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6. Site Characterization

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Introduction

Site characterization provides the information needed to identify site hazards and to select worker protection methods. The more accurate, detailed, and comprehensive the information available about a site, the more the protective measures can be tailored to the actual hazards that workers may encounter.

The person with primary responsibility for site characterization and assessment is the Project Team Leader. In addition, outside experts, such as chemists, health physicists, industrial hygienists, and toxicologists, may be needed to accurately and fully interpret all the available information on site conditions.

Site characterization generally proceeds in three phases:

- Prior to site entry, conduct offsite characterization: gather information away from the site and conduct reconnaissance from the site perimeter.
- Next, conduct onsite surveys. During this phase, restrict site entry to reconnaissance personnel.
- Once the site has been determined safe for commencement of other activities, perform ongoing monitoring to provide a continuous source of information about site conditions.

It is important to recognize that site characterization is a continuous process. At each phase of site characterization, information should be obtained and evaluated to define the hazards that the site may pose. This assessment can then be used to develop a safety and health plan for the next phase of work. In addition to the formal information gathering that takes place during the phases of site characterization described here, all site personnel should be constantly alert for new information about site conditions.

The sections below detail the three phases of site characterization and provide a general guide which should be adapted to meet the specific situation. Within each phase of information gathering, the most appropriate sequence of steps should be determined, particularly if there are time or budget considerations that limit the scope of the work. Wherever possible, all information sources should be pursued.

Offsite Characterization

As much information as possible should be obtained *before* site entry so that the hazards can be evaluated an preliminary controls instituted to protect initial entry personnel. Initial information-gathering missions should focus on identifying all potential or suspected conditions that may pose inhalation hazards that are immediately dangerous to life or health (IDLH)[1] or other conditions that may cause death or serious harm (see Table 6-1).

Offsite information can be obtained by two methods: interview/records research and perimeter reconnaissance.

Table 6-1. Visible Indicators of Potential IDLH and Other Dangerous Conditions

- Large containers or tanks that must be entered.
- Enclosed spaces such as buildings or trenches that must be entered.
- Potentially explosive or flammable situations (indicated by bulgin drums, effervescence, gas generation, or instrument readings).
- Extremely hazardous materials (such as cyanide, phosgene, or radiation sources).
- Visible vapor clouds.
- Areas where biological indicators (such as dead animals or vegetation) are located.

Interview/Records Research

As much data as possible should be collected before an personnel go on site. Where possible, the following information should be obtained:

- Exact location of the site.
- Detailed description of the activity that occurred at the site.
- Duration of the activity.
- Meteorologic data, e.g., current weather and foreca prevailing wind direction, precipitation levels, tempe ature profiles.
- Terrain, e.g., historical and current site maps, site pr tographs, aerial photographs, U.S. Geological Surve topographic quadrangle maps, land use maps, and land cover maps.

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[1] IDLH conditions refer to inhalation hazards (see section on *I Concentrations* later in this chapter).

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- Geologic and hydrologic data.
- Habitation – population centers, population at risk.
- Accessibility by air and roads.
- Pathways of dispersion.
- Present status of response and who has responded.
- Hazardous substances involved and their chemical and physical properties. Information sources include:
    - Company records, receipts, logbooks, or ledgers.
    - Records from state and federal pollution control regulatory and enforcement agencies, state Attorney General's office, state occupational safety and health agencies, state Fire Marshal's office.
    - Waste storage inventories and manifests or shipping papers.
    - Interviews with personnel and their families (all interview information should be verified).
    - Generator and transporter records.
    - Water department and sewage district records.
    - Interviews with nearby residents (note possible site-related medical problems and verify all information from interviews).
    - Local fire and police department records.
    - Court records.
    - Utility company records.
    - Media reports (verify all information from the media).
- Previous surveying (including soil, ground-penetrating radar, and magnetometer surveys), sampling, and monitoring data.

Perimeter Reconnaissance

At a site in which the hazards are largely unknown or there is no need to go on site immediately, visual observations should be made, atmospheric concentrations of airborne pollutants at the site perimeter should be monitored (see Chapter 7, *Air Monitoring*), and samples should be collected near the site. While these data are not definitive indicators of onsite conditions, they can assist in the preliminary evaluation. Perimeter reconnaissance of a site should involve the following actions:

- Develop a preliminary site map, with the locations of buildings, containers, impoundments, pits, ponds, and tanks.
- Review historical and current aerial photographs. Note:
    - Disappearance of natural depressions, quarries, or pits.
    - Variation in reforestation of disturbed areas.
    - Mounding or uplift in disturbed areas or paved surfaces, or modifications in grade.
    - Changes in vegetation around buildings.
    - Changes in traffic patterns at the site.
- Note any labels, markings, or placards on containers or vehicles.
- Note the amount of deterioration or damage of containers or vehicles.
- Note any biologic indicators, such as dead animals or plants.
- Note any unusual conditions, such as clouds, discolored liquids, oil slicks, vapors, or other suspicious substances.
- Monitor the ambient air at the site perimeter (see Chapter 7, *Air Monitoring*) for:
    - Toxic substances.
    - Combustible and flammable gases or vapors.
    - Oxygen deficiency.
    - Ionizing radiation.
    - Specific materials, if known.
- Note any unusual odors.
- Collect and analyze offsite samples, including (see reference [1] for methods):
    - Soil.
    - Drinking water.
    - Ground water.
    - Site run-off.
    - Surface water.

Protection of Entry Personnel

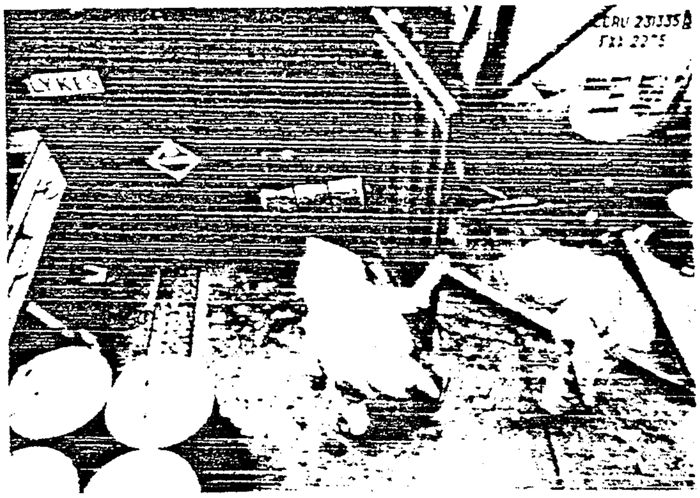
The information from interview/records research and perimeter reconnaissance is used as the basis for selecting the protective equipment for the initial site survey. In addition, the proposed work to be accomplished must be considered. For example, if the purpose of the survey is to inspect onsite conditions, count containers, measure the ambient air for "hot spots" (i.e., areas with high concentrations of toxic chemicals), and generally become familiar with the site, the level of protection may be less stringent than if containers are to be opened and samples taken. (Chapter 8, *Personal Protective Equipment*, provides more detail on the selection of protective items.)

The ensemble of clothing and equipment referred to as Level B protection is generally the minimum level recommended for an initial entry until the site hazards have been further identified and the most appropriate protective clothing and equipment chosen. Level B equipment is described in Table 8-7, Chapter 8.

Onsite Survey

The purpose of an onsite survey is to verify and supplement information from the offsite characterization. Prior to going on site, the offsite characterization should be used to develop a Site Safety Plan for site entry that addresses the work to be accomplished and prescribes the procedures to protect the health and safety of the entry team. Priorities should be established for hazard assessment and site activities after careful evaluation of probable conditions. Because team members may be entering a largely unknown environment, caution and conservative actions are appropriate. The composition of the entry team depends on the site characteristics but should always consist of at least four persons: two workers who will enter the site and two outside support persons, suited in personal protective equipment and prepared to enter the site in case of emergency. Upon entering the site, entry personnel should:

- Monitor the air for IDLH and other conditions that may cause death or serious harm (combustible or



As part of site characterization, workers suited in Level A protective ensembles work in pairs when investigating confined spaces.

explosive atmospheres, oxygen deficiency, toxic substances). Chapter 7 provides detailed information on air monitoring.

- Monitor for ionizing radiation. Survey for gamma and beta radiation with a Geiger-Mueller detection tube or a gamma scintillation tube; if alpha radiation is expected, use a proportional counter.
- Visually observe for signs of actual or potential IDLH or other dangerous conditions (see Table 6-1).

Any indication of IDLH hazards or other dangerous conditions should be regarded as a sign to proceed with care and deliberation. *Extreme caution* should be exercised in continuing the site survey when such hazards are indicated. Table 6-2 provides some basic guidelines for decision-making. If IDLH or other dangerous conditions are not present, or if proper precautions can be taken, continue the survey:

- Conduct further air monitoring as necessary (see Chapter 7).
- Note the types of containers, impoundments, or other storage systems:
  Paper or wood packages.
  Metal or plastic barrels or drums.
  Underground tanks.
  Aboveground tanks.
  Compressed gas cylinders.
  Pits, ponds, or lagoons.
  Other.
- Note the condition of waste containers and storage systems:
  Sound (undamaged).
  Visibly rusted or corroded.
  Leaking.
  Bulging.
  Types and quantities of material in containers.
  Labels on containers indicating corrosive, explosive, flammable, radioactive, or toxic materials.
- Note the physical condition of the materials:
  Gas, liquid, or solid.
  Color and turbidity.
  Behavior, e.g., corroding, foaming, or vaporizing.
  Conditions conducive to splash or contact.
- Identify natural wind barriers:
  Buildings.
  Hills.
  Tanks.
- Determine the potential pathways of dispersion:
  Air.
  Biologic routes, such as animals and food chains.
  Ground water.
  Land surface.
  Surface water.
- If necessary, use one or more of the following remote sensing or subsurface investigative methods to locate buried wastes or contaminant plumes:
  Electromagnetic resistivity.
  Seismic refraction.
  Magnetometry.
  Metal detection.
  Ground-penetrating radar.
- Note any indicators of potential exposure to hazardous substances:
  Dead fish, animals or vegetation.
  Dust or spray in the air.
  Fissures or cracks in solid surfaces that expose deep waste layers.
  Pools of liquid.
  Foams or oils on liquid surfaces.
  Gas generation or effervescence.
  Deteriorating containers.
  Cleared land areas or possible landfilled areas.
- Note any safety hazards. Consider:
  Conditions of site structures.
  Obstacles to entry and exit.
  Terrain homogeneity.
  Terrain stability.
  Stability of stacked material.
- Identify any reactive, incompatible, flammable, or highly corrosive wastes.
- Note land features.
- Note the presence of any potential naturally occu ring skin irritants or dermatitis-inducing agents, f example:
  Poison ivy.
  Poison oak.
  Poison sumac.
- Note any tags, labels, markings, or other identif ing indicators.

