a soft cloth to wipe dirt, oil, moisture, or foreign material from the instrument.
F. BIOAEROSOL MONITORS

DESCRIPTION AND APPLICATIONS

A bioaerosol meter, usually a two-stage sampler, is also a multiorifice cascade impactor. This unit is used when size distribution is not required and only respirable-nonrespirable segregation or total counts are needed.

Ninety-five to 100% of viable particles above 0.8 microns in an aerosol can be collected on a variety of bacteriological agar. Trypticase soy agar is normally used to collect bacteria and malt extract agar is normally used to collect fungi. They can be used in assessing sick-(tight-) building syndrome and mass psychogenic illness.

These samplers are also capable of collecting virus particles. However, there is no convenient, practical method for cultivation and enumeration of these particles.

CALIBRATION

Bioaerosol meters must be calibrated before use. This can be done using an electronic calibration system with a high-flow cell, available through the OR-OSHA Lab.

SPECIAL CONSIDERATIONS

Prior to sampling, determine the type of collection media required and an analytical laboratory. The OR-OSHA Lab can provide this information.

This specialized equipment is available from the OR-OSHA Lab with accompanying instructions.

MAINTENANCE

The sampler should be decontaminated prior to use by sterilizer or chemical decontamination with isopropanol.
G. RADIATION MONITORS AND METERS

LIGHT

DESCRIPTION AND APPLICATIONS

The light meter is a portable unit designed to measure visible, UV, and near-UV light in the workplace. A series of interchangeable filters and diffusers with a hand-held photodetector measure workers' exposure to light in the near-UV range (320-400 nm), the normal range, and in the actinic UV range (200-315 nm).

The light meter is capable of reading any optical unit of energy or power level if the appropriate detector has been calibrated with the meter. The spectral range of the instrument is limited only by the choice of detector.

Steady-state measurements can be made from a steady-state source using the "normal operation" mode. Average measurements can be obtained from a flickering or modulated light source with the meter set in the "fast function" position. Flash measurements can be measured using the "integrate" function.

CALIBRATION

No field calibration is available. These instruments are generally very stable and require only periodic calibration at a laboratory.

SPECIAL CONSIDERATIONS

Exposure of the photomultiplier to bright illumination when the power is applied can damage the sensitive cathode or conduct excessive current.

MAINTENANCE

Little maintenance is required unless the unit is subjected to extreme conditions of corrosion or temperature. Clean the optical unit with lens paper to avoid scratching.

Detector heads should be recalibrated annually by the manufacturer only. All calibrations are NIST traceable.

The nickel-cadmium batteries can be recharged. Avoid overcharging, which will reduce battery life.
NONIONIZING RADIATION

DESCRIPTION AND APPLICATIONS

Broad-band field strength meters are available for measuring electromagnetic radiation in the frequency range from 0.5 MHz to 6000 MHz. Each meter comes with probes for measuring either magnetic or electric field strength, batteries, headset, and carrying case.

This unit is designed for laboratory and field use to measure magnetic and electric fields near RF induction heaters, RF heat sealers, radio and TV antennas, or any other radio frequency sources.

SPECIAL CONSIDERATIONS

All units have automatic zeroing. There is no need to place the unit in a zero-field condition to zero it.

All units have a peak memory-hold circuit that retains the highest reading in memory.

All units operate with either electric (E) or magnetic (H) field probes based on diode-dipole antenna design. Total field strength is measured at the meter regardless of the field orientation or probe receiving angle. The diode-dipole antenna design of the probe is much more resistant to burnout from overload than the thermocouple design of probes used with other meters.

MAINTENANCE

No field maintenance is required other than battery-pack charging or replacement.

H. AIR VELOCITY MONITORS AND METERS

FLOW HOODS

DESCRIPTION AND APPLICATIONS

These instruments measure air velocities at air supply or exhaust outlets.

CALIBRATION

No field calibration is available. Yearly calibration by a laboratory is essential.

MAINTENANCE

These typically require little field maintenance other than battery-pack servicing and zero balancing of analog scales. (Check manufacturer's manual.)

THERMOANEMOMETER

DESCRIPTION AND APPLICATIONS

These instruments monitor the effectiveness of ventilation by measuring air velocities.

CALIBRATION

No field calibration is available. Yearly calibration by OR-OSHA Lab is essential.

