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Standard Guide for Air Monitoring at Waste Management Facilities for Worker Protection[1]

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1. Scope

1.1 This guide is intended to provide a standardized approach for establishing and carrying out an air monitoring program to protect workers at waste management facilities. This guide may apply to routine operations at an active treatment, storage, or disposal site or the extraordinary conditions that can be encountered in opening and cleaning up a remedial action site.

1.2 Any user of this guide must understand that it is impossible to predict all the difficulties that could develop at a waste management facility due to hazardous airborne emissions. Although air contaminant measurements obtained in accordance with this guide may indicate acceptable or tolerable levels of toxic agents are present, care and judgment must still be exercised before concluding that all atmospheric contaminants at the site are under control.

2. Referenced Documents

2.1 *ASTM Standards:*

D 1356 Terminology Relating to Atmospheric Sampling and Analysis[2]

D 1357 Practice for Planning the Sampling of the Ambient Atmosphere[2]

D 1605 Practices for Sampling Atmospheres for Analysis of Gases and Vapors[2]

D 3614 Guide for Evaluating Laboratories Engaged in Sampling and Analysis of Atmospheres and Emissions[2]

D 4687 Guide for General Planning of Waste Sampling[3]

E 548 Guide for General Criteria Used for Evaluating Laboratory Competence[4]

2.2 *Federal Standards:*

OSHA Analytical Methods Manual[5]

NIOSH Manual for Analytical Methods[6]

OSHA, 29 CFR Part 1910 Hazardous Waste Operations and Emergency Response; Interim Final Rule, December 1986[7]

3. Terminology

3.1 *Definitions:*

3.1.1 *General*—Terminology commonly used in air monitoring can be found in Terminology D 1356.

3.2 *Descriptions of Terms Specific to This Standard:*

3.2.1 *operating site*—an operating site is a location or facility where waste is treated, stored, or disposed as part of an on-going operation.

3.2.2 *remedial action site*—a remedial action site is a location or facility that may pose a threat to human health and the environment.

4. Summary of Guide

4.1 The procedures described in this guide address safety considerations, acute health hazards, and chronic health hazards due to airborne hazardous materials.

4.2 Monitoring concepts are described for cleanup operations at remedial action sites as well as routine activities at operational waste management sites.

5. Significance and Use

5.1 The techniques of air monitoring are many and varied. This guide is intended to describe the standard approaches that are used in designing an air monitoring program to protect waste management site workers.

5.2 When entering a remedial action site to initiate an investigation or a cleanup operation, operating personnel may be faced with the extreme hazards of fire, explosion, and acute or chronic health hazards. A thorough safety and health program, including a site-specific safety and health plan, must be in place to direct worker activity. Details for such plans can be found in the OSHA Interim Final Rule for Hazardous Waste Operations and Emergency Response and Refs **(1, 2)**.[8] Air monitoring is an integral part of such a program. This guide describes equipment and sampling procedures which can be used to evaluate the airborne hazard potential so as to gain and maintain control over the situation at the site.

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[1] This guide is under the jurisdiction of ASTM Committee D34 on Waste Management and is the direct responsibility of Subcommittee D34.01.01 on Planning for Sampling.

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[2] *Annual Book of ASTM Standards*, Vol 11.03.

[3] *Annual Book of ASTM Standards*, Vol 11.04.

[4] *Annual Book of ASTM Standards*, Vol 14.02.

[5] 1985 manual available from Occupational Safety and Health Administration, OSHA Analytical Laboratory, Salt Lake City, UT.

[6] Third edition manual, February 1984, available from the National Institute of Occupational Safety and Health, (NIOSH), Cincinnati, OH.

[7] Available from the Superintendent of Documents, Government Printing Office, Washington, DC, 20401.

[8] The boldface numbers in parentheses refer to the list of references at the end of this guide.

5.3 Upon obtaining readings at the site, a decision must be made as to whether conditions are under control or not. That decision will depend on the nature of the contaminants (toxicity, reactivity, volatility, etc.), the extent (area affected, number of workers, etc.) of the problem and the level of worker protection available. Since all such parameters will be site specific, the necessary decision-making is beyond the range of this guide.