Table 6-2. Guidelines for Some Atmospheric Hazards[a]

ZARD[b]	MONITORING EQUIPMENT[c]	MEASURED LEVEL	ACTION
Explosive atmosphere	Combustible gas indicator	< 10% LEL[d]	Continue investigation.
		10%-25% LEL	Continue onsite monitoring with extreme caution as higher levels are encountered.
		> 25% LEL	Explosion hazard. Withdraw from area immediately.
Oxygen	Oxygen concentration meter	< 19.5%	Monitor wearing self-contained breathing apparatus. NOTE: Combustible gas readings are not valid in atmospheres with < 19.5% oxygen.
		19.5%-25%	Continue investigation with caution. Deviation from normal level may be due to the presence of other substances.
		> 25%	Fire hazard potential. Discontinue investigation. Consult a fire safety specialist.
Radiation	Radiation survey equipment	≤ 2 mrem/hr[e,f]	Radiation above background levels (normally 0.01-0.02 mrem/hr)[g] signifies the possible presence of radiation sources. Continue investigation with caution. Perform thorough monitoring. Consult with a health physicist.
		> 2 mrem/hr	Potential radiation hazard. Evacuate site. Continue investigation only upon the advice of a health physicist.
Inorganic and organic gases and vapors	Colorimetric tubes Chemical-specific instruments, including halide meter, hydrogen sulfide detector, carbon monoxide monitor, and mercury meter	Depends on chemical	Consult standard reference manuals for air concentration/toxicity data. Action level depends on PEL/REL/TLV.[h]
Organic gases and vapors	Portable photoionizer Organic vapor analyzer 1) Operated in gas chromatography (GC) mode 2) Operated in survey mode	Depends on chemical	Consult standard reference manuals for air concentration/toxicity data. Action level depends on PEL/REL/TLV.[h]

ased on *Standard Operating Guides*. U.S EPA. December, 1984.

[b] These are general classes of hazards. Not all components of these classes can be measured.

[c] Consult manufacturers' literature for use limitations associated with the specific equipment and for the specific substances the equipment can detect. See Tables 7-1 and 7-2 for more complete descriptions.

[d] LEL = lower explosive limit.

[e] mrem/hr = milliroentgen equivalent in man per hour.

[f] Source: U.S. Nuclear Regulatory Commission Rules and Regulations, 10 CFR Chapter 1, Part 20.105.

[g] Source: Sax, I.N. 1979. Dangerous Properties of Industrial Materials. Fifth Edition. p. 167. Van Nostrand Reinhold Company, New York.

[h] PEL = OSHA permissible exposure limit.
REL = NIOSH recommended exposure limit.
TLV = threshold limit value.
See Table 6-4.

- Collect samples in:
    - Air (see Chapter 7, *Air Monitoring*).
    - Drainage ditches.
    - Soil (surface and subsurface).
    - Standing pools of liquids.
    - Storage containers.
    - Streams and ponds.
    - Ground water (upgradient, beneath site, downgradient).
- Sample for or otherwise identify:
    - Biologic or pathologic hazards.
    - Radiologic hazards.

Information Documentation

Proper documentation and document control are important for ensuring accurate communication; ensuring the quality of the data collected; providing the rationale for safety decisions; and substantiating possible legal actions. Documentation can be accomplished by recording information pertinent to field activities, sample analysis, and site conditions in one of several ways, including:

- Logbooks.
- Field data records.
- Graphs.
- Photographs.
- Sample labels.

- Chain-of-custody forms.
- Analytical records.

These documents should be controlled to ensure that they are all accounted for when the project is completed. The task of document control should be assigned to one individual on the project team and should include the following responsibilities:

- Numbering each document (including sample labels) with a unique number.
- Listing each document in a document inventory.
- Recording the whereabouts of each document in a separate document register so that any document can be readily located. In particular, the name and location of site personnel that have documents in their possession should be recorded.
- Collecting all documents at the end of each work period.
- Making sure that all document entries are made in waterproof ink.
- Filing all documents in a central file at the completion of the site response.

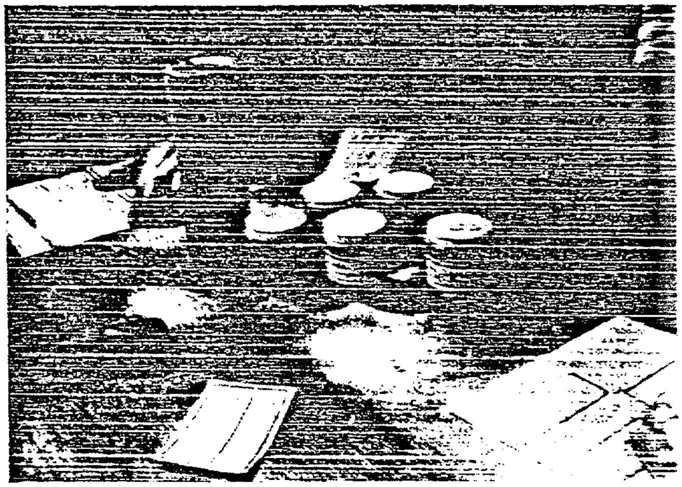
Field personnel should record all onsite activities and observations in a field logbook—a bound book with consecutively numbered pages. Entries should be made during or just after completing a task to ensure thoroughness and accuracy. Table 6-3 shows the level of detail that should be recorded during sampling.

Photographs can be an accurate, objective addition to a field worker's written observations. For each photograph taken, the following information should be recorded in the field logbook:

- Date, time, and name of site.
- Name of the photographer.
- Location of the subject within the site.
- General compass direction of the orientation of the photograph.
- General description of the subject.
- Sequential number of the photograph and the film roll number.
- Camera, lens, and film type used for photography.

Serially numbered sample labels or tags should be assigned to sampling team personnel and recorded in the field logbook. Lost, voided, or damaged labels should be noted in the logbook. Labels should be firmly affixed to the sample containers using either gummed labels or tags attached by string or wire. Information should be recorded on the tag in waterproof ink and should include items such as:

- The unique sample log number.
- Date and time that the sample was collected.
- Source of the sample, e.g., name, location, and type of sample.
- Preservative used.
- Analysis required.



Sample jars are labelled prior to sampling as part of site documentation procedures.

- Name of collector.
- Pertinent field data.

In addition to supporting litigation, written records of sample collection, transfer, storage, analysis, and destruction help ensure the proper interpretation of analytical test results. Information describing the chain of custody should be recorded on a form that accompanies the sample from collection to destruction.

Hazard Assessment

Once the presence and concentrations of specific chemicals or classes of chemicals have been established, the hazards associated with these chemicals must be determined. This is done by referring to standard reference sources for data and guidelines on permissible levels of exposure, flammability, etc. Some key guidelines are listed in Table 6-4 and are described below.

Threshold Limit Value (TLV)©

TLVs can be used as a guideline for determining the appropriate level of worker protection. These values have been derived for many substances and can be found in *Threshold Limit Values for Chemical Substances and Physical Agents*, which is published annually by the American Conference of Governmental Industrial Hygienists (ACGIH) [2]. The ACGIH defines three categories of TLVs: time-weighted average (TWA); short-term exposure limit (STEL); and ceiling (C). All three categories may be useful in selecting levels of protection at a hazardous waste site. Refer to the *Threshold Limit Values for Chemical Substances and Physical Agents* [2] for additional details.

Permissible Exposure Limit (PEL)

Permissible exposure limits are enforceable standards promulgated by OSHA. In many cases they are derived from TLVs published in 1968. The PEL for a substance the 8-hour time-weighted average or ceiling concentrat

Table 6-3. Example of Field Logbook Entries to Describe Sampling

- Date and time of entry.
- Purpose of sampling.
- Name, address, and affiliation of personnel performing sampling.
- Name and address of the material's producer, if known.
- Type of material, e.g., sludge or wastewater.
- Description of material container.
- Description of sample.
- Chemical components and concentrations, if known.
- Number and size of samples taken.
- Description and location of the sampling point.
- Date and time of sample collection.
- Difficulties experienced in obtaining sample (e.g., is it representative of the bulk material?).
- Visual references, such as maps or photographs of the sampling site.
- Field observations, such as weather conditions during sampling periods.
- Field measurements of the materials, e.g., explosiveness, flammability, or pH.
- Whether chain-of-custody forms have been filled out for the samples.

above which workers may not be exposed. Although personal protective equipment may not be required for exposures below the PEL, its use may be advisable where there is a potential for overexposure. See the tables and substance-specific standards in 29 CFR Part 1910, Subpart Z, for additional details.

Recommended Exposure Limit (REL)

A NIOSH recommended exposure limit (REL) is the workplace exposure concentration recommended by NIOSH for promulgation by OSHA as a PEL, but is not enforceable as is the OSHA PEL. In some cases, NIOSH has described time-weighted average concentrations in terms of 10-hour, rather than 8-hour, averages.

