III. DIRECT-READING INSTRUMENTATION FOR AIR CONTAMINANTS

Direct-reading instruments or monitors (also called real-time instruments or monitors) provide information at the time of sampling, thus enabling rapid decision-making. These instruments can often provide the trained and experienced user the capability to determine if site personnel are exposed to airborne concentrations which exceed instantaneous (ceiling or peak) exposure limits for specific hazardous air contaminants. Direct-reading monitors can be useful in identifying oxygen-deficient or oxygen-enriched atmospheres, immediately dangerous to life or health (IDLH) conditions, elevated levels of airborne contaminants, flammable atmospheres, and radioactive hazards. Direct reading instruments are particularly useful for identifying point source contamination or emissions. Periodic monitoring of airborne levels with a real-time monitor is often critical, especially before and during new work activities. Direct-reading instruments are useful for performing screening surveys to determine areas where additional evaluation is warranted. Data obtained from direct-reading monitors can be used to evaluate existing health and/or safety programs and to assure proper selection of personal protective equipment (PPE), engineering controls and work practices.

CSHO Safety

Before bringing monitoring equipment or other electrical devices into an area with the potential for an explosion, always check the Class and Division number marked on the instrument. Use only the type of battery specified on the safety approval label, and replace batteries in a nonhazardous area. Do not assume that an instrument is intrinsically safe. If uncertain, verify by contacting the instrument manufacturer or the CTC.

For atmospheres or work surfaces contaminated with hazardous chemicals, use a plastic bag to cover appropriate parts of equipment to limit contamination. Ensure that the plastic bag is not tightly sealed as this can cause back pressure on the air sampling pump (if equipped). Properly decontaminate all equipment to minimize potential contamination of other persons or objects when sampling is complete. To the extent possible, gross decontamination should be performed onsite.

Before using a direct-reading instrument, review information in the instrument manual regarding the following characteristics:

- Battery life - how long can the instrument run from battery power?
- Datalogging - can the instrument record readings electronically? If so, how is this information retrieved?
- Size and weight - how practical will the instrument be for short-term breathing zone measurements? Will a cart be needed for moving the instrument around?

- Sampling wand - does the unit have a sampling hose and probe to allow for remote sampling, or to allow breathing zone measurements for larger instruments?

- Warm-up time - how long does the unit need to be powered on before it can produce accurate readings?

- Response time (lag time) - how long is the delay between exposing the inlet to a contaminated atmosphere and obtaining an accurate reading?

- Sensitivity - can the analyte be detected, and what is the minimum contaminant concentration that can be reliably measured or detected?

- Specificity - can the instrument discriminate between one contaminant and another?

- Interferences - are there chemicals which, if present, may produce false readings? Are there chemicals, dusts, or other conditions which may damage the sensor?

- Environmental conditions - what is the acceptable temperature and humidity range for use of the instrument? Will temperature and humidity affect the accuracy of the readings? What about altitude? Can the unit be used in a dusty environment without damaging it or requiring factory service? Are there filters available to protect the instrument in these situations?

- Hazardous areas - can the instrument be used in electrical classified areas?

The sections which follow describe the principal types of direct-reading instrumentation. The types discussed include the following:

- Photoionization detectors
- Infrared analyzers
- Gas, oxygen and explosibility (combustible gas) monitors
- Detector tubes
- Mercury analyzers
- Dust/particulate monitors

A. PHOTOIONIZATION DETECTORS

Application and Principle of Operation

Photoionization detectors (PIDs) are used for nonspecific detection of a variety of chemicals, particularly hydrocarbons. PIDs are useful for pinpointing contaminant sources, or for identifying concentration gradients throughout a space, because the readout is proportional to the concentration of contaminant present. However, PIDs cannot positively identify contaminants present in an environment. Where more than one airborne contaminant is present, the instrument may not distinguish one from the other.

PIDs use a high energy ultraviolet (UV) light source to ionize chemicals in an airstream. The charged molecules are collected on a charged surface, which generates a current that is directly

proportional to the concentration of the chemical in the air being sampled.