5.4 This guide does not include monitoring sites containing radioactive materials, nor does it cover general safety aspects, such as access to emergency equipment or medical support of emergency needs. These items should be covered in a safety and health plan.

5.5 It is recommended that this guide be used in conjunction with Guide D 4687.

6. General Considerations

6.1 That aspect of science which routinely deals with the assessment of airborne hazards to workers is known as industrial hygiene. Professional industrial hygienists, besides measuring the concentration of contaminants in air, recommend means for controlling such airborne hazards, protecting workers, and demonstrating compliance with applicable laws and regulations. A certified industrial hygienist generally offers the optimum combination of background and credentials for recognizing, evaluating, and controlling workplace health hazards. If industrial hygiene staff support is not available on site, coverage can be obtained through the use of consultants and possibly through loss prevention insurance carriers. The remainder of this guide reflects the general thought process that an industrial hygiene professional would most likely go through in establishing an air monitoring program to protect workers at a waste management site.

6.2 *Establishing a Test Protocol*:

6.2.1 Various combinations of equipment and sampling techniques are used in work place air monitoring. The best monitoring program is one that combines accuracy with timely response in a cost effective manner.

6.2.2 The particular test protocol which is selected for an industrial hygiene study depends on the nature of the contaminants and the end purpose of the monitoring effort (that is, routine monitoring, searching for worst case exposure, looking for contaminant leaks in a process).[9]

6.3 *Selecting Specific Methods*:

6.3.1 The choice of sampling method is most often tied in with the analytical method. There may be no difference in the analytical work whether it is for a 15-min ceiling sample or a 7-h full day sample. If the analytical method has poor sensitivity, however, it may be necessary to increase the pump flow rate for the short duration sample to make certain that sufficient sample is collected. Such fine adjustments must be worked out between the sampling personnel and the laboratory personnel. Extensive guidance on the latest developments in air sampling technology is available in Refs **(3, 4)**.

6.3.2 A number of sources of information are available to describe general methodology. Practice D 1605 lists some of the classic methods that have been used when sampling for gases or vapors. The American Conference of Governmental Industrial Hygienists offers a publication, Ref **(5)**, that provides a review of newer equipment and methodology. The final combination of equipment and procedures is predicted on the precision, accuracy, and sensitivity needed to support the test protocol.

6.3.3 Once the goals and protocol for the sampling program have been set, specific sampling/analytical methods must be selected. Within the *Annual Book of ASTM Standards*, Volume 11.03 is dedicated to atmospheric analysis and to occupational health and safety issues. Some applicable methods from that reference are listed in Annex A1. Other sources of health and safety support include the NIOSH Manual of Analytical Methods and the OSHA Analytical Methods Manual. The specific equipment and sampling media for a particular set of airborne contaminants are selected from sources such as these.

7. Procedures

7.1 *Operating Site*:

7.1.1 The procedures described in this section apply to air monitoring activities at an operational waste treatment, storage, or disposal site. At an operating site, controls (work practices, engineering controls, and personal protective equipment) would be in place to minimize the exposure of workers to hazardous conditions. These are defined in the health and safety plan.

7.1.2 *Knowledge of Materials*—Knowledge of the materials arriving at or present at an operating site is critical to the design of a sampling plan. If hazardous wastes are arriving, be sure that they are listed on the manifest. The results of waste sample analyses will also help to identify contaminants of greatest concern in an incoming shipment. It is also likely that specific users of the disposal site will tend to be consistent in the types of wastes they send to the site based on the generating process and history of shipment. For example, paint manufacturers will most likely send mixtures of solvents, resins, and pigments, whereas plating firms will generally send alkaline sludge of heavy metal waste; and so on. Deviation from established patterns, however, is possible and should not be discounted in sampling plan design.

7.1.3 *Worker Sampling*:

7.1.3.1 Of all the different techniques for workplace air monitoring, personal sampling of the worker's breathing zone is paramount. While some workers may be quite sedentary in an operations trailer at a control panel, others may be out covering all areas of the work site. For this reason, the assessment must be capable of following the activity of the worker.