IDLH Concentrations

IDLH exposure concentrations have been established by the NIOSH/OSHA Standards Completion Program (SCP) as a guideline for selecting respirators for some chemicals. The definition of IDLH varies depending on the source. For example, the Mine Safety and Health Administration Standard (30 CFR Part 11.3[t]) defines IDLH conditions as those that pose an immediate threat to life or health or that pose an immediate threat of severe exposure to contaminants such as radioactive materials that are likely to have adverse cumulative or delayed effects on health. The NIOSH *Pocket Guide to Chemical Hazards* [3] defines IDLH concentration as the ". . . maximum level from which one could escape within 30 minutes without any escape-impairing symptoms or any irreversible health effects . . . ." The American National Standards Institute, Inc. (ANSI) defines IDLH as ". . . any atmosphere that poses an immediate hazard to life or produces immediate irreversible debilitating effects on health . . ." [4]. Regardless of their exact definition, all IDLH values indicate those concentrations of toxic substances from which escape is possible without irreversible harm should a worker's respiratory protective equipment fail. At hazardous waste sites, IDLH concentrations should be assumed to represent concentrations above which only workers wearing respirators that provide the maximum protection (i.e., a positive-pressure, full-facepiece, self-contained breathing apparatus [SCBA] or a combination positive-pressure, full-facepiece, supplied-air respirator with positive-pressure SCBA [see Chapter 8]) are permitted. Specific IDLH values for many substances can be found in the NIOSH *Pocket Guide to Chemical Hazards* [3].

Potential Skin Absorption and Irritation

Information on skin absorption is provided in the ACGIH publication, *Threshold Limit Values for Chemical Substances and Physical Agents* [2] and in OSHA standard 29 CFR Part 1910.1000 and other standard references. These documents identify substances that can be readily absorbed through the skin, mucous membranes, and/or eyes by either airborne exposure or direct contact with a liquid. This information, like most available information on skin absorption is qualitative. It indicates whether, but not to what extent, a substance may pose a dermal hazard. Thus decisions made concerning skin hazards are necessarily judgmental.

In addition, many chemicals, although not absorbed through the skin, may cause skin irritation at the point of contact. Signs of skin irritation range from redness, swelling, or itching to burns that destroy skin tissue. Standard references can be used to determine whether a chemical may act as an irritant.

Potential Eye Irritation

Quantitative data on eye irritation are not always available. Where a review of the literature indicates that a substance causes eye irritation, but no threshold is specified, have a competent health professional evaluate the data to determine the level of personal protection needed for onsite workers.

Explosion and Flammability Ranges

The lower explosive limit (LEL) or lower flammable limit (LFL) of a substance is the minimum concentration of gas or vapor in air below which the substance will not burn when exposed to a source of ignition. This concentration is usually expressed in percent by volume. Below this concentration, the mixture is too "lean" to burn or explode.

The upper explosive limit (UEL) or upper flammable limit (UFL) of a substance is the maximum concentration of gas or vapor above which the substance will not burn when exposed to a source of ignition. Above this concentration, the mixture is too "rich" to burn or explode.

The flammable range is the range of concentrations between the LFL and UFL where the gas-air mixture will support combustion.

The flashpoint of a substance is the minimum temperature at which it gives off sufficient vapor to form an ignitable mixture with the air just above the surface of the substance. Ignition of a substance at the flashpoint is not continuous.

Table 6-4. Guidelines for Assessing Chemical and Physical Hazards

HAZARD	GUIDELINE		EXPLANATION	SOURCES FOR VALUES[a]
Inhalation of airborne contaminants	TLV	Threshold Limit Value	One of three categories of chemical exposure levels, defined as follows:	
	TLV-TWA	Threshold Limit Value–Time-Weighted Average	The time-weighted average concentration for a normal 8-hour workday and a 40-hour work week, to which nearly all workers may be repeatedly exposed without adverse effect. Should be used as an exposure guide rather than an absolute threshold.	ACGIH
	TLV-STEL	Threshold Limit Value–Short-Term Exposure Limit	A 15-minute time-weighted average exposure that should not be exceeded at any time during the work day.	ACGIH
	TLV-C	Threshold Limit Value–Ceiling	The concentration that should not be exceeded even instantaneously.	ACGIH
	PEL	Permissible Exposure Limit	Time-weighted average and ceiling concentrations similar to (and in many cases derived from) the threshold limit values published in 1968.	OSHA
	REL	Recommended Exposure Limit	Time-weighted averages and ceiling concentrations based on NIOSH evaluations.	NIOSH
	IDLH	Immediately Dangerous to Life or Health	The maximum level from which a worker could escape without any escape-impairing symptoms or any irreversible health effects.[b]	NIOSH
Dermal absorption of chemicals through airborne or direct contact	Designation "skin"		The designation "skin" in the ACGIH, OSHA, and NIOSH references[a] indicates that a substance may be readily absorbed through the intact skin; however, it is not a threshold for safe exposure. Direct contact with a substance designated "skin" should be avoided.	ACGIH/ OSHA/ NIOSH
Dermal irritation			Many substances irritate the skin. Consult standard references.	
Carcinogens	TLV	Threshold Limit Value	Some carcinogens have an assigned TLV.	ACGIH
	PEL	Permissible Exposure Limit	OSHA has individual standards for some specific carcinogens.	OSHA
	REL	Recommended Exposure Limit	NIOSH makes recommendations regarding exposures to carcinogens.	NIOSH
Noise	TLV	Threshold Limit Value	Sound pressure levels and durations of exposure that represent conditions to which it is believed that nearly all workers may be repeatedly exposed without an adverse effect on their ability to hear and understand normal speech.	ACGIH
	PEL	Permissible Exposure Limit	Limits for acceptable noise exposure.	OSHA
	REL	Recommended Exposure Limit	Limits for acceptable noise exposure.	NIOSH
Ionizing Radiation	Maximum permissible body burden and maximum permissible concentrations of radionuclides in air and in water.			NCRP
	PEL	Permissible Exposure Limit	Dose in rems per calendar quarter.	OSHA

The ignition temperature or autoignition temperature is the minimum temperature required to initiate or cause self-sustained combustion without an ignition source.

When evaluating the fire or explosion potential at a hazardous waste site, all equipment used should be intrinsically safe or explosion-proof. Where flammable or explosive atmospheres are detected, ventilation may dilute the mixture to below the LEL/LFL. However, ventilation is generally not recommended if concentrations exceed the UFL/UEL, since the mixture will pass through the flammable/explosive range as it is diluted. Note that combustible gas indicator readings may not be accurate when oxygen concentrations are less than 19.5 percent.

Hazardous Substance Information Form

Information on the chemical, physical, and toxicologic properties of each compound known or expected to occu on site should be recorded on a Hazardous Substance Information Form (see Appendix C). Response personnel will then have the necessary health and safety information in one place, and new personnel can be quickly briefed. As many reference sources as possible should be used to fill out the sheets because the information may vary from one source to another. Material Safety Data Sheets provided by chemical manufacturers are one source for this information.

Table 6-4. (cont.)

HAZARD	GUIDELINE		EXPLANATION	SOURCES FOR VALUES[a]
Explosion	LEL	Lower Explosive Limit	The minimum concentration of vapor in air below which propagation of a flame will not occur in the presence of an ignition source.	NFPA
	UEL	Upper Explosive Limit	The maximum concentration of a vapor in air above which propagation of a flame will not occur in the presence of an ignition source.	NFPA
Fire	Flash point		The lowest temperature at which the vapor of a combustible liquid can be made to ignite momentarily in air.	NFPA

[a] Sources:

ACGIH. 1984-85. Threshold Limit Values for Chemical Substances and Physical Agents in the Workplace Environment and Biological Exposure Indices with Intended Changes for 1985-86. American Conference of Governmental Industrial Hygienists, Cincinnati, Ohio.

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NCRP. Basic Radiation Protection Criteria. NCRP Report No. 39. National Council on Radiation Protection and Measurements, Washington, D.C.

NCRP. Maximum Permissible Body Burdens and Maximum Permissible Concentrations of Radionuclides in Air and Water for Occupational Exposure. NCRP Report No. 22. National Council on Radiation Protection and Measurements, Washington, D.C.

NFPA. 1985. Fire Protection Guide on Hazardous Materials. Eighth Edition. National Fire Protection Association, Boston, Massachusetts.

OSHA. 29 CFR Part 1910. (OSHA standards are legally binding.)

[b] Other sources have slightly different definitions of IDLH (see *IDLH Concentrations* in this chapter).

Monitoring

Because site activities and weather conditions change, an ongoing air monitoring program should be implemented after characterization has determined that the site is safe for the commencement of operations.

The ongoing monitoring of atmospheric chemical hazards should be conducted using a combination of stationary sampling equipment, personnel monitoring devices, and periodic area monitoring with direct-reading instruments (see Chapter 7, *Air Monitoring*). Data obtained during off-site and onsite surveys can be used to develop a plan that details the procedures to be used for monitoring ambient conditions during cleanup operations. Where necessary, routes of exposure other than inhalation should be monitored. For example, skin swipe tests may be used to determine the effectiveness of personal protective clothing (see Chapter 10, *Decontamination*). Depending on the physical properties and toxicity of the onsite materials, community exposures resulting from hazardous waste site operations may need to be assessed [5].

Monitoring also includes continual evaluation of any changes in site conditions or work activities that could affect worker safety. When a significant change occurs, the hazards should be reassessed. Some indicators of the need for reassessment are:

- Commencement of a new work phase, such as the start of drum sampling.
- Change in job tasks during a work phase.
- Change of season.
- Change in weather.
- Change in ambient levels of contaminants.

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4. ANSI. 1980. Practices for Respiratory Protection. ANSI Z88.2-1980. American National Standards Institute, 1430 Broadway, New York, NY 10018.
5. U.S. Department of Health and Human Services. 1984. A System for Prevention, Assessment and Control of Exposures and Health Effects from Hazardous Sites (S.P.A.C.E. for Health), U.S. Department of Health and Human Services, Public Health Service, Center for Disease Control, Atlanta, GA.