The ionization potential (IP) describes the amount of energy needed to induce ionization in a particular chemical. If the energy of the UV lamp is greater than or equal to the IP of the chemical being sampled, then the chemical will be detected. PIDs may be configured with lamps of different energies. Typical lamp energies are 9.5, 10.6, and 11.7 electron volts (eV). The higher the lamp energy, the greater the number of chemicals that can be detected. For example, benzene (IP 9.25 eV) can be detected with a 9.5 eV lamp, while methylene chloride (IP 11.35 eV) requires use of the 11.7 eV lamp. In general, higher energy lamps have a much shorter lifespan than lower energy lamps. Further, the lamp energy must be lower than background atmospheric gases to be of practical use. For example, the IP of carbon monoxide is 14.01 eV, while the IP of molecular oxygen is 12.08 eV; because the IP of carbon monoxide is higher than for oxygen, a lamp that could ionize carbon monoxide would not be useful for quantifying parts per million (ppm) concentrations of carbon monoxide in the presence of percent concentrations of oxygen (1 percent = 10,000 ppm). Similarly, the IP of many chlorinated hydrocarbons may be too high to be detected by use of a PID.

The amount of electric current (signal response) generated in a PID varies with the chemical to which the PID is exposed, along with the lamp energy. The response factor is the ratio of the detector response for a particular chemical relative to a reference gas, usually isobutylene. The signal response must be multiplied by the response factor to quantify the concentration of the contaminant of interest. Response factors for a large number of chemicals are pre-programmed into the instrument. When sampling in an environment where a single identified gas is known to be present, select the display name for that gas and the readout will be automatically corrected using the response factor for that gas. For chemicals which are not preprogrammed into the instrument, the response factor should be determined by exposing the detector to a known concentration of the gas of interest, by preparing a bag sample (i.e., using a nonreactive Tedlar® bag). Follow the process described in the instrument manual.

Please note that the response factor also depends on the lamp energy. Ensure that the instrument has been set for the energy of the lamp which has been installed. If an incorrect response factor is applied, the displayed reading would significantly under- or over-estimate the concentration of the contaminant in question. The instrument manual includes a table listing the IP and response factor for a variety of common chemicals.

Calibration

PIDs are calibrated using a reference gas, usually isobutylene. Because the response is linear with concentration, a two point calibration is sufficient. Zero gas contains 0 ppm of contaminant, while span gas contains a specified concentration of the reference gas. Use the calibration gases available through the Agency Expendable Supplies Program (AESP) that are specified for the instrument you are using. Calibration gases are typically delivered in nonrefillable 1 liter cylinders. Be sure the gas has not exceeded the expiration date marked on the cylinder. When multiple sensors are present on the same instrument, the right gas mix is necessary to ensure that the span gases for the different sensors do not adversely affect other sensors on the same instrument.

In most cases a calibration check is sufficient, in which the instrument is “zeroed” in fresh air (such as an office environment), then the calibration gas is applied, and if the reading matches the concentration of the span gas, full calibration is unnecessary. Perform a calibration check before each day’s use. If the reading is off, perform a full calibration using zero gas and span gas. Follow the instructions in the manual to enter calibration mode; the unit will auto calibrate, that is, it will

internally adjust the signal response so that the displayed reading matches the span gas concentration.

Performing a calibration check using the chemical of interest is recommended where practical, but may not be necessary or possible. In a well-ventilated area, prepare a bag sample of known concentration of the chemical of interest, select that chemical from the instrument library, and ensure that the reading matches the bag concentration.

Special Considerations

Photoionization sensitivity is dependent upon the age of the lamp and cleanliness of the lamp window. Over time, the output of the lamp will be reduced. A spare lamp is sometimes included in the case. Also, the accumulation of organic deposits or buildup of film on the surface of the lamp will reduce sensitivity.

PIDs are also affected by high humidity. For the most sensitive results, it is best to zero the instrument using representative air; that is, zero the instrument in the field in a “clean” area of similar temperature and humidity. The lamp may need to be cleaned more frequently when used in a high temperature, high humidity environment.