7.1.3.2 The first order of personal monitoring is long duration time-weighted-average (TWA) sampling. For an 8-h work shift, be sure that TWA samples are at a minimum of 7-h duration either as a single sample or a series of two or more samples. For any other work hour situation, the procedure is to sample for the duration of the shift less 1 h. For workers handling organic wastes (for example, vapor degreaser solvent waste) the program would call for charcoal tube sampling with

[9] Subcommittee E34.18 of ASTM Committee E34 on Occupational Health and Safety is developing a guide for industrial hygiene air monitoring programs titled "Standard Guide to Air Sampling Strategies for Worker and Workplace Protection.''

analysis for one or two of the chlorinated solvents most likely to be present in the waste. Such TWA monitoring, as well as the following information, would be repeated periodically to ensure that worker exposure is not increasing.

7.1.3.3 Another form of personal monitoring that would be carried out is for peak exposures. For example, 15-min ceiling samples might be taken while a set of containers was being opened to inspect or remove the contents. The same type of sampling might be done while pumping the contents of a truck into a holding tank. At these times, personal protective equipment (for example, respiratory protection) is often used to minimize worker exposure to vapors. Ceiling samples will help ensure that workers are using respirators having a high enough protection factor.

7.1.3.4 Ceiling samples might be the only form of monitoring for certain toxic agents. If waste acid pickling solution were to come in from a steel mill for neutralization, it might be appropriate to sample for hydrogen chloride. In that instance, only 15-min samples would be of interest, because that is how exposure to HCl is controlled by health/regulatory agencies.

7.1.3.5 New equipment has come into use to cover both TWA and peak sampling. Some personal dosimeters, worn by the employees, give an overall average exposure and also record the instantaneous exposures of the worker during the day. These units, which are read out on a portable computer, are generally good for only one particular contaminant, though all the different types are read using the same computer. These might be very useful in monitoring a heavy equipment operator for carbon monoxide or a waste treatment plant attendant for sulfur dioxide.

7.1.3.6 Another concept to be considered in both the monitoring and safety and health plans is the additive effect of certain substances. Paragraph 7.1.3.2 presented the concept of screening for only one or two solvents. When this is done, the eventual comparison with permissible exposure limits must be done using a safety factor. This safety factor is intended to take account of the possible effects of other similar compounds which are likely to be present, but are not measured routinely.

7.1.4 *Area Monitoring*:

7.1.4.1 A good complement to personal monitoring is fixed location area monitoring. This can be done with either sample collecting-type equipment, direct reading instruments, or specialized fixed-parameter monitors such as those described in 7.1.3.5. Area monitoring offers the advantage of potentially providing an early warning.

7.1.4.2 A combustible vapor meter in a solvent storage area can give warning before an employee must walk in to find a leak.

7.1.4.3 A carbon monoxide monitoring system around a pyrolyzer or incinerator can warn both the operator in the control room and workers in the loading area of a system upset.

7.1.4.4 An oxygen meter permanently mounted in a below ground pit can warn an employee of an oxygen deficient atmosphere before he enters the confined space.

7.1.4.5 Direct reading colorimetric tubes Ref **(6)**, offer a convenient means for obtaining a quick reading. Besides their suitability for qualitative checks (see Annex A2), they also provide reasonable quantitative estimates.

7.1.5 *Complex Exposure Potential*:

7.1.5.1 Although much of the sampling effort may involve monitoring for one or two particular contaminants on specific operations, there will be other times when the exposure potential is more complex. Examples of more complex monitoring might include: *1*) where a sludge is handled on site, and there is a chance of spillage and eventual spreading of the debris around the site by vehicular traffic and wind, dust samples will need to be analyzed periodically for heavy metals; *2*) where waste from a polymer plant (in particular one processing nitrile rubber or acrylonitrile butadiene styrene, (ABS) plastic) is handled on site, it may be necessary to devise a sampling protocol which looks for trace quantities of acrylonitrile in an atmosphere dominated by one or two less harmful organic vapors; *3*) where polychlorinated biphenyl, (PCB) vapor can be carried into the atmosphere by methane gas evolving from a closed site, Ref **(7)**, monitoring must cover these and perhaps other compounds; and *4*) where a wide range of similar compounds arise, such as in some organic wastes and landfill gas, the cumulative effect must be estimated rather than the potential effect of individual contaminants.