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Patrick J. Ford
Paul J. Turina
Douglas E. Seely
GCA CORPORATION
GCA/TECHNOLOGY DIVISION
Bedford, Massachusetts 01730

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Lockheed Engineering and Management
Services Company, Inc.
Las Vegas, Nevada 89109

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EPA Project Officer

Charles K. Fitzsimmons
Advanced Monitoring Systems Division
Environmental Monitoring Systems Laboratory
Las Vegas, Nevada 89114

ENVIRONMENTAL MONITORING SYSTEMS LABORATORY
OFFICE OF RESEARCH AND DEVELOPMENT
U.S. ENVIRONMENTAL PROTECTION AGENCY
LAS VEGAS, NEVADA 89114

Enclosure (2)

1.3 PURPOSE AND OBJECTIVE OF SAMPLING

The basic objective of any sampling compaign is to collect a sample which is representative of the media under investigation. More specifically, the purpose of sampling at hazardous waste sites is to acquire information that will aid investigators in determining the presence and identity of onsite contaminants and the extent to which these compounds have become integrated into the surrounding environment. This information can then be used as support for future litigations or as input to remedial investigations and risk assessments.

The term "sample" has already been defined as a representative part of the media under investigation. Representativeness, however, is a relative term and must be carefully considered, along with several other criteria, prior to the acquisition of samples. A list of the criteria is as follows.

- Representativeness--This sample possesses the same qualities or properties as the material under consideration. The degree of resemblance of the sample to the material in question is determined by the desired qualities under investigation and analytical techniques used.
- Sample size--This should be chosen carefully in respect to physical properties of the entire object and the requirements and/or limitations of both sampling and analytical techniques.
- Number and/or the frequency of subsample--Decisions on these considerations are based on what types of statistical information are desired and the nature of the material collected.
- Maintenance of sample integrity--The sample must retain the properties of the original medium conditions (at the time of sampling) through collection, transport, and delivery to the analyst.

1.4 TYPES OF SAMPLES

Before defining the general sample types, the nature of the media or materials under investigation must be discussed. Materials can be divided into three basic groups as outlined in Figure 1-1.[1]

Of least concern to the sampler are homogeneous materials. These materials are generally defined as having uniform composition throughout. In this case, any sample increment can be considered representative of the material. On the other hand, heterogeneous samples present problems to the sampler because of changes in the quality of the material over distance.

When discussing types of samples, it is important to distinguish between the type of media to be sampled and the sampling technique that yields a specific type of sample. In relation to the media to be sampled, two basic types of samples can be considered: the environmental sample and the hazardous sample.

Environmental samples (ambient air, soils, rivers, streams, or biota) are generally dilute (in terms of pollutant concentration) and usually do not require the special handling procedures used for concentrated wastes. However, in certain instances, environmental samples can contain elevated concentrations of pollutants and in such cases would have to be handled as hazardous samples.

Hazardous or concentrated samples are those collected from drums, tanks, lagoons, pits, waste piles, fresh spills, etc., and require special handling procedures because of their potential toxicity or hazard. These samples can be further subdivided based on their degree of hazard; however, care should be taken when handling and shipping any wastes believed to be concentrated, regardless of the degree.

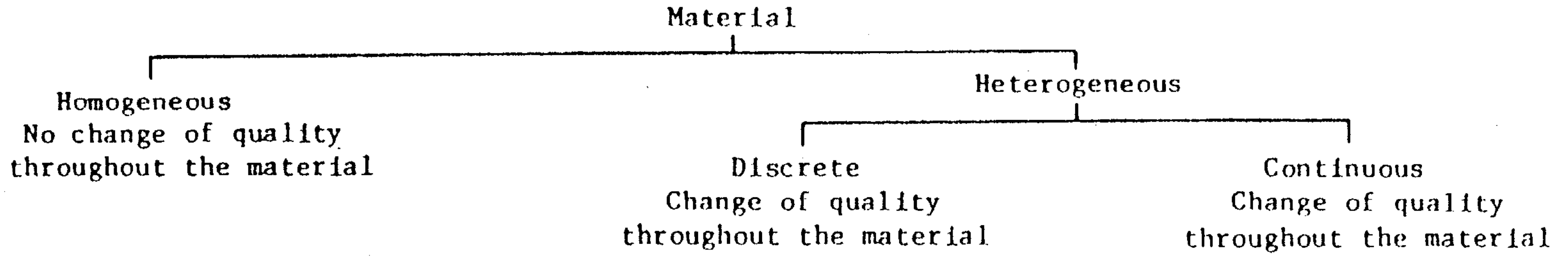
In general, two basic types of sampling techniques are recognized, both of which can be used for either environmental or concentrated samples.

Grab Samples

A grab sample is defined as a single sample representative of a specific location at a given point in time. The sample is collected all at once and at one particular point in the sample medium. The representativeness of such samples is defined by the nature of the materials being sampled. In general, as sources vary over time and distance, the representativeness of grab samples will decrease.

Composite Samples

Composites are combinations of more than one sample collected at various sampling locations and/or different points in time. Analysis of composite yields an average value and can, in certain instances, be used as an alternative to analyzing a number of individual grab samples and calculating an average



Homogeneous	Discrete Changes	Continuous Changes
Well-mixed liquids	Ore pellets	Fluids or gases with gradients
Well-mixed gases	Tablets	Mixture of reacting compounds
Pure metals	Crystallized rocks	Granulated materials with granules much smaller than sample size
	Suspensions	

Source: Reference 1.

Figure 1-1. Types of material.

value. It should be noted, however, that compositing can mask problems by diluting isolated concentrations of some hazardous compounds below detection limits.

For sampling situations involving hazardous wastes, grab sampling techniques are generally preferred because grab sampling minimizes the amount of time sampling personnel must be in contact with the wastes, reduces risks associated with compositing unknowns, and eliminates chemical changes that might occur due to compositing. Compositing is still often used for environmental samples and may be used for hazardous samples under certain conditions. For example, compositing of hazardous waste is often performed (after compatibility tests have been completed) to determine an average value over a number of different locations (groups of drums). This procedure provides data that can be useful by providing an average concentration within a number of units, can serve to keep analytical costs down and can provide information useful to transporters and waste disposal operations.

1.5 SAMPLING PLAN

Before any sampling activities are begun, it is imperative that the purpose and goals of a program and the equipment, methodologies, and logistics to be used during the actual sampling be identified in the form of a work or sampling plan. This plan is developed when it becomes evident that a field investigation is necessary and should be initiated in conjunction with or immediately following the preliminary assessments. This plan should be concise, comprehensible and address the following items:

- Review existing work or background;
- Define goals and scope of work;
- Organization of the field teams;
- Statistical strategy;
- Quality assurance/Quality control procedures;
- Safety considerations; and
- Decontamination procedures.

Please note that this list of sampling plan components is not all inclusive. Additional elements may be inserted or altered depending on the needs of the project. It should be understood that in emergency situations personal judgement may have to be implemented. In any event, actions should be dictated by plan to maintain logical and consistent order to the task. (Additional details concerning the development of a Sampling Plan can be found in Volume I, Section 6.)

Reviewing Existing Work or Background Information

A synopsis of the site operational history as well as a review of previous study conclusions and recommendations are necessary in order to familiarize the field team members with the investigation.

In addition, this section should include regional or state maps locating the investigation area as well as detailed maps and photos of the local site. Of particular importance to the investigators is information pertaining to the following points: (1) the composition and characteristics of the wastes, (2) the adequate storage or destruction of wastes on the site, (3) the routes which the wastes could migrate off site, and (4) the effects that would occur (or might have occurred) through the discharge of waste.

Goals and Scope

A clear definition of the goals of the investigation and a detailed explanation of the tasks and phases designed to provide the information necessary to obtaiin the goals should be included.

The goals may be a general characterization of the site or a determination of offsite migration of contaminants or the collection of physical evidence for enforcement proceedings. Generally it is a combination of these or other potential goals which must be considered. Investigators must be aware that short-sighted goal assignment may limit utility of data for future applications.

The scope of the investigation should be outlined as discrete phases and tasks. The sequence and timeframe for each task should be delineated on a project time table or time line with key decision points and options clearly displayed.

Efficient arrangement of tasks to minimize onsite time will lead to reduced risks by reducing exposure times.

Organization of the Field Teams

Before sampling can commence, the following responsibilities must be delegated into the following roles:

- Project Team Leader--is primarily an administrator when not participating in the field investigation.
- Field Team Leader--is responsible for the overall operation and safety of the field team.
- Site Safety Officer--is primarily responsible for all safety procedures and operations.
- Command Post Supervisor--serves as a means of communication and never enters the exclusive area except for emergencies.
- Work Party--performs the onsite tasks necessary to fulfill the objectives.

Please note, that in many hazardous waste projects, one person may fulfill many roles.

Statistical Strategy

Implementation of the proper statistical strategy depends upon two essential points, the objectives or goals of the sampling plan and the amount of information available on the parameter or parameters of interest, i.e. time, spatial distribution, variability, etc. The following are among the different sampling schemes that could be chosen.

Random Sampling--

Random sampling uses the theory of random chance probabilities to choose representative sample locations. Random sampling is generally employed when little information exists concerning the material, location, etc. It is most effective when the population of available sampling locations is large enough to lend statistical validity to the random selection process. Since one of the main difficulties with random sampling deals with achieving a truly random sample, it is advisable to use a table of random numbers to eliminate or reduce bias (Appendix G).

Systematic Sampling--

Systematic sampling involves the collection of samples at predetermined, regular intervals. It is the most often employed sampling scheme; however, care must be exercised to avoid bias. If, for example, there are periodic variations in the material to be sampled such that the systematic plan becomes partially phased with these variations, bias will result.

A systematic sampling plan is often the end result of an approach that was begun as random due to the tendency of investigators to subdivide large sample areas into smaller increments before randomizing.