Consult the user manual regarding potential interferences. Water vapor, carbon dioxide, methane, and carbon monoxide can all produce a low reading for the gas of interest if present in the air being sampled due to quenching by these non-ionizable gases.

Maintenance

Follow the manufacturer's recommendations for maintaining the detector in optimal condition. This will include routine cleaning of the UV lamp using methanol and frequent replacement of the dust filter. Exercise caution in cleaning the lamp window, as these are fragile. 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 and do not attempt to clean the instrument while it is connected to a power source.

B. INFRARED ANALYZERS

Application and Principle of Operation

Infrared (IR) analyzers are useful for measuring a broad range of inorganic and organic chemicals in air. The sensitivity of IR analyzers can be sufficient to quantify chemical concentrations below the OSHA Permissible Exposure Limits (PEL) for many chemicals. IR analyzers can also be used to identify unknown chemicals by using spectral matching. Due to their weight (approximately 10 kg), IR analyzers are most suitable for area sampling rather than personal sampling, although they can be used to analyze a bag sample of contaminated air collected in the breathing zone of a worker (e.g., using a Tedlar® bag). IR analyzers can be used for continuous sampling, although battery life is generally not sufficient for full-shift sampling. Some of the routine applications for IR analyzers include measuring carbon dioxide in IAQ assessments; waste anesthetic gases and vapors including nitrous oxide, halothane, enflurane, penthrane, and isoflurane; and fumigants, including ethylene oxide, ethylene dibromide, chloropicrin, and methyl bromide. IR analyzers are also used in tracer gas studies, such as fume hood performance testing (although these studies are not generally conducted by CSHOs).

IR analyzers operate by passing IR radiation generated from a heated metal source through a gas sample. The IR radiation is absorbed by the chemical at specific wavelengths determined by the type of bonds present in the molecule. The absorbance is proportional to the concentration of the chemical in the sample. The portable IR analyzer is preloaded with a library of known chemicals; to quantify a known chemical in the environment, the user selects the appropriate wavelength for that chemical from the library. The wave number, or number of wavelengths in one centimeter, is commonly used to describe IR spectra. The wave number is the reciprocal of the wavelength and is expressed in cm^{-1}. The infrared spectrum typically used in infrared analysis ranges from the far infrared region at 400 cm^{-1} (25 micrometers) to the near infrared region 4,000 cm^{-1} (2.5 micrometers).

The sensitivity (detection limit) can be increased by increasing the path length through which the light source travels. The Miran SapphIRe portable ambient analyzer can measure at a path length of either 0.5 meters or 12.5 meters. Generally the response time is slightly slower for the longer path length.

Where multiple chemicals may be present in the environment, interference can be a problem. A unique absorbance wavelength must be identified to distinguish one chemical from another. The instrument may offer more than one wavelength for measuring concentrations of the same chemical, in order to avoid interferences from different chemicals. The user needs to assess what other chemicals are likely to be present and select the wavelength least likely to have interferences. In some instances, a weaker absorbance band at a different wavelength is chosen to measure a chemical in air, if that alternate wavelength is uniquely absorbed by the chemical of interest.

The selected wavelength for analysis of a chemical is chosen both because the chemical of interest has sufficient absorbance at that wavelength and sufficient specificity to exclude the absorbance of other chemicals. For example, acetone in air absorbs IR at both 8.4 and 11.0 micrometers. If methyl acrylate was also known to be present in the air, the 11.0 micrometer IR wavelength would be selected because methyl acrylate absorbs at 8.4 micrometers.

An IR analyzer can be used to identify unknown chemicals by matching measured spectral absorbance with spectra for known chemicals. The Miran SapphIRe ThermoMatch spectrum correlation software includes 150 common industrial chemicals, and additional spectra can be added by the user. Please note that the ThermoMatch feature is NOT intrinsically safe and must not be used in electrical classified areas.

Calibration

The Miran SapphIRe analyzer is pre-calibrated for a list of chemicals which are stored in the instrument library. A calibration check can be performed using the sampling loop kit. The sampling loop kit recirculates a known volume of air and allows the injection of a known amount of a volatile liquid or gas into the IR sampling cell. Instrument zeroing is performed by using a charcoal filter attachment to remove chemicals from the air. Conduct field calibration in accordance with the

manufacturer's recommendations.