MAINTENANCE

These typically require little field maintenance other than battery-pack servicing and zero balancing of analog scales. (Check manufacturer's manual.)

OTHER VELOMETERS

Other velometers include rotating-vane and swinging vane velometers.

Note: Barometric pressure and air temperature should be noted when using air velocity meters.
I. NOISE MONITORS AND METERS

SOUND LEVEL METERS AND DOSIMETERS

DESCRIPTION AND APPLICATIONS

The sound level meter is a lightweight instrument for the measurement of sound pressure level (SPL) in decibels.

All ANSI-approved meters meet minimum requirements that include an A-weighted network, a slow-response meter characteristic, and a fully graduated scale with measurements ranging from 80 to 130 dBA.

The Type II meter is most frequently used. Applications are in worker exposure and noise evaluations.

Octave Band Analyzer. Some sound level meters may have an octave or one-third octave band filter attached or integrated into the instrument. The filters are used to analyze the frequency content of noise. They are also valuable for the calibration of audiometers and to determine the suitability of various types of noise control.

CALIBRATION

In normal operation, calibration of the instrument usually requires only checking. Prior to and immediately after taking measurements, check the sound level of the instrument with a calibrator. As long as the sound level readout is within 0.2 dB of the known source, it is suggested that no adjustments to the calibration pot be made. If large fluctuations in the level occur (more than 1 dB), then either the calibrator or the instrument may have a problem.

Send the meter to the OR-OSHA Lab yearly for a thorough calibration.

SPECIAL CONSIDERATIONS

Always check the batteries prior to use. Use the microphone windscreen to protect the microphone when the wearer will be outdoors or in dusty or dirty areas. (The windscreen will not protect the microphone from rain or extreme humidity.)

Never use any other type of covering over the microphone (e.g., plastic bag or plastic wrap) to protect it from moisture. These materials will distort the noise pickup, and the readings will be invalid.

Never try to clean a microphone, particularly with compressed air, since damage is likely to result. Although dirt and exposure will damage microphones, regular use of an acoustical calibrator will detect such damage so that the microphones can be replaced.

Remove the batteries from any meter that will be stored for more than 5 days. Protect meters from extreme heat and humidity.

MAINTENANCE

No field maintenance is required other than replacement of batteries.
PERSONAL DOSIMETERS

DESCRIPTION AND APPLICATIONS

These meters can be worn by personnel to obtain individual readings of noise exposure.

Typical dosimeters consist of a pocket-sized monitor with remote microphone and an indicator for readout of exposure data. Some have a preset threshold; others have a selector switch that may be preset.

CALIBRATION

Field calibrate at the measurement site according to the manufacturer's instructions both before and after each use.

Use an acoustical calibrator that was designed to be used with the particular model noise dosimeter being used.

Send the meter to the OR-OSHA Lab yearly for a thorough calibration.

SPECIAL CONSIDERATIONS

Always check the batteries prior to use.

Be very careful with the microphone cable. Never kink, stretch, pinch, or otherwise damage the cable.

Use the microphone windscreen to protect the microphone when the wearer will be outdoors or in dusty or dirty areas. (The windscreen will not protect the microphone from rain or extreme humidity.)

Never use any type of covering over the microphone (e.g., plastic bag or plastic wrap) to protect it from moisture. Such materials will distort the noise pickup, and readings will be invalid.

Never try to clean a microphone, particularly with compressed air, since damage is likely to result. Although dirt and exposure to industrial environments will damage the microphones, regular use of an acoustical calibrator will detect such damage so that microphones can be replaced.

Remove the batteries when the dosimeter will be stored for more than 5 days. Protect dosimeters from extreme heat and humidity.

MAINTENANCE

No field maintenance is required other than replacement of batteries.

OCTAVE BAND ANALYZERS

DESCRIPTION AND APPLICATIONS

This instrument is used to make precise sound-level measurements and analyze the levels into octave bands using an octave band filter network. It is also valuable for the calibration of audiometers and to determine sources of noise contamination for possible control.

CALIBRATION

Field calibrate at the measurement site according to the manufacturer's instructions before and after each use.

Use an acoustical calibrator designed for use with the model octave-band analyzer being used.

SPECIAL CONSIDERATIONS

Always check the batteries prior to use.

Use the microphone windscreen to protect the microphone when the meter will be outdoors or in dusty or dirty areas. (The windscreen will not protect the microphone from rain or extreme humidity.)