Stratified Sampling--

Data and background information made available from the preliminary site survey, prior investigations conducted on site, and/or experience with similar situations can be useful in reducing the number of samples needed to attain a specified precision. Stratified sampling essentially involves the division of the sample population into groups based on knowledge of sample characteristics at these divisions. The purpose of the approach is to increase the precision of the estimates made by sampling. This objective should be met if the divisions are "selected in such a manner that the units within each division are more homogeneous than the total population."[2] The procedure used basically involves handling each division in a simple random approach.

Judgment Sampling--

A certain amount of judgment often enters into any sampling approach. In fact, a biased approach is the one most often employed when the intent is to document the presence of contamination (e.g., for enforcement purposes). Since judgment approaches tend to allow investigator bias to influence decisions, care must be exercised. Poor judgment can lead to poor quality data and improper conclusions. If judgment sampling is employed, it is generally advisable that enough samples be collected to lend credence to any conclusion drawn about the area under investigation because it is very difficult to actually measure sample accuracy. This is especially true for enforcement samples where the analytical results indicate no apparent sign of contamination. In such cases it is important to reduce the chance of committing a Type II statistical error. In such cases the inability to measure sample accuracy makes it difficult to rule out Type II errors (i.e., the likelihood that contaminants are present at the site even if not found in the samples).

Hybrid Sampling Schemes--

In reality, most sampling schemes consist of a combination or hybrid of the types previously described. For example, when selecting an appropriate plan for sampling drums at a hazardous waste site, the drums might be initially staged based on preliminary information concerning contents, program objectives, etc. (judgment, stratified sampling), and then sampled randomly within the specified population groups (random sampling). Hybrid schemes are usually the method of choice as they can allow for greater diversity without compromising the objectives of the program.

For further details on this subject, please refer to Volume I, Section 6 of this series.

Quality Assurance/Quality Control

The adherence to a proper Quality Assurance--Quality Control plan is essential for a successful sampling effort. The two major concerns of a QA/QC plan are quality assurance samples and document control (chain of custody).

Quality Assurance Samples--

Quality assurance samples must be collected at any time legal action is anticipated. It is recommended that quality assurance samples be collected in all sampling surveys in order to know the quality of data collected. These additional samples are essential to any quality control aspects of the project and may also assist in reducing costs associated with resampling brought about by container breakage, errors in the analytical procedure, and data confirmation. The following is a list of the types of quality assurance samples required.

- Sample Blanks--Sample blanks are samples of deionized/distilled water, rinses of collection devices or containers, sampling media (e.g., sorbent), etc. that are handled in the same manner as the sample and subsequently analyzed to identify possible sources of contamination during collection, preservation, handling, or transport.

- Duplicates--Duplicates are essentially identical samples collected at the same time, in the same way, and contained, preserved, and transported in the same manner. These samples are often used to verify the reproducibility of the data.

- Split Samples--Split samples are duplicate samples given to the owner, operator, or person in charge for separate independent analysis.

- Spiked Samples--Spiked samples are duplicate samples that have a known amount of a substance of interest added to them. These samples are used to corroborate the accuracy of the analytical technique and could be used as an indicator of sample quality change during shipment to the laboratory.

Document Control/Chain-of-Custody--

Strict adherence to document and data control procedures is essential from the standpoint of good quality assurance/quality control and should be instituted as routine in any hazardous waste investigation. It becomes especially important when collected data is used to support enforcement litigations. All collected information, data, calibration and maintenance records, samples, and documents, must therefore be accounted for and retrievable at any time during an investigation.

The purpose of document control is to ensure that all project documents be accounted for when the project is complete. Types of documents considered essential include maps, drawings, photographs, project work plans, quality assurance plans, serialized logbooks, data sheets, coding forms, confidential information, reports, etc.

Chain-of-custody procedures are necessary to document the sample identity, handling and shipping procedures, and in general to identify and assure the traceability of generated samples. Custody procedures trace the sample from collection, through any custody transfers, and finally to the analytical facility at which point internal laboratory procedures take over. Chain-of-custody is also necessary to document measures taken to prevent and/or detect tampering with samples, sampling equipment or the media to be sampled. A detailed description of Document Control/Chain-of-Custody Procedures can be found in Appendix D and in Volume I, Section 2.

Safety--

A more detailed discussion of safety considerations can be found in Volume I, Section 3 and Volume IV (pending release of Volume IV refer to "Interim Standard Operating Safety Guides, Revised September 1982). These considerations should be carefully reviewed before engaging in any hazardous waste sampling endeavors. It is important, however, that safety be generally discussed at this time to provide a necessary reminder of the importance of taking proper, well developed precautions when dealing with hazardous materials.

Decontamination Procedures

Decontamination procedures are designed to provide two primary safeguards.

- Prevent the movement of contaminated materials into noncontaminated areas.
- Insure that samples collected during the investigation are not exposed to additional contamination from onsite materials or sampling equipment.

Proper decontamination is not only a health and safety concern but also an analytical and sampling consideration. The Sampling Plan will detail proper decontamination procedures to safeguard both the onsite personnel and the sample integrity. Appendix E provides generalized decontamination guidelines exerpted from Interim Standard Operating Safety Guides, September 1982, Office of Emergency and Remedial Response.

1.6 IMPLEMENTATION OF SAMPLING PLAN

It is the responsibility of the Field Team Leader to implement and obtain the goals of the Sampling Plan. This involves overseeing and coordinating five primary tasks:

- Management of the sampling team(s),
- Coordination with the analytical lab(s),
- Coordination with additional subcontractor efforts,
- Implementation of the Safety Plan or Coordination with the Safety Officer, and
- Implementation of the QA/QC Plan or Coordination with the Quality Assurance Officer.

Small scale efforts often utilize the Field Team Leader (FTL) as the Safety Officer and the Quality Assurance Officer. As the Sampling Plan increases in complexity, it becomes essential that the FTL designate Safety and Quality Assurance Officers in order to insure proper implementation. It then becomes the task of the FTL to coordinate their activities. Each of the five primary tasks are described below:

Management of the Sampling Team

The key task here is to insure that the goals of the sampling plan are obtained. In addition to the selection and proper implementation of methods, the FTL must continually adjust, and carefully document changes to the sampling plan to accomodate situations which may arise. This may involve, for example, relocating or adding sampling locations if the investigation uncovers new sources or should adverse weather make some locations inaccessible.

Thorough and detailed documentation of all onsite activities is also a critical responsibility. This includes records of all expenditures, manpower, and equipment uses and any changes of scope. These records are particularly important for Superfund investigation or any investigation where attempts will be made to recover costs from responsible parties. This aspect of the FTL's responsibilities is often overlooked or downplayed, but to do so is likely to later result in tremendous problems in cost recovery.

Coordination with the Analytical Lab

The sampling plan also serves to integrate the responsibilities of Sampling Teams and the analytical labs. It is critical that the sampling activities are coordinated with the laboratory. The following points illustrate the extent of this coordination and its importance to the project:

- Sampling schedules must be arranged with the laboratory manager to insure that the samples can be processed within the specified holding times.

- Labels and labeling information should be discussed. This will aid in the orderly transfer of field information to the proper laboratory personnel and insure that each sample receives only the specified analyses.

- Shipping arrangements, if necessary, must be agreed to in advance. Selection of a carrier, delivery times, and billing procedures must be mutually acceptable.

- Preservation requirements and equipment decontamination procedures should be specified. This would include specific recommendations reagents and cleaning solvents.

- A field and a laboratory coordinator should be designated from both groups to serve as points of communication. In most situations, the laboratory will specify the number and type of Quality Assurance/ Quality Control samples. Should this decision be made by field personnel, information regarding these samples must be transmitted to the Laboratory's QA/QC director.

Failure to properly coordinate these activities can result in complete data loss, or at a minimum a reduction in its quality and overall reliability. Either of these outcomes translates into potentially significant waste of time and money.

Coordination with Other Subcontractor Efforts

Many investigations require the services of a team of subcontractors. These include Drilling Contractors, Geophysical Investigation Teams, Aerial Photographic Contractors, and Trade Contractors (electricians, plumbers, carpenters and fencing contractors). It is the FTL's responsibility to coordinate their activities, insure adherence to the sampling plan, or contractural requirements.

Here again, thorough recordkeeping and documentation is critical.

Implementation of the Safety Plan

The Safety Plan must be implemented prior to full scale mobilization of onsite activities. This would include establishing decontamination stations, command posts, first aid stations, etc. If the scope of the investigation is large, the FTL should designate a Site Safety Officer to implement the safety plan.

Volume I, Section 3 discusses the basic aspects of a Safety Plan. Volume IV will provide details on the preparation and provisions of safety plans, however until release of this document, this information is contained in the Interim Standard Operation Safety Guides, September 1982, U.S. EPA, OERR.

Implementation of the QA/QC Plan.

The QA/QC Plan must address all phases of the investigation including field measurements, laboratory analysis, subcontractor activities, documentation/recordkeeping and report preparation. As with the Safety Plan, the complexity and time demands of this task increase with the overall project complexity. Therefore on larger projects, the FTL may designate a QA/QC officer.

The FTL must be familiar with the terms of the QA/QC Plan and insure that they are implemented by all field and laboratory personnel. Of particular concern to the FTL are document control and chain of custody procedures. As stated earlier, and cannot be over emphasized, are the demands on the FTL for documentation and recordkeeping, these tasks must also closely adhere to document control procedures. Without these records and documented assurance of their completeness and validity litigation and cost recovery efforts will be severely handicapped.

1.7 REFERENCES

1. Kateman, G. and F. W. Pijpers. Quality Control in Analytical Chemistry. John Wiley and Sons, New York, 1981.

2. Smith, R. and G. James. The Sampling of Bulk Materials. Analytical Sciences Monographs, Volume 8. The Royal Society of Chemistry, London, 1981.