Special Considerations

Infrared analyzers may not be specific for the chemical of interest because other chemicals present in the work environment air may also absorb at the same wavelength. Cell window degradation will occur if the analyzer is used in the presence of ammonia and many alkyl amines, such as methyl amine.

Maintenance

Field maintenance is limited to replacement of the zeroing filter after a specified number of uses and replacement of the particulate filter in situations where adsorbed particulates or non-volatile liquids may have contaminated the filter surface.

C. GAS, OXYGEN AND EXPLOSIBILITY (COMBUSTIBLE GAS) MONITORS

A variety of hand-held monitors are supported by the CTC for single, dual, or multi-gas monitoring. Single or dual gas monitors are available from the CTC which can monitor carbon dioxide, carbon monoxide, hydrogen sulfide, and a variety of additional toxic gases. Multi-gas monitors incorporate separate sensors for oxygen, combustible atmosphere, and up to three toxic gases in the same hand-held monitor. The sample concentration is displayed in ppm, percent oxygen or percent LEL (Lower Explosive Limit), as applicable. The monitors are available through the Agency Loan Equipment Program ALEP and the Agency Technical Equipment Procurement Program (ATEPP).

Multi-gas monitors typically feature datalogging capability, as well as audible and/or visual alarms that warn of IDLH or time-weighted average toxic gas concentrations, low oxygen levels, LEL conditions, or malfunction. These monitors may operate in passive (diffusive) mode, or in active mode, in which a pump module draws air across the sensors. Active mode speeds the response time on the meter, but care must be taken to avoid drawing particulates into the monitor. Use active mode for remote sampling of a hazardous atmosphere: introduce the extendable wand, or probe attached to the meter by tubing, into the hazardous atmosphere while the user remains outside the hazardous area (e.g., confined spaces).

Calibration gases for both multi and single gases are available through the AESP. Ensure that the calibration (span) gas is intended for the meter make and model you are using. This is particularly important for multi-gas use because some gases in the mixture can adversely affect other sensors in the same meter. Span Gas Cylinder Recycling is available for empty span (calibration) gas cylinders obtained through the AESP.

Order of testing: *Confined spaces, such as sewers and well pits, commonly contain a hazardous atmosphere which may be oxygen deficient and contain a flammable or toxic gas. Many flammable gas sensors are oxygen dependent and will not provide reliable readings in an oxygen deficient atmosphere. Therefore, oxygen content must always be determined before taking combustible gas readings. Flammable gases and vapors are tested second because the risk of fire or explosion is typically more life-threatening than exposure to toxic air contaminants. Monitoring for toxicity is usually conducted last. This monitoring process is greatly simplified by using a multigas monitor containing sensors for oxygen, LEL, and the relevant toxic gases.*

The sections which follow describe in further detail the various sensor types which may be installed on a hand-held monitor. Oxygen sensors are discussed first, followed by combustible gas (explosibility) sensors, and lastly, toxic gas sensors.

1. Oxygen Sensors

Application and Principle of Operation

Oxygen sensors are typically based on electrochemical (galvanic) cells. The generated current in the sensor, which is produced from an oxidation reaction, is directly proportional to the rate of oxygen diffusion into the cell. Most meters are calibrated to measure oxygen concentrations between 0 and 25 percent by volume in air. Normal air contains about 20.9 percent oxygen. Meter alarms are usually set to indicate an oxygen deficient atmosphere at concentrations lower than 19.5 percent and an oxygen rich atmosphere at concentrations greater than 23.5 percent. Oxygen concentrations below 19.5 percent may result in difficulty breathing and impaired judgment. Oxygen concentrations below 16 percent result in rapid heartbeat and headache. Sudden physical exertion in an oxygen deficient environment may lead to loss of consciousness. Oxygen concentrations below 12 percent will bring about unconsciousness rapidly and without warning, and are considered IDLH. Oxygen enriched atmospheres present a fire and explosion hazard because ordinary combustible materials will burn more rapidly.