7.1.6 *Data Storage and Analysis*:

7.1.6.1 The various forms of air monitoring described in 7.1.3, 7.1.4, and 7.1.5 will result in the accumulation of a substantial amount of data by the site operator. The data need to be recorded and catalogued in a manner that provides for ready retrieval and comparison.

7.1.6.2 Store and retrieve data so that the level of airborne contamination can be reviewed over time. In this way seasonal or diurnal trends may be identified.

7.1.6.3 The site operator may want to determine if certain shipments or customers are sending waste material that is difficult to handle.

7.1.7 *Quantitative Considerations*:

7.1.7.1 The premise of most of the discussion of Section 7 is that the site operator has at least some working knowledge of the materials being handled. As stated previously, however, surprises can be expected.

7.1.7.2 An unexpected odor or phase separation may indicate an unknown is present in the waste material.

7.1.7.3 An abnormal reaction in a neutralization process may be a sign that an unexpected volatile is being emitted. Given this reality, even the best run waste site may have to analyze for unknowns in the work atmosphere. For the following reasons it is important to be aware of the qualitative aspects of air monitoring as they are described in 7.2.

7.2 *Remedial Action Site*:

7.2.1 The level of hazard that is found by air monitoring at a remedial action waste site can vary from relatively innocuous to very dangerous. The uncertainty associated with the types and composition of wastes present at these sites complicates virtually every aspect of site cleanup and monitoring. For these reasons a thorough site characterization must be made before work is started to provide data for a site-specific health and safety plan, including subsequent air monitoring requirements.

7.2.2 *Qualitative Assessment*:

7.2.2.1 From an operational viewpoint, a prime difference between a remedial action site and an operating site is the need for qualitative assessment. The unknowns at an abandoned site require a qualitative analysis of the work environment prior to any quantitative measurements.

7.2.2.2 Before starting cleanup activity, check available records to gain knowledge of the materials that might have been treated, stored, or buried on the site. Be sure that labels on drums also are checked to see if there is some information on the hazardous nature of the material contained inside.

7.2.2.3 Qualitative assessment must be conducted in a systematic fashion. Be sure that the operating areas are mapped and perhaps gridded so that the assessment can be done with minimal chance of overlooking important zones.

7.2.3 *Safety Monitoring*:

7.2.3.1 Identify life threatening situations due to fire, explosion, and toxic hazards as the first air monitoring concerns for personnel starting a cleanup action.

7.2.3.2 Enclosed spaces bring the danger of suffocation by excessive chemical vapors causing an oxygen deficiency.

7.2.3.3 For these reasons make sure that the first pieces of equipment on site, Ref **(8)** are the organic and combustible vapor meters and oxygen meters. These would be used to scan the area and map out any high hazard areas.

7.2.3.4 Personal monitoring devices are also available to warn workers of unsafe conditions immediately. This type of unit, which has a preset alarm, is worn by the worker on his belt as he goes about the site performing his work.

7.2.3.5 When a new area of the site is entered or another level is unearthed, the mapping routine for imminent danger situation would be repeated. The routine monitoring of the site-specific health and safety plan would be run from then on.

7.2.4 *Direct Reading Meters and Dosimeters*:

7.2.4.1 Once the initial safety survey has been completed, a more sensitive screening is needed to determine the presence of acute and chronic health hazards. It may be necessary to use the air data to define potentially contaminated zones where specific personal protective equipment and decontamination procedures are required.

7.2.4.2 A wide array of direct reading instruments and personal dosimeters can be used to search for classes of, or specific, chemical agents.

7.2.4.3 Most direct reading instruments either lack specificity or are susceptible to interferences. The technology used for the basic design, the relative price of the instrument within a given design, and the skill of the operator will determine the suitability of an instrument in terms of freedom from such bias.

7.2.4.4 The complexity of the chemical matrix at the site will determine the level of sophistication of instrument array that will be needed to obtain a reliable identification of the hazardous agents that are present.