SECTION 2.0

SOLIDS

2.1 GENERAL

The sampling of solid or semi-solid materials is complicated by the structural properties of the material. For example, the presence of entrapped gases and fluids is often an integral part of the substance and may be of consequence in the analytical techniques for which the sample was collected. It is necessary in most cases to collect a sample which does not alter this balance. In addition, physical strength and density of the material demand sampling devices of significant rigidity and strength. As a result a great deal of disturbance will occur at the sample-sampler interface. These effects can be reduced by careful sampling and by collecting aliquots with a high volume to surface area ratio.

A solid does not necessarily have uniform characteristics with respect to distance or depth. Those portions which form boundaries with the container, define the edges of a pile, or contact the atmosphere do not necessarily represent the material as a whole. Care must be exercised in order to prevent aeration or significant changes in moisture content. Samples should be tightly capped and protected from direct light.[1]

Most commercially available solids sampling devices are steel, brass or plastic. In general, use of stainless steel is the most practical and several manufacturers will fabricate their equipment with all stainless steel parts on a special order basis. Another alternative is to have sampler contact surfaces Teflon coated. This can be accomplished by either sending the device to a commercial coater or by in-house application of spray-on Teflon coatings. Some devices, especially those for soil sampling, have traditionally been chrome- or nickel-plated steel. These should be particularly avoided, or the plating should be removed because scratches and flaking of the plating material can drastically effect the results of trace element analysis. Plated or painted surfaces, can be used in many cases if the outside coating is first removed by using abrasives. Such practice can yield a significant cost savings over more expensive materials, so long as the exposed material will affect the sample.

This section is divided into three subsections which address the sampling of soils, sludge and sediments, and bulk materials.

3. Begin drilling, periodically removing accumulated soils. This prevents accidentally brushing loose material back down the borehole when removing the auger or adding drill rods.

4. After reaching desired depth, slowly and carefully remove auger from boring. (Note: When sampling directly from auger, collect sample after auger is removed from boring and proceed to Step 10.)

5. Remove auger tip from drill rods and replace with a precleaned thin-wall tube sampler. Install proper cutting tip.

6. Carefully lower corer down borehole. Gradually force corer into soil. Care should be taken to avoid scraping the borehole sides. Hammering of the drill rods to facilitate coring should be avoided as the vibrations may cause the boring walls to collapse.

7. Remove corer and unscrew drill rods.

8. Remove cutting tip and remove core from device.

9. Discard top of core (approximately 2.5 cm), which represents any material collected by the corer before penetration of the layer in question. Place remaining core into sample container.

10. Check that a Teflon liner is present in the cap if required. Secure the cap tightly. The chemical preservation of solids is generally not recommended. Refrigeration is usually the best approach supplemented by a minimal holding time. Consult Appendix A for containerization and preservation recommendations.

11. Label the sample bottle with the appropriate sample tag. Be sure to label the tag carefully and clearly, addressing all the categories or parameters. Complete all chain-of-custody documents and record in the field logbook.

12. Decontaminate sampling equipment after use and between sampling locations. Refer to Appendix E for decontamination requirements.

Sources

deVera, E. R., Simmons, B. P., Stephens, R. D., and Storm, D. L. "Samplers and Sampling Procedures for Hazardous Waste Streams." EPA 600/2-80-018, January 1980.

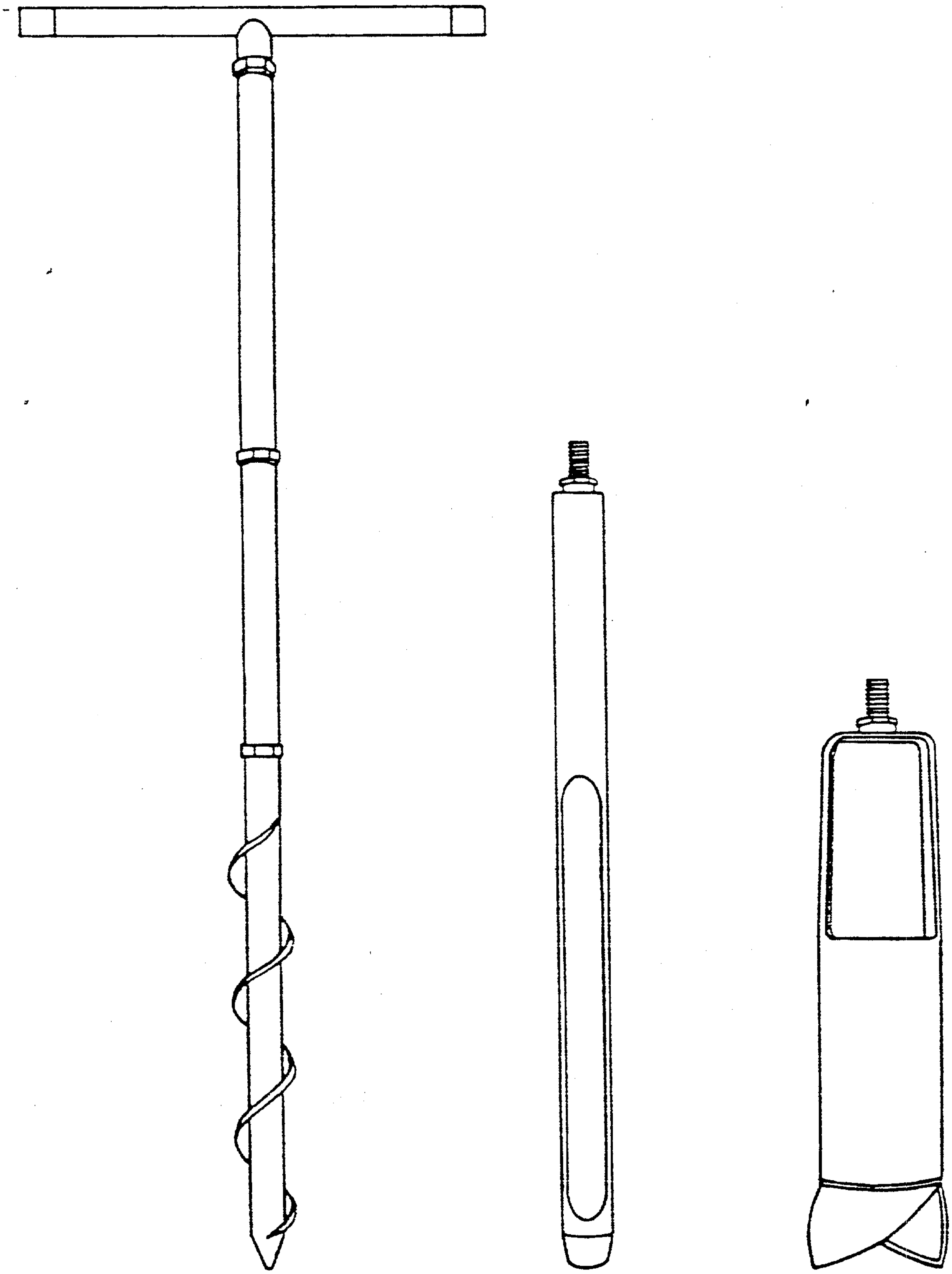


Figure 2-1. Augers and thin-wall tube sampler.

2.2.2 METHOD II-2: SUBSURFACE SOLID SAMPLING WITH AUGER AND THIN-WALL TUBE SAMPLER

Discussion

This system consists of an auger bit, a series of drill rods, a "T" handle, and a thin-wall tube corer (see Figure 2-1). The auger bit is used to bore a hole to the desired sampling depth and then withdrawn. The auger tip is then replaced with the tube corer, lowered down the borehole, and forced into the soil at the completion depth. The corer is then withdrawn and the sample collected.

Alternately the sample can be recovered directly from the auger. This technique however, does not provide an "undisturbed" sample as would be collected with a thin tube sampler. In situations where the soil is rocky, it may not be possible to force a thin tube sampler through the soil or sample recovery may be poor. Sampling directly from the auger may be the only viable method. Several auger types are available which include Bucket type, continues flight (screw) and posthole augers. Bucket types are good for direct sample recovery and are fast and provide a large volume of sample. When continuous flight (screw) augers are utilized, the sample can be collected directly off the flights, however, this technique will provide a somewhat unrepresentative sample as the exact sample depth will not be known. The continuous flights auger are, however, satisfactory for use when a composite of the entire soil column is desired. Posthole augers have limited utility for sample acquisition as they are designed more for their ability to cut through fibrous, heavily rooted, swampy areas. In soils where the borehole will not remain open when the tool is removed, a temporary casing can be used until the desired sampling depth is reached.

Uses

This system can be used in a wide variety of soil conditions. It can be used to sample both from the surface, by simply driving the corer without preliminary boring, or to depths in excess of 6 meters. The presence of rock layers and the collapse of the borehole, however, usually prohibit sampling at depths in excess of 2 meters. Interchangable cutting tips on the corer reduce the disturbance to the soil during sampling and aid in maintaining the core in the device during removal from the borehole.

Procedures for Use

1. Attach the auger bit to a drill rod extension and further attach the "T" handle to the drill rod.

2. Clear the area to be sampled of any surface debris (twigs, rocks, litter). It may be advisable to remove the first 8 to 15 cm of surface soil for an area approximately 15 cm in radius around the drilling location.

2.2.1 METHOD II-1: SOIL SAMPLING WITH A SPADE AND SCOOP

Discussion

The simplest, most direct method of collecting soil samples for subsequent analysis is with the use of a spade and scoop. A normal lawn or garden spade can be utilized to remove the top cover of soil to the required depth and then a smaller stainless steel scoop can be used to collect the sample.

Uses

This method can be used in most soil types but is limited somewhat to sampling the near surface. Samples from depths greater than 50 cm become extremely labor intensive in most soil types. Very accurate, representative samples can be collected with this procedure depending on the care and precision demonstrated by the technician. The use of a flat, pointed mason trowel to cut a block of the desired soil will be of aid when undisturbed profiles are required. A stainless steel scoop or lab spoon will suffice in most other applications. Care should be exercised to avoid the use of devices plated with chrome or other materials. Plating is particularly common with garden implements such as potting trowels.