Calibration

Calibration is typically accomplished using fresh outdoor air (20.9 percent oxygen). Calibrate immediately before testing at or near the temperature of the tested atmosphere.

Maintenance

Oxygen sensors are inherently self-consuming and generally last from six to 12 months. When the unit cannot hold calibration, return it to the CTC for sensor replacement and repair (i.e., complete an Instrument Service Request).

2. Explosibility (combustible gas) Sensors

Application and Principle of Operation

Combustible gas sensors use an oxidizing catalyst such as platinum or palladium. Combustible gas meters measure flammable gas concentration as a percentage of the LEL of the calibrated gas. When possible, to maximize the accuracy of the combustible gas readings, calibrate the instrument with the gas that will actually be monitored. If monitoring for combustible atmospheres other than the reference gas (i.e., calibration gas) consult the manufacturer's instructions and correction charts/curves to determine a more accurate reading of the true gas concentration. Please note that LEL values for most flammable gases and vapors are a few percent in air (i.e., tens of thousands of ppm) and are NOT appropriate for assessing PEL concentrations of flammable toxic gases.

Calibration

Before using the monitor each day, calibrate it with an appropriate calibration gas as described in the user manual or in consultation with CTC. Follow the instructions in the user manual.

Consult the instruction manual before calibration, and ensure that the calibration gas is introduced at the proper pressure and flow rate, using the appropriate regulator and adaptors. Overpressurization can damage the sensor. For some instruments with an active sampling pump, the pump must be disconnected from the sensor and the span gas flow rate set to match the sampling rate of the pump.

Special Considerations

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

- High relative humidity (90 percent to 100 percent) 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. Always note the oxygen concentration reading before assessing the LEL reading.

- In extraordinary circumstances, gas concentrations above the Upper Explosive Limit (UEL) may give a false reading indicating a noncombustible atmosphere; be aware that if air is suddenly introduced into such a space, the atmosphere can quickly become explosive.

- Vapors from liquids with flash points above 90°F such as turpentine, diesel fuel, and jet fuel, may not be adequately detected by combustible gas sensors. Use of a photoionization detector may be more appropriate.

- In drying ovens or unusually hot locations, solvent vapors with high boiling points may condense in the sampling lines and produce erroneous (low) readings. Consider taking readings at several different locations around the oven.

- 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.

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.

3. Toxic Gas Sensors

Application and Principle of Operation

Available toxic gas sensors include sensors for carbon monoxide, hydrogen sulfide, nitrogen dioxide, sulfur dioxide, chlorine, chlorine dioxide, phosphine, ammonia, hydrogen cyanide and hydrogen. While the toxic gas sensors are interchangeable, these instruments are not easily serviced in the field. Should a different gas sensor need to be installed, return the instrument to the CTC for a change of sensors.

Toxic gas sensors generally use an electrochemical (voltammetric) sensor or polarographic cell to provide continuous analyses. In operation, sample gas is 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.

Interference from other gases can be a problem. Before use, consult the user manual to identify interfering chemicals of concern. Some interfering compounds can result in false positive readings. In other cases, the sensor can be damaged, or "poisoned" by exposure to certain compounds, in which case it will need to be returned to the CTC for sensor replacement.

Calibration

Calibration against a known standard is required. Tests have shown the method to be linear; thus, calibration at a single concentration, along with checking the zero point, is sufficient. Calibrate with the appropriate calibration (span) gases before and after each use in accord with the manufacturer's instructions.

The monitor should be calibrated at the altitude at which it will be used. Changes in total atmospheric pressure caused by changes in altitude will influence the instrument's response. The unit's instruction manual provides additional details on the calibration of sensors.

Consult the instruction manual before calibration, and ensure that the calibration gas is introduced at the proper pressure and flow rate, using the appropriate regulator and adaptors.

Overpressurization can damage the sensor. For some instruments with an active sampling pump, the pump must be disconnected from the sensor and the span gas flow rate set to match the sampling rate of the pump.