7.2.4.5 A listing of such equipment along with a discussion of capabilities and limitations is presented in Annex A1. Additional information on the useful application of such equipment is available in Ref **(4)**.

7.2.5 *Qualitative Sample Collection*:

7.2.5.1 Just as with quantitative determination, the most reliable technique in qualitative sampling, for the most part, is concentration of airborne contaminants using a collection device followed by appropriate laboratory analysis.

7.2.5.2 For metal dusts (or dust containing heavy metal contaminants) a series of 37-mm diameter membrane samples or high volume filter samples would be taken at various locations around the site.

7.2.5.3 These would then be submitted for analysis via some general analytical technique such as inductively-coupled plasma spectrometry, which can determine a large number of metals per sample. Certain volatile materials, such as arsenic compounds or mercury, would have to be sampled separately.

7.2.5.4 Organic vapors can be sampled by drawing site air through an array of absorbent packed tubes. By using different tube packing materials in a manifold system, it is possible to sample for a wide range of organics concurrently.

7.2.5.5 A popular combination of packings is charcoal, magnesium silicate,[10] phenylene oxide porous polymer,[11] and silica gel. These sample tubes would be desorbed either thermally or using an appropriate mix of solvents for eventual analysis via a combination gas chromatograph/mass spectrometer or other appropriate analytical method. Decomposition can be a problem using thermal desorption.

7.2.5.6 Additional techniques, more specific in nature, can be used for other agents. If acid gases are suspect, air can be bubbled through a buffer solution which is then checked by pH meter, specific ion electrode, or ion chromatography. For pesticides and PCBs even more specific sampling/analysis combinations are available.

7.2.5.7 No direct reading meter is available for asbestos, so care is required if suspicious deposits are encountered or anticipated. Bulk samples will have to be taken for qualitative identification using a technique such as polarizing light microscopy. Any attempt to use an air sample for qualitative identification of asbestos fibers will most likely end up in the use of an extremely demanding analytical procedure, such as a scanning electron microscope with X-ray diffraction analysis. Once asbestos has been positively identified, conventional fiber counting techniques are used for quantitation in air samples.

7.2.6 *Select Toxic Agents for Monitoring*:

7.2.6.1 Previous procedures described in 7.2.1 through 7.2.5 should provide site operating or surveying personnel with an appreciable amount of qualitative information from direct reading instruments and laboratory analysis of collected air samples. In addition, data should be available from the preliminary paper studies and from laboratory results on the analysis of bulk samples taken from waste drums, lagoons, tanks, other equipment, and perhaps contaminated soil.

7.2.6.2 Select key parameters to be monitored quantitatively based on:

a) Those which must be monitored due to applicable air regulatory controls (for example, lead, benzene).

b) Those offering the most severe risk to health, even in trace quantities (for example, methyl isocyanate).

c) Those that are dominant in the site environment due to quantity and volatility or dispersion (for example, chlorinated solvents).

[10] Magnesium silicate available from various sources under the tradename Florisil, has been found suitable for this purpose.

[11] Phenylene oxide porous polymer available from various sources under the tradename Tenax, has been found suitable for this purpose.

7.2.7 *Quantitative Assessment*:

7.2.7.1 Once the hazardous agents have been identified, air sampling routines must be established to determine the concentration of those substances in the site atmosphere. This information is needed to ensure that site workers are adequately protected and for regulatory requirements.

7.2.7.2 *Operating Site Similarity*—Once the unknowns at the remedial action site are for the most part accounted for, establishment of a testing program is similar to that for an operating disposal site. Refer then to 7.1 for guidance except for the modifications that follow.

7.2.7.3 *Increased Sampling Frequency*—Conditions at a cleanup site are much more unstable than at an operating disposal site. The level of control over airborne emissions is greatly reduced in a cleanup operation. As a result, much wider inter-day and intra-day fluctuations in the concentrations of airborne contaminants can be expected. To account for such variations, increase frequency. In a cleanup operation, daily quantitative monitoring may be required.