Never use any type of covering over the microphone (e.g., plastic bag or plastic wrap) to try to protect it from moisture. Such materials will distort the noise pickup, and readings will be invalid.

Never try to clean a microphone, particularly with compressed air, since damage is likely to result. Although dirt and exposure to industrial environments will damage the microphones, regular use of an acoustical calibrator will detect such damage so that the microphones can be replaced.

Remove the batteries when the dosimeter will be stored for more than 5 days. Protect dosimeters from extreme heat and humidity.

MAINTENANCE

No field maintenance is required other than replacement of batteries.
J. ELECTRICAL TESTING METERS

DESCRIPTION AND APPLICATIONS

Electrical testing meters include multimeters, clip-on current meters, megohmmeters, battery testers, ground-wire impedance testers, 120-V AC receptacle testers, ground fault interrupt testers, electrostatic meters, and AC voltage detectors.

Multimeters can check for AC leakage, proper line voltage, batteries, continuity, ground connection, integrity of shielded connections, fuses, etc.

Other specialized equipment is described in Appendix I:3-3.

CALIBRATION

Few, if any, field calibrations are available. Check manufacturer's manual. Send the meter to the laboratory yearly for calibration.

MAINTENANCE

No field maintenance is required other than battery-pack servicing.

K. HEAT STRESS INSTRUMENTS

DESCRIPTION AND APPLICATIONS

Heat-stress monitors are portable instruments used to measure environmental factors that may cause heat-related injuries.

Personal heat-stress monitors measure body temperature and sometimes heartbeat through sensor belts around the chest or ear-canal sensors.

CALIBRATION

Send the instrument to the OR-OSHA laboratory yearly for calibration.

MAINTENANCE

Some field servicing is required (check manufacturer's manual).
L. BIBLIOGRAPHY


APPENDIX I:3-1. CALIBRATION INTERVALS

<table>
<thead>
<tr>
<th>Instrument</th>
<th>Interval (years)</th>
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<td>Combustible gas indicators</td>
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<tr>
<td>Electrical Testers</td>
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<td>Gilibrator</td>
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<tr>
<td>Buck</td>
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<tr>
<td>Heat stress monitors</td>
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</tr>
<tr>
<td>Reuter Stokes RSS-214</td>
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<tr>
<td>Vista</td>
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</tr>
<tr>
<td>Nonionizing radiation meters</td>
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</tr>
<tr>
<td>Holiday Meters &amp; Probes</td>
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<tr>
<td>Pumps (hand)</td>
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</tr>
<tr>
<td>Draeger</td>
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</tr>
<tr>
<td>Gastech</td>
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<tr>
<td>Sensidyne</td>
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<td>Staplex</td>
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<td>Sound Instruments</td>
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<td>All sounds instruments</td>
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<td>Toxic gas monitors</td>
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<tr>
<td>Mini Rae PID</td>
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<tr>
<td>Velocity meters</td>
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<tr>
<td>Kurz 441 and 441S</td>
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<tr>
<td>TSI 8357</td>
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</tbody>
</table>
APPENDIX I:3-2. GENERAL PROCEDURES FOR SENDING INSTRUMENTS TO THE OR-OSHA LAB

Never use a carrying case like a shipping case. Carrying cases should be carefully stuffed to avoid any instrument movement during shipping and securely packed in a cardboard box.

**All Hot Wire Anemometers:** Return with their probes. Instrument and probe serial numbers are usually the same.

**SKC, Gilian, MSA and DuPont Pumps:** Return with battery packs. Several types of battery packs can be repaired.

If instrument is shipped with batteries or battery pack inside, turn off all switches.

**All Sound Level Meters:** Send all microphones, both 1" and ½", and all attenuators with the instruments.

Any instrument with gauges, meters, glass or plastic parts exposed should have special protection over or around these parts before final packing for shipment. If a case has been furnished with the instrument, the case should be used whenever the instrument is not actually being operated. The case provides necessary protection. Styrofoam packing, bubbled polyethylene film, or crumpled newspaper may be used for packing.

Those instruments not specifically listed should be shipped using the customary precautions. Contact OR-OSHA Lab if you have questions about specific instruments.
APPENDIX I:3-3. INSTRUMENT CHART

**Note:** Brand names are for identification purposes only and do not imply approval or acceptance by the Occupational Safety and Health Administration.