D. DETECTOR TUBES

Application and Principle of Operation

There is a wide variety of commercially available detector tubes which can be used to measure over 200 organic and inorganic gases and vapors in air. Detector tubes are sealed glass tubes filled with a granular material that is coated with an appropriate indicator chemical that will react with a particular gas or vapor to give a color change. Their operation consists of using a portable pump to draw a known volume of air through a detector tube designed to measure the concentration of the substance of interest. The color change is read in terms of either the length of stain generated inside the tube or the degree of color change. This color change is compared either to a scale printed on the tube or to a reference chart included with the tube kit to determine the airborne concentration.

The pumps can be hand-operated (weight: 8-11 ounces), or they can be an automatic type (weight: about 4 pounds [lbs]) that samples using a preset number of pump strokes. Detector tubes of a given brand are to be used only with a pump of the same brand. A brand of tubes is calibrated specifically for the same brand of pump and may give erroneous results if used with a pump of another brand.

Important considerations for use of detector tubes include measurement accuracy, limits of detection, interferences, temperature and humidity, shelf life, and the time period for which the color stain is stable after the sample is drawn. Always consult the manufacturer's printed

instructions to determine these specifications, along with the required number of pump strokes and the time between pump strokes.

Detector tubes are most useful for screening purposes to determine whether levels of contaminant present in an area warrant further sampling. Several different types and brands of detector tubes have been evaluated for screening use by the SLTC. Information regarding these evaluations can be obtained by contacting the SLTC. Detector tubes can also be used for compliance sampling relative to TWA (8-hour time-weighted average), STEL (short-term exposure limit) and Ceiling limits. For example, the SLTC has documented procedures for use of direct-reading devices, including detector tubes, for the measurement and tracking of methylene chloride exposure. This document discusses the specific detector tubes recommended to determine workplace methylene chloride concentrations based on laboratory studies and includes an example calculation of a methylene chloride TWA exposure. The minimum number of pump strokes required to get a positive response near the STEL is also discussed.

Detector tubes are obtained through the CTC AESP. OSHA's Chemical Sampling Information (CSI) files list specific manufacturer's models of detector tubes for individual gases/vapors. The specific tubes listed are designed to cover a concentration range near the PEL. Concentration ranges are tube-dependent and can be anywhere from one-hundredth ppm to several thousand ppm. The limits of detection depend on the particular detector tube. Detector tube accuracy varies with tube manufacturer and with each detector tube range.

Before use, refer to the manufacturer's instructions for the particular tube type. Determine the measurement precision, which is typically +/- 25-35%, and be sure to record the measurement accuracy when recording the sample result on the Form OSHA-93, Direct Reading Report Form. Also, perform a pump leak test as shown in Figure 2.

To use, break the ends with a tube opener, which is generally part of the manufacturer's sampling kit. Attach the tube to the pump of the correct brand. Tubes generally have a directional arrow printed on each tube. As shown in Figure 1, ensure that the directional arrow is oriented toward the pump. Use the number of pump strokes specified by the manufacturer for that tube type.

FIGURE 1. PROPER INSERTION OF DETECTOR TUBE INTO PUMP.

FIGURE 2. PUMP LEAK TEST.

On each day of use, before taking measurements, perform a pump leakage test as

per the user instruction manual. The general procedure is to insert an unopened detector tube into the pump and attempt to draw in 100 milliliters (mL) of air. After a few minutes, check for pump leakage by examining the 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. The leak test procedure is shown in Figure 2.

In the event of pump leakage that cannot be repaired in the field, send the pump to the CTC for repair. Record that the leakage test was performed on the Direct Reading Report Form (OSHA-93).

The Dräger Chip Measurement System is an accurate and reliable hand-held reader based on colorimetric detection which is very useful for spot gas measurements. It combines an electronic-based analyzer with substance specific chips which are available through the AESP. Each chip contains 10 capillaries filled with a reagent system. The results of up to 50 measurements can be stored in a data recorder integrated in the analyzer.

Interferences

A limitation of many detector tubes is the lack of specificity of the chemical indicator. Many indicators are not highly selective and can cross-react with other gases and vapors. Manufacturer's manuals describe the effects of interfering contaminants.