7.2.7.4 *Timely Analytical Support*—Considering the wide range of conditions that are possible at remedial action sites, it is most important that timely analytical support be available. If an intense sampling program has been designed in attempting to correct an out-of-control condition, a 2 to 4-week wait for analytical results is out of the question. Since some samples in the program may very well be of lesser significance, it would not matter if site personnel had to wait for those results. For that reason, it is recommended that some type of priority system be established to identify those samples which are critical and those which can be put on a slower schedule.

7.2.7.5 *Periodic Qualitative*—To detect residual unknown emissions at the site, it is recommended that qualitative determinations be carried out periodically. The results of these tests may require additional quantitative monitoring. As a minimum, the results for the analysis of bulk samples should be reviewed periodically to identify any new compounds which may become airborne hazards.

8. Quality Assurance

8.1 Regardless of the end purpose of the particular air sampling effort, the work must be conducted with a firm awareness of quality control. Procedures must be in place to control the calibration of direct reading meters and sampling equipment, sample handling, analytical precision and bias, and data handling.[12]

8.2 A full-range quality assurance program can be developed using Practice D 3614.

8.3 If a certain segment of the surveillance effort, such as analytical support, is to be handled by an outside organization, then the quality program must be extended over the outside organization. One approach to this particular situation is to restrict analytical support to a professionally accredited industrial hygiene laboratory. Though the laboratory would have its own quality control program, it would still be necessary to evaluate the outside organization in the manner of Guide E 548.

[12] Subcommittee D34.01 is in the process of developing a standard for quality assurance in waste and environmental sampling that has an excellent discussion on the use of control samples.

ANNEXES

(Mandatory Information)

A1. INDUSTRIAL HYGIENE TEST METHODS AND PRACTICES

TABLE A1.1 ASTM Standards[2]

Test Requirements	
Asbestos	D 4240 Test Method for Airborne Asbestos Concentration in Workplace Atmosphere
bis (Chloromethyl) Ether	D 3476 Test Method for *bis* (Chloromethyl) Ether (*bis* CME) in Workplace Atmospheres (Gas Chromatography—Mass Spectrometry)
Metals	D 4185 Practice for Measurement of Metals in Workplace Atmosphere by Atomic Absorption Spectrophotometry
Hydrocarbon Gases	D 2820 Test Method for C_1 through C_5 Hydrocarbons in the Atmosphere by Gas Chromatography
Carbon Monoxide	D 3162 Test Method for Carbon Monoxide in the Atmosphere (Continuous Measurement by Nondispersive Infrared Spectrometry)
Oxides of Nitrogen	D 3824 Test Methods for Continuous Measurement of Oxides of Nitrogen in the Ambient or Workplace Atmosphere by the Chemiluminescent Method
Fluoride	D 3269 Test Methods for Fluoride Content of the Atmosphere and Plant Tissues (Manual Procedures), Analysis for
Hydrogen Sulfide	D 4323 Test Method for Hydrogen Sulfide in the Atmosphere by Rate of Change of Reflectance
Inorganic Lead	D 3413 Test Method for Lead (Inorganic) in Workplace Atmospheres by Atomic Absorption Spectrometry
Mercaptans	D 2913 Test Method for Mercaptan Content of the Atmosphere
Particulate (Coke Ovens)	D 4600 Test Method for Benzene-Soluble Particulate Matter in Workplace Atmospheres, Determination of
Respirable Dust	D 4532 Test Method for Respirable Dust in Workplace Atmospheres
Sulfur Dioxide	D 3449 Test Method for Sulfur Dioxide in Workplace Atmospheres (Barium Perchorate Method)
Organic Vapors	D 3687 Practice for Analysis of Organic Compound Vapors Collected by the Activated Charcoal Tube Adsorption Method
General Air Analyzer	D 3249 Practice for General Ambient Air Analyzer Procedures
Particulate (Hi-Vol)	D 4096 Practice for Particulate (Airborne Matter), Collection and Mass Determination of, Application of the Hi-Vol (High Volume) Sampler Method
Organic Vapors	D 3686 Practice for Sampling Atmospheres to Collect Organic Compound Vapors (Activated Charcoal Tube Adsorption Method)
Detector Tubes	D 4490 Practice for Toxic Gases or Vapors Using Detector Tubes, Measuring the Concentration of
Length-of-Stain Dosimeters	D 4599 Practice for Toxic Gases or Vapors Using Length-of-Stain Dosimeter, Measuring the Concentration of

A2. DIRECT READING AIR MONITORING EQUIPMENT AND DOSIMETERS

A2.1 *Photo-Ionization Meter-Battery Operated Device*:

A2.1.1 *Basic Design*—Draws in air and ionizes organic compounds using ultra-violet radiation; charged plates measure proportional current flow due to ionized field Ref **(2)**.