**PHYSICAL MEASUREMENTS**

<table>
<thead>
<tr>
<th>Measured substance</th>
<th>Application</th>
<th>Brands</th>
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<tbody>
<tr>
<td>Noise dosimeters</td>
<td>Noise</td>
<td>Quest Q300, 400 and 500, Metrosonics</td>
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<tr>
<td>SLM kits type 1</td>
<td>Noise</td>
<td>GenRad 1986-9700</td>
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<tr>
<td>Omnicals</td>
<td>Noise meter calibration</td>
<td>Kurz 441 and 441S, TSI 8357</td>
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<tr>
<td>Thermoanemometer</td>
<td>Air movement</td>
<td>Sensidyne, Gastech, National Draeger</td>
</tr>
<tr>
<td>Hand pumps</td>
<td>Detector tubes</td>
<td>Gilian LFS-113, SKC</td>
</tr>
<tr>
<td>Pumps, low</td>
<td>Air volume sampling with charcoal tubes</td>
<td>Pocket Pump</td>
</tr>
<tr>
<td>Pumps, medium flow</td>
<td>Air volume sampling</td>
<td>Dupont P4LC, MSA Flowlite, SKC AirChek 52 and 2000, MSA Elf, Gilian HFS-113 and HFS-513</td>
</tr>
</tbody>
</table>

**GAS & VAPOR METERS**

<table>
<thead>
<tr>
<th>CO dosimeter</th>
<th>CO</th>
<th>Metrosonics 7700, TSI QTrak</th>
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<tbody>
<tr>
<td>Carbon dioxide meter</td>
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<td>TSI QTrak</td>
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<tr>
<td>Infrared analyzers</td>
<td>CO, CO₂, organic substances</td>
<td>Foxboro Miran 1B</td>
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<tr>
<td>Mercury vapor meters</td>
<td>Mercury</td>
<td>Jerome, Bacharach</td>
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</table>

**RADIATION METERS**

<table>
<thead>
<tr>
<th>Heat Stress Meters</th>
<th>Ambient (environmental) heat</th>
<th>Reuter-Stokes RSS-217, Vista Thermal 860</th>
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<tbody>
<tr>
<td>Photoionization</td>
<td>Ionizable substances</td>
<td>HNU, MiniRae</td>
</tr>
<tr>
<td>Nonionizing radiation meters</td>
<td>Nonionizing radiation waves, heaters</td>
<td>Holaday Field Strength Meter with E and H probes, Narda</td>
</tr>
</tbody>
</table>

**BIOLOGICAL MONITORS**

| Microbial Sampler | Microbes | indoor air quality | Anderson Air Sampler |
SECTION I: CHAPTER 4

SAMPLE SHIPPING AND HANDLING

A. INTRODUCTION

This chapter contains sample handling, packaging, and mailing instructions for industrial hygiene samples to be shipped to the OR-OSHA Lab or another accredited facility. Certain Department of Transportation (DOT) Regulations (49 CFR) may apply to shipment of materials. Contact the OR-OSHA Resource Center to see a current copy of the Code of Federal Regulations Title 49 for Department of Transportation regulations.

SAMPLE COLLECTION

CHEMICAL INFORMATION FILE

Collect all samples following the procedures outlined for the specific chemical or agent in the Chemical Information Table. The current version of the Chemical Information Table is available in Chapter 13, Appendix A of the OR-OSHA Field Operations Manual or at http://www.cbs.state.or.us/internal/osha/lab/lab.htm on the Internet.

SINGLE COMPONENT ANALYSIS

Particular attention should be given to substances that must be submitted for analysis of a single component of a mixture.

INTERFERENCE

@ Lab notification. Laboratory analysis methods and their results may be susceptible to interference by compounds sometimes present in the sample. For this reason, the laboratory must be notified if a suspected interfering substance may be present in the sample.

@ Interfering substances. The following substances should be noted, if suspected or known to be present, on the OSHA-91S form:

- Solvents. Solvents with the same boiling point and polarity as the substance being tested may cause interference, although mass spectral identification will usually resolve any conflict

- Free silica. The following chemicals should be noted on the Field and Laboratory Analysis Report form if they are considered to be present in the work environment or as part of the sample:
aluminum phosphate
feldspars (microcline, orthoclase, plagioclase)
graphite
iron carbide
lead sulfate
micas (biotite, muscovite)
montmorillonite
potash
sillimanite
silver chloride
talc
zircon (zirconium silicate)

- Asbestos. All fibrous materials and high nonfibrous dust levels.
- Metals. High concentrations of other metals and inorganic dust.