Temperature and Humidity

Temperature, humidity and pressure can also affect detector tube readings. Read and follow the manufacturer's instructions regarding corrections that must be made to sample readings for these factors.

Long-Term Sampling

Most detector tubes only give near-instantaneous measurements, and thus will not reflect time-weighted average (TWA) levels of the hazardous substances present. Some long duration tubes for TWA measurements are available. Some are a diffusive/dosimeter type which requires no pump. Others are used with a portable lightweight pump which continuously draws a measured volume of air through the tube. These tubes can be worn by the worker in a special holder. At the end of the shift, the tube can be evaluated to give a TWA exposure for the working day (e.g., see the SLTC procedure to determine methylene chloride in workplace air by long-term detector tubes).

Another technique which could be used for long-term measurements with detector tubes is to wear a gas sampling bag such as a Tedlar® or Teflon® bag connected to a low flow pump and then periodically measure the concentration of contaminant in the bag (with a detector tube) to get a TWA exposure over the time period worn (e.g., see the SLTC utilization of direct-reading devices for the measurement and tracking of methylene chloride exposure). The sampling bag is connected to the outlet from a portable sampling pump set to a calibrated flow rate such as 0.05 liters per minute (50 cubic centimeters per minute). Once the long-term bag sample is collected, an air sample could be extracted in the field by connecting the bag to a detector tube and hand pump. Massage the bag to ensure good air mixing before extracting the air sample. This technique can only be used for assessing contaminants that would not react over time inside the bag. Consult the sampling pump manual to ensure that atmospheres that may be damaging to the pump are not drawn into it.

Storage and Shelf Life

Detector tubes normally have a shelf life of one to two years when stored at 25°C. Expiration dates are generally printed on the box or on each tube. In general, avoid excessively low (less than 35°F) or high (greater than 78°F) temperatures and direct sunlight which can adversely affect the properties of the tubes. Refrigerated storage prolongs shelf life. Detector tubes should not be used when they are cold. They should be kept at room temperature for about one hour prior to use. Outdated detector tubes (i.e., beyond the printed expiration date) should not be used.

Calibration

Annually or after any repair or maintenance work, send detector tube pumps to the CTC for calibration (volume verification). Calibration in the field is no longer performed. Consult the CTC if there is reason to suspect that a pump may not be operating properly prior to its scheduled calibration due date.

E. MERCURY ANALYZERS

Application and Principle of Operation

Handheld mercury analyzers can be used for compliance sampling and for source and leak detection. These instruments measure airborne mercury vapor by drawing an air sample over a gold film. The mercury adsorbed onto the gold surface changes the resistance of current flow. The change in resistance is a function of the mass of mercury collected on the gold film. The results can be displayed in milligrams of mercury per cubic meter of air (mg/m^3) or total mass of mercury in the air sample collected. Models available through ALEP include the Jerome Model 431X, which has a lower limit of detection of 0.003 mg/m^3 and achieves +/- 5 percent accuracy at 0.1 mg/m^3; and the Jerome 405-0007, which has a lower limit of detection of 0.5 micrograms per cubic meter of air ($\mu g/m^3$) and achieves +/- 5 percent accuracy at 25 $\mu g/m^3$ and +/- 10 percent accuracy at 1 $\mu g/m^3$.

Potential interferences which can produce a positive reading include chlorine, nitrogen dioxide, hydrogen sulfide, high concentrations of ammonia, and most mercaptans. Depending on the model, various filters are available from the manufacturer to remove chlorine, ammonia, and other interfering contaminants upstream of the sensor.

Calibration

Factory calibration is required annually. Because of the gold film/mercury interaction, the instrument should produce stable, accurate readings without the need for frequent recalibration. A calibration check can be performed using the manufacturer's Functional Test Kit.

Special Considerations

The instrument must be zeroed before use at the temperature at which it will be used. Both models have a zero air filter which removes mercury vapor, mercaptans, and hydrogen sulfide.
The instrument should be regenerated before and after use because the gold film sensor becomes saturated with mercury. The meter must be placed on line power and the gold film sensor regenerated at elevated temperature. After regeneration, wait half an hour before taking readings to allow the sensor to equilibrate to room temperature.