A2.1.2 *Limits*—Sensitivity down to the ppm range, but non-specific except for very broad categories (for example, aromatic versus non-aromatic) by selection of lamp with appropriate UV output.

A2.2 *Colorimetric Indicator Tubes*:

A2.2.1 *Basic Design*—Single use glass tubes containing chemical reactants which change color in presence of the pertinent analyte; length of stain is proportional to concentration Ref **(3)**.

A2.2.2 *Limits*—Convenient apparatus with poor precision but good sensitivity. Response is generally for an entire class of compounds (for example, chlorinated hydrocarbon) and sometimes susceptible to interferences (oxidizer may bleach out color).

A2.3 *Electrolytic Cell Detectors*:

A2.3.1 *Basic Design*—Battery operated monitors using solid state electrolytic cell in which conductivity of cell material changes in proportion to concentration of H_2S, CO, CH_4, SO_2 or O_2.

A2.3.2 *Limits*—Good sensitivity and freedom from interferences, but each cell is for a specific gas resulting in five different instruments to cover all five gases.

A2.4 *Portable Gas Chromatograph*:

A2.4.1 *Basic Design*—Truly portable GC equipment with choice of Flame Ionization Detector (FID), Electron Capture Detector, (ECD), or Photo Ionization Detector, (PID) and with choices of standard packed columns; though not a direct reading instrument, it is used in the field.

A2.4.2 *Limits*—Relatively good sensitivity and can separate mixtures in a gas sample, but as with GC, requires calibration with analytes of interest at time of use.

A2.5 *Portable Combustible Gas Meter*:

A2.5.1 *Basic Design*—Battery operated catalytic combustion changes electrical conductivity of detector; for H_2, CO, and any combustible organic.

A2.5.2 *Limits*—Used for higher concentrations, particularly in low % range to check for explosive atmospheres. Non-specific and can be a source of ignition.

A2.6 *Portable Infrared Analyzer*:

A2.6.1 *Basic Design*—Sometimes battery operated, senses organic or inorganic gases capable of IR absorption.

A2.6.2 *Limits*—If a non-dispersive instrument, it is not specific. Dispersive instruments not battery powered, but are selective. Requires experienced analyst when dealing with a mixture of compounds.

REFERENCES

(**1**) *Occupational Safety and Health Guidance Manual for Hazardous Waste Site Activities*, NIOSH/OSHA/USCG/EPA, DHHS, NIOSH Publication No. 85-115, NIOSH, 1014 Broadway, Cincinnati, OH 45202, October 1985.

(**2**) *Standard Operating Safety Guides*, U.S. Environmental Protection Agency, Environmental Response Branch, November 1984.

(**3**) *Instrumentation for Monitoring Air Quality, ASTM STP 555*, ASTM, 1973.

(**4**) *Sampling and Analysis of Toxic Organics in the Atmosphere, ASTM STP 721*, ASTM, 1979.

(**5**) *Air Sampling Instruments for Evaluation of Atmospheric Contaminants*, American Conference of Governmental Industrial Hygienists, latest edition.

(**6**) *Direct Reading Colorimetric Indicator Tubes Manual*, American Industrial Hygiene Association, AIHA, latest edition.

(**7**) Lewis, R. G., Martin, B. E., Sgontz, D. L., and Howes, Jr., J. E., "Measurement of Fugitive Atmospheric Emissions of Polychlorinated Biphenyls from Hazardous Waste Landfills," *Environmental Science & Technology*, October 1985.

(**8**) *Manual of Recommended Practice for Combustible Gas Indicators and Portable, Direct Reading Hydrocarbon Detectors*, AIHA, latest edition.