BULK SAMPLES

Bulk samples should be submitted to the laboratory in the following circumstances:

- When an analysis is required to support a potential violation (e.g., 1% silica in sand-blasting operations).
- As an analytical reference, or to assess solvent or interference.

B. MAILING INSTRUCTIONS

SAMPLE IDENTIFICATION

Samples sent to the laboratory shall be packaged with a copy of the original Field and Laboratory Analysis Report. Samples are usually sent by shuttle, but for those areas outside the shuttle’s service area, U.S. Mail or other appropriate methods (UPS, Greyhound) may be used. When such methods are used carrier receipts shall be retained by the field office until the samples arrive at the lab.
FILTER CASSETTES

Pack filter cassettes inside a sturdy cardboard box with sufficient packing material so the samples will not be damaged by outside shocks or striking against each other.

NOTE: Asbestos cassettes in particular should not be used with polystyrene packing, because the static electricity may cause the fibers to cling to the sides of the cassette instead of the filter. Take extra care to ensure that the cassettes are not loose in the box during shipping.

Ship with a completed Field and Laboratory Analysis Report form to identify the samples. If the report sheet is to be sent by e-mail, then identify the samples with your name, date, firm name or inspection number, and analytes.

Do not ship bulk samples in the same mailing package as air samples.

SOLID SORBENT TUBES

Sealed tubes should be put in a sealable plastic bag or whirlpak to prevent individual tubes from being mixed with the packing material. For sorbent tubes which must be shipped cold, pack the tubes in a plastic bag with blue ice to prevent the tubes from slipping away from the ice during shipping, then wrap the plastic bag with bubble pack, and ship with Field and Laboratory Analysis Report sheet in a sturdy container.

MIDGET IMPINGER OR FRITTED GLASS BUBBLER SAMPLES

Samples may be left in the impinger if they are to be delivered personally to the lab. For samples which are going to be shipped, transfer the sample into a small sample bottle. Tighten the cap and wrap elastic tape counterclockwise around the cap so that as the tape shrinks, it will tighten the lid. Fed OSHA uses black electrical tape.

Seal the bottle inside a whirlpak. This is done to prevent leaking through the package even if an individual sample does leak. Label and seal whirlpak with a sample seal. If the sampling media needs to be kept cold, ship in a cooler with blue ice.

Include the Field and Laboratory Analysis Report sheet with samples.

Ship by state shuttle mail or Greyhound Package Express, depending upon the requirements of the sampling media. If Greyhound is used, also use the package delivery service from the station to the lab.

MSDS’s are included with sampling media shipments. DOT regulations exempt us from hazardous labeling of packages containing less than 5L of Toluene.
WIPE SAMPLES

Wipe filters should be in liquid-proof containers to prevent cross-contamination from any source or contaminants in the mailing container. If a hazardous solvent was used to wet the filters, proper labeling and packaging may be required. Wipe samples must be identified as such on the accompanying Field and Laboratory Analysis Report.

BULK SAMPLES

Bulk solvent samples should never be mailed to the laboratory in the same package with any other type of air sample.

Bulk solvent samples should be shipped in vials with caps having Teflon liners and wrap the vials with tape to prevent the caps from loosening. Then wrap an evidence seal over the cap, down around the bottom. The vials should be well packaged in adsorbent material, and sent in a sturdy container. If the material is hazardous according to DOT regulations, it should be properly labeled and packaged.

A copy of the Field and Laboratory Analysis Report (if the original is with the air samples) must accompany each bulk sample. The sheet must identify the shipped material as a bulk sample and must list the air sample numbers corresponding to the bulk sample. The air sample's Field and Laboratory Analysis Report should also indicate that an associated bulk sample is being shipped and also the mode of shipment to the Lab. If available, include a copy of the material safety data sheet for the bulk sample.

SOIL SAMPLES

For contaminated soil, pesticide and other nonroutine samples the HCO/SCO must directly contact the laboratory to which the sample will be sent to ascertain how the samples are to be shipped.

The OR-OSHA lab will assist the HCO/SCO in determining which laboratory will conduct the needed analysis.