Procedures for Use

1. Carefully remove the top layer of soil to the desired sample depth with a precleaned spade.
2. Using a precleaned stainless steel scoop or trowel, remove and disca a thin layer of soil from the area which comes in contact with the shovel.
3. Transfer sample into an appropriate sample bottle with a stainless steel lab spoon or equivalent.
4. Check that a Teflon liner is present in the cap if required. Secure the cap tightly. The chemical preservation of solids is generally not recommended. Refrigeration is usually the best approach supplemented by a minimal holding time. For specific containerization an preservation requirements consult Appendix A.
5. Label the sample bottle with the appropriate sample tag. Be sure t label the tag carefully and clearly, addressing all the categories parameters. Complete all chain-of-custody documents and record in the field log book.
6. Decontaminate equipment after use and between sample locations. Fo specific decontamination guidelines, consult Appendix E.

leach out and become incorporated as part of the sample. The liner tubes can further be capped off and used as sample containers for transport to the lab.

Interchangeable cutting tips facilitate smoother penetration with reduced sample disturbance. They are available in various styles and construction suitable for moist, dry, sandy or heavy-duty applications. The design of these cutting tips will further aid in maintaining the sample in the tube during sample extraction.

Augers are also very effective for soil sampling. Bucket type augers can be used directly for soil sample collection or to advance a borehole to the desired depth so then a thin wall tube can be employed.

Kits are available that include, in conjunction with the tube sampler and cutting tips, an auger point and a series of extension rods. These kits allow for hand augering a borehole. The auger can then be removed and a tube sampler lowered and forced into the soil at the completion depth. Though kits are available with sufficient tools to reach depths in excess of 7 meters, soil structure, impenetrable rock, and water levels usually prevent reaching such completion depths. Kits that include 1 meter of drill rod and the ability to order additional extensions will in practice prove satisfactory. The need for soil information at greater depths will normally require professional assistance. Consideration should be given to supplementing this information with groundwater monitoring since soil sampling can be conducted in conjunction with well completion.

For those wishing a more in-depth discussion of soils and soil sampling, refer to the Preparation of Soil Sampling Protocol: Techniques and Strategies, (EPA 600/4-83-020) by Dr. Benjamin J. Mason, prepared under contract to the U.S. Environmental Protection Agency, Environmental Monitoring Systems Laboratory--Las Vegas, August 1983. This report discusses in detail the factors that influence the selection of a particular sampling scheme or the use of a particular sampling method with a strong emphasis on statistical design and data analysis. Another document, Soil Sampling Quality Assurance User's Guide, (EPA 600/4-84-043) by Dr. Delbert S. Barth and Dr. Benjamin J. Mason, prepared by the Environmental Research Center, University of Nevada-Las Vegas under a cooperative agreement with the Environmental Protection Agency (May 1984) will also be helpful.

2.2 SOILS

Soil sampling is an important adjunct to groundwater monitoring. Sampling of the soil horizons above the groundwater table can detect contaminants before they have migrated into the water table, and can help establish the amount of contamination sorbed on aquifer solids that have the potential of contributing to the groundwater contamination.

Soil types can vary considerably on a hazardous waste site. These variations, along with vegetation, can effect the rate of contaminant migration through the soil. It is important, therefore, that a detailed record be maintained during sampling operations, particularly of location, depth, and such characteristics as grain size, color and odor, and/or readings obtained on field monitoring equipment. Subsurface conditions are often stable on a daily basis and may demonstrate only slight seasonal variation especially with respect to temperature, available oxygen, and light penetration. Changes in any of these conditions can radically alter the rate of chemical reactions or the activity of associated microbiological community. As a result samples should be kept at their at-depth temperature or lower, protected from direct light, sealed tightly in glass bottles, and analyzed as soon as possible.

The physical properties of the soil, its grain size, cohesiveness, associated moisture, and such factors as depth to bedrock and water table will limit the depth from which samples can be collected and the method required to collect them. Often this information on soil properties can be acquired from published soil surveys obtainable through the U.S. Geological Survey (USGS) and other government and farm agencies. A comprehensive listing of these offices and currently available soil surveys is included in the "NEIC Manual for Groundwater/Subsurface Investigations at Hazardous Waste Sites."[2] Most of the methods employed for soil sampling at hazardous waste sites are adaptations of techniques long employed by foundation engineers and geologists. This section presents those methods which can be employed with a minimum of special training, equipment or cost. More detailed methods capable of sampling to greater depths in more difficult soil conditions, or that can simultaneously install groundwater monitor wells, usually require professional assistance. These techniques are discussed more fully in the "Manual for Ground-water Sampling Procedures."[3]

Collection of samples from near the soil surface can be accomplished with tools such as spades, shovels, and scoops. With this type of readily available equipment the soil cover can be removed to the required depth; then a stainless steel scoop can be used to collect the sample. An undisturbed sample can be collected from this excavation by employing a thin wall tube sampler. This device is, as the name implies, a metal tube generally 2.5 to 7.5 cm in diameter and 30.5 to 61.0 cm long. The tube is forced into the soil, then extracted. Friction will usually hold the sample material in the tube during the extraction. The construction material is generally steel, and some samplers can utilize plastic liners and interchangable cutting tips. The liners are useful for trace element sampling but are generally not suitable for organic analysis due to the possibility that materials in the liner will

4.3 SOIL GASES AND VAPORS

Monitoring of soil gases can often serve as a quick method of determining the extent of pollutant migration or establishing perimeters of a site containing buried wastes. Soil-gas exchange with the ambient atmosphere greatly dilutes gaseous components making them difficult to detect. Therefore, sampling in the soil can provide a more concentrated source for underground waste detection. Soil-gas sampling also has particular applicability to the identification of methane fluxes at sanitary landfills.

4.3.1 METHOD IV-10: MONITORING GAS AND VAPORS FROM TEST HOLE

Discussion

Gas samples can be withdrawn from test holes by using a nonsparking probe, brass and Teflon being the most suitable. The probe is then attached to the gas inlet of the desired gas monitor such as those described in the ambient gases section and Method IV-1 through IV-8. The test holes are easily prepared by driving a metal rod (approximately 1 in. diameter) into the soil with a drive weight. Commercial bar hole-makers are available that combine the steel hole-making bar and drive weight into one unit (see Figure 4-7).[39]

Uses

This system is particularly adapted for rapid evaluation of waste sites for soil gas generation. When used in conjunction with a hydrocarbon analyzer or an explosimeter it can rapidly determine the areal extent of a waste site or the location of a particular emission source. It is recommended that the test area be screened with a metal detector before sampling.

Procedures for Use

1. Select location free from rocks and debris. Screen location with metal detector to varify absence of drums and pipes.
2. Place bar point on ground and raise drive weight, then allow weight to fall on bar. It is only necessary to guide the weight in its vertical travel.
3. Continue until desired depth or any penetration resistance is reached.
4. Remove bar hole-maker.
5. Attach suitable length of Teflon tubing (stainless steel or brass may be used in some instances but may result in some gas adsorption/absorption) to monitor instrument gas inlet.
6. Lower tubing into test hole and operate monitor or gas sampling device as listed in Methods IV-1 through IV-8.
7. Record results.
8. Remove sample tubing and observe that instrument readings return to background. If not, change tubing before proceeding to next test location.
9. Tramp over and recover test hole.

Sources

Flower, F.B. "Case History of Landfill Gas Movement Through Soils." Rutgers University, New Brunswick, New Jersey.