Maintenance

Routine maintenance includes periodic replacement of filters and regeneration of the gold film sensor to remove mercury after use of the instrument.

F. DUST / PARTICULATE MONITORS

1. Aerosol Photometers

Application and Principle of Operation

Aerosol photometers operate by detecting scattered light or infrared radiation. The amount of light reaching the detector is proportional to the number of particles passing through the detection chamber. Also known as nephelometers, these instruments are used to monitor particulate matter such as dusts, smokes, mists, and fumes. Some models can be used for monitoring the respirable fraction of dust, and some are small enough to use for personal exposure monitoring. Results are reported in $\mu g/m^3$ or mg/m^3. Some models are also a fibrous aerosol monitor (FAM), which report the number of fibers per volume of air (e.g., these instruments are useful for real-time measurements of airborne asbestos).

Calibration

Annual factory calibration is arranged by the CTC. Field zeroing prior to use is also required.

Special Considerations

Certain instruments have been designed to satisfy the requirements for intrinsically safe operation in methane-air mixtures.

Relative humidity conditions above 80 percent may result in readings which are higher than the actual dust concentration. Follow the manual for any necessary adjustments.

Maintenance

When the photodetector is not being operated, it should be placed in its plastic bag, which should then be closed. This will minimize particle contamination of the inner surfaces of the sensing chamber.

The unit will be cleaned as part of the annual calibration service. Follow the user manual in regards to field servicing. Excessive buildup of particles in the sensing chamber may affect the accuracy of measurements.

After prolonged operation or exposure to particulate-laden air, the interior walls and the two glass windows of the sensing chamber may become contaminated with particles. Although repeated updating of the zero reference following the manufacturer's procedure will correct errors resulting from such particle accumulations, this contamination could affect the accuracy of the measurements as a result of excessive spurious scattering and significant attenuation of the radiation passing through the glass windows of the sensing chamber.

2. Condensation Nuclei Counters

Application and Principle of Operation

Condensation nuclei counters take particles too small to be easily detected, enlarge them to a detectable size, and then count them. Common uses for this technology include quantitative respirator fit-testing and testing the removal efficiency of high efficiency particulate air (HEPA) filters.

Submicrometer particles are grown with alcohol or another liquid vapor as they pass through a heated saturator lined with alcohol-soaked felt. The alcohol vapor becomes super-saturated and condenses on the particles in a cooled condenser. Optics focus laser light into a sensing volume. As the droplets pass through the sensing volume, the particles scatter the light. The light is directed onto a photodiode which generates an electrical pulse from each droplet. The concentration of particles is counted by determining the number of pulses generated. This instrument is sensitive to particles as small as 0.02 micrometers. However, it is non-specific to variations in size, shape, composition, and refractive index.

A counter totals individual airborne particles from sources such as smoke, dust, and exhaust fumes. Common models operate in one of three possible modes, each with a particular application. In the "count" mode, the counter measures the concentration of these airborne particles. In the "test" (or fit- test) mode, measurements are taken inside and outside a respirator and a fit factor is calculated. In the "sequential" mode, the instrument measures the concentration on either side of a filter and calculates filter penetration.

Calibration

Check the counter before and after each use in accordance with the manufacturer's instructions. This procedure usually involves checking the zero of the instrument. Annual calibration is handled through the CTC.

Maintenance

Reagent-grade isopropyl alcohol for use in these types of instruments can be obtained from the CTC AESP. Isopropyl alcohol must be added to the unit after five to six hours of operation under normal conditions. Take care not to overfill the unit.

A fully charged battery pack will normally last for about five hours of operation. Low battery packs should be charged for at least six hours. Battery packs should not be stored in a discharged condition.

To prepare the unit for long-term storage, follow the instructions in the equipment manual. It may be necessary to dry the saturator felt by installing a freshly charged battery pack without adding alcohol. Allow the instrument to run until the LO message (low battery) or the E-E message (low particle count) appears. Some instruments allow you to remove the alcohol cartridge for storage purposes. Remove the battery pack and install the tube plugs into the ends of the twin-tube assembly.