Bagging

- Soil should be placed in a heavy-duty plastic bag that will not tear, and secured and sealed air-tight with tape. Place the first plastic bag in a second heavy-duty bag for additional protection.

Size of Samples

- Samples should vary from one pint for very fine-grained samples to two quarts for coarse gravel. A typical sample should be approximately one quart and weigh three pounds.

Sample Identification

- Each plastic bag should be sealed for identification with a seal containing a field number, sampling date, and the sampler's name. A laboratory number will be assigned to each sample at the OR-OSHA lab.

Sample Shipping

- The heavy-duty bags containing soil samples should be tied at the top and placed in a box for shipment to the OR-OSHA lab. The Field and Laboratory Analysis Report should not be in contact with the soil.

A Field and Laboratory Analysis Report must be submitted for each soil sample.
C. FEDERAL MAILING REGULATIONS

JURISDICTION

When shipping hazardous materials to the Lab, Department of Transportation (DOT) regulations must be followed. Such regulations may prohibit the use of the United States Postal Service (USPS) or the state shuttle service.

RESPONSIBILITY

The shipper is responsible for compliance with applicable transportation or postal laws and regulations governing acceptability to the carrier and additional packaging requirements.

All items that are acceptable for mailing are subject to provisions of Part 124, USPS Manual and Publication 52 of the USPS, Acceptance of Hazardous or Perishable Articles.

The Transportation Safety Act of 1974 extended the Department of Transportation's (DOT) authority over transportation of hazardous or restricted materials. The full text of the hazardous materials regulations is contained in Title 49, Code of Federal Regulations, Part 100-199. It is the shipper's responsibility to comply with all applicable DOT regulations.

HAZARDOUS MATERIALS

The main categories of hazardous materials sent to the laboratory are:

@ poisons,
@ flammable liquids,
@ oxidizers,
@ flammable solids,
@ corrosive materials (acids and alkalies), and
@ irritating materials.
@ Biological samples

Publication 49 CFR Table 172.101 is the key to understanding current DOT regulations for domestic shipment of hazardous materials. If hazardous materials are to be shipped internationally, then either the International Civil Aviation Organization (ICAO) technical instructions or the International Air Transport Association (IATA) instructions are to be used. To ensure that current regulations are followed, it is important to use only the most recent edition of 49 CFR, ICAO, or IATA.

The USPS and private carriers base their shipping procedures for hazardous materials on the DOT 49 CFR regulations. These regulations are the minimum acceptable for hazardous materials. In some case, the carriers have chosen to be more restrictive than DOT regulations. In using these procedures, it is the shipper's responsibility to determine if the carrier they plan to use is more restrictive than DOT. The shipper must comply with the carrier's requirements.

NOTICE TO THE CARRIER

For all modes of transportation, the carrier must be clearly informed that hazardous material is being tendered.

Notification must be given. Any person who violates a provision of Title 49 in shipping a hazardous material shall be subject to a civil penalty of not more than $10,000 per violation, and if any such violation constitutes a separate offense. A person who willfully violates a provision of this title and is convicted of a criminal offense is subject to a fine of not more than $25,000, imprisonment for a term not to exceed 5 years, or both.

The great variety of chemicals precludes the listing of each item that may be mailed.

Publications available from the United States Postal Service give an indication of what can be mailed.

Certain chemicals are not mailable as bulk samples.
Examples are:
Nitric acid
Aniline
Gasoline
Chloropicrin
Perchloric acid
Organic phosphate compounds
Benzyol peroxide
Parathion (liquid)
Class A poisons

Special handling or analysis may be needed in these cases.
Most solid sorbent tubes, silica-gel tubes, filters, and wipe samples will not be classified as hazardous materials and can be shipped as regular certified mail through the USPS.

When a restricted article is tendered for shipment, the customer is required properly to identify, classify, package, mark, label, and certify all articles as specified in Title 49. A Shipper’s Certification and labels for restricted articles can be obtained from:

American Labelmark
5724 N Pulaski Rd
Chicago, IL 60646
(312) 478-0900

Since all samples are subject to possible litigation, there has to be a chain and/or proof of custody of the samples from the field to the Laboratory. The preferred form is the certified mail receipt. Samples shipped by certified mail go first class (air mail).

Detailed instructions on sample shipping according to DOT regulations are available directly from the DOT.