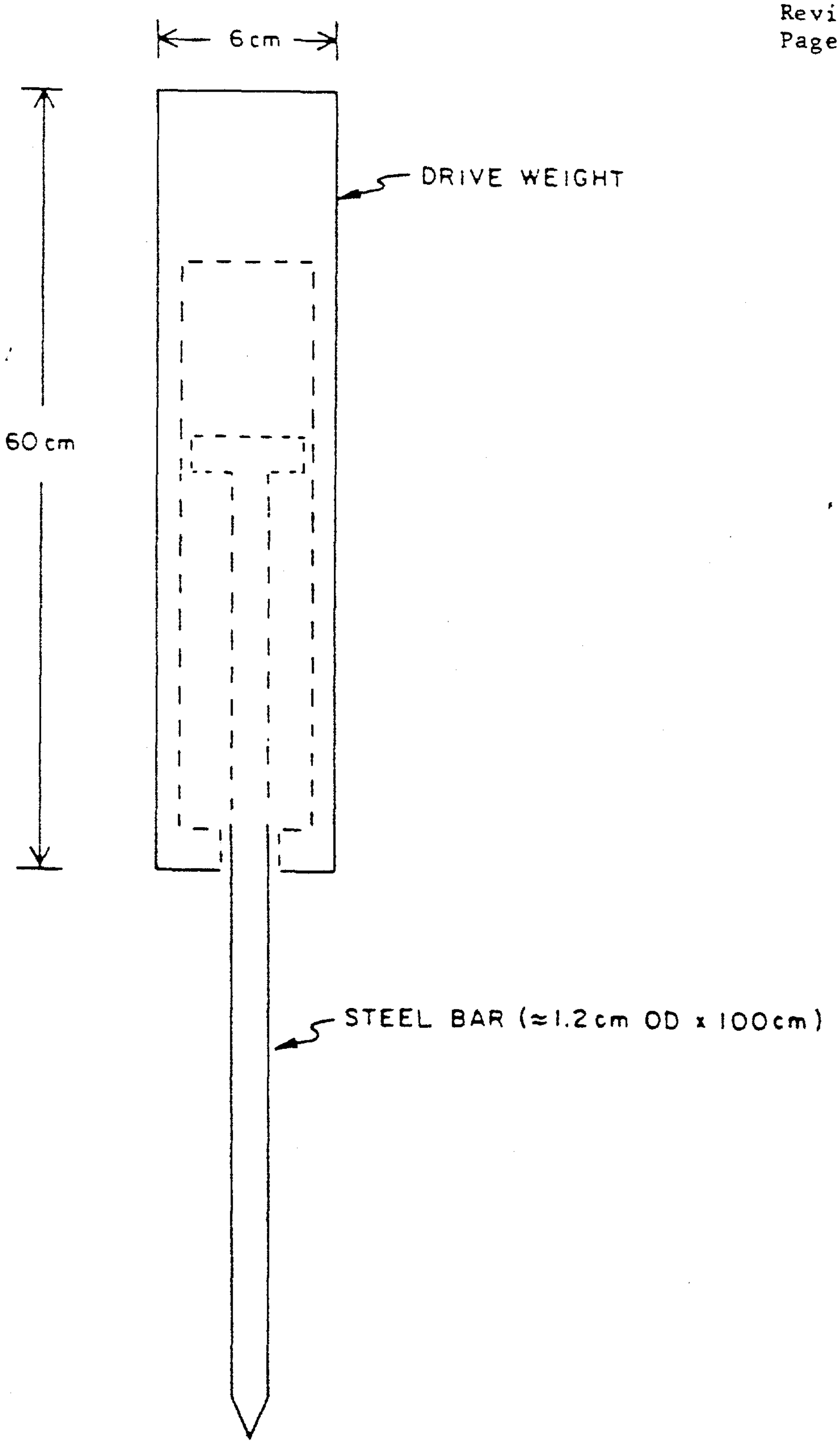


Figure 4-7. Bar hole-maker.

TABLE A-1. RECOMMENDED SAMPLING A ESERVATION PROCEDURES FOR WATER AND WASTEWATER

Parameter	Collection technique	Container[a]	Preservation	Holding time[b]	Minimum required volume (mL)
Acidity	Grab or composite	P,G	Cool, 4°C	14 days	100
Alkalinity	Grab or composite	P,G	Cool, 4°C	14 days	100
Asbestos	Grab or composite	P	Cool, 4°C	48 hours	1000
Bacteria	Grab only	Pro, G	Cool, 4°C, 10% $Na_2S_2O_3$, EDTA	6 hours	200
Bicarbonate	Grab only	P,G	Determine onsite	No holding	100
BOD	Grab only	P,G	Cool, 4°C	48 hours	1000
Bromide	Grab or composite	P,G	None required	28 days	100
Carbonate	Grab only	P,G	Determine onsite	No holding	100
Chloride	Grab or composite	P,G	None required	28 days	50
Chlorine demand	Grab only	P,G	Determine onsite	No holding	200
Chromium VI	Grab or composite	P,G	Cool, 4°C	24 hours	100
COD	Grab only	P,G	H_2SO_4 to pH <2; Cool, 4°C	28 days	50
Color	Grab or composite	P,G	Cool, 4°C	48 hours	50
Conductance	Grab or composite	P,G	Cool, 4°C	28 days	100
Cyanide	Grab or composite	P,G	NaOH to pH >12, 0.6g Ascorbic acid[d]	14 days	500
Fluoride	Grab or composite	P	None required	28 days	300
Hardness	Grab or composite	P,G	HNO_3 to pH <2	6 months	100
Hydrazine	Grab or composite	P,G	If not analyzed immediately, collect under acid. Add 90 ml of sample to 10 ml (1 + 9) HCl	7 days	100

(continued)

TABLE A-1 (continued)

Parameter	Collection technique	Container[a]	Preservation	Holding time[b]	Minimum required volume (mL)
Iodide	Grab or composite	P,G	Cool 4°C	24 hours	100
Iodine	Grab only	P,G	Determine onsite	No holding	500
Metals (Except Cr VI)					
Dissolved	Grab or composite	P,G	Filter onsite, HNO_3 to pH <2	6 months, except Hg--28 days	200
Suspended	Grab or composite	P,G	Filter onsite	6 months, except Hg--28 days	200
Total	Grab or composite	P,G	HNO_3 to pH <2	6 months, except Hg--28 days	100
Nitrogen					
Ammonia	Grab or composite	P,G	Cool, 4°C, H_2SO_4 to pH <2	28 days	400
Kjeldahl (total)	Grab or composite	P,G	Cool, 4°C, H_2SO_4 to pH <2	28 days	500
Nitrate plus Nitrite	Grab or composite	P,G	Cool, 4°C, H_2SO_4 to pH <2	28 days	100
Nitrate	Grab or composite	P,G	Cool, 4°/C, H_2SO_4 to pH <2	48 hours	100
Nitrite	Grab or composite	P,G	Cool 4°C, H_2SO_4 to pH <2	48 hours	50
Oil and Grease	Grab only	G	Cool 4°C, H_2SO_4 to pH <2	28 days	1000
Organics					
Extractables base/neutrals and acids)	Grab or composite	G, Teflon-lined cap	Cool, 4°C	7 days until extraction, 30 days after extraction	1000

(continued)

Parameter	Collection technique	Container[a]	Preservation	Holding time[b]	Minimum required volume (mL)
<u>Organics</u> (cont.)					
Purgeables (halocarbons-aromatics)	Grab only	G, Teflon-lined cap	Cool, 4°C	14 days	40
Purgeables (acrolein and acrylonitrile)	Grab only	G, Teflon-lined cap	Cool, 4°C	14 days	40
Pesticides and PCBs	Grab or composite	G, Teflon-lined cap	Cool, 4°C	7 days until extraction, 30 days after extraction	250
pH	Grab only	P,G	Determine onsite	2 hours	25
Phenol	Grab or composite	G	Cool, 4°C, H_2SO_4 to pH <2	24 hours	500
<u>Phosphorus</u>					
Ortho phosphate	Grab or composite	P,G	Filter onsite, cool, 4°C	48 hours	50
Phosphorus, Total	Grab or composite	P,G	Cool, 4°C, H_2SO_4 to pH <2	28 days	50
Radioactivity	Grab or composite	P,G	HNO_3 to pH <2	6 months	1 gal
<u>Silica</u>					
Dissolved	Grab or composite	P	Cool, 4°C	28 days	50
Total	Grab or composite	P	Cool, 4°C	28 days	50
<u>Solids</u>					
Dissolved	Grab or composite	P,G	Cool, 4°C	7 days	100
Volatile Dissolved	Grab or composite	P,G	Cool, 4°C	7 days	100
Suspended	Grab or composite	P,G	Cool, 4°C	7 days	100

TABLE A-1 (continued)

Parameter	Collection technique	Container[a]	Preservation	Holding time[b]	Minimum required volume (mL)
Solids (cont.)					
Volatile Suspended	Grab or composite	P,G	Cool, 4°C	7 days	100
Total	Grab or composite	P,G	Cool, 4°C	7 days	100
Volatile Total	Grab or composite	P,G	Cool, 4°C	7 days	100
Settleable	Grab or composite	P,G	Cool, 4°C	48 hours	100
Sulfate	Grab or composite	P,G	Cool, 4°C	28 days	50
Sulfide	Grab or composite	P,G	Cool, 4°C, 2 ml zinc acetate plus NaOH to pH >9	7 days	500
Sulfite	Grab or composite	P,G	Determine onsite	No holding	50
Surfactants	Grab or composite	P,G	Cool, 4°C	48 hours	250
TOC	Grab or composite	G, Teflon-lined cap	Cool, 4°C, HCl to pH <2	28 days	25
TOX	Grab or composite	G, Amber, Teflon-lined cap	Cool, 4°C, add 1 ml 0.1 M sodium sulfite	7 days	100
Turbity	Grab or composite	P,G	Cool, 4°C	48 hours	100

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[a] P = Polyethylene, G = Glass, Pro = Polypropylene

[b] The holding times are those listed in Technical Additions to Methods for Chemical Analysis of Water and Wastes, EPA-600/4-82-055 and Methods for Organic Chemical Analysis of Municipal and Industrial Wastewater, EPA-600/4-82-057.

[c] If samples cannot be filtered within 48 hours, add 1 ml of a 2.71% solution of mercuric chloride to inhibit bacterial growth.

[d] Should only be used in the presence of residual chlorine.

EQUIPMENT AVAILABILITY

Apparatus

- Stainless Steel Scoops, Trays, Beakers, Ladles
  8,9,15
- Thin Wall Tube Samplers, Soil Augers, Hand Corers
  45,50
- Gravity Corers, Dredges and Grabs
  40,45
- Thiefs and Triers
  9,34
- Water Level Indicators
  38,45
- Down Hole Submersible Probes
  23,25,43,51
- Bailers, Coliwasa
  26,34,48
- Peristaltic Pumps
  8,9,15,29
- Gas Displacement Pumps
  5,48
- Combustible Gas Detectors
  3,13,16,17,33,36,41
- Oxygen Monitors
  6,13,16,17,33,36,41
- Portable Flame Ionization Detectors
  1,2
- Portable Photoionization Detectors
  22,37
- Stain Detector Tubes
  7,17,31,33,35
- Personal Sampling Pumps
  7,11,14,19,28,32,33,39,46
- High Volume Air Samplers
  18,39,44

- Radiation Dosimeters
  4,10,20,47,49

- Radiation Film Badges
  12,20,24,42

- Radiation Survey Instruments
  4,10,12,20,21,27,30,47,49

Vendors

1. Analabs, Inc.
80 Republic Drive
North Haven, CT 06473
(203) 288-8463

2. Analytical Instrument Development, Inc.
Rt. 41 and Newark Rd.
Avondale, PA 19311
(215) 268-3181

3. Bacharach Instrument Company
301 Alpha Drive
Pittsburgh, PA 15238
(412) 782-3500

4. Baird Atomic
125 Middlesex Turnpike
Bedford, MA 01730
(617) 276-6000

5. BarCad System, Inc.
P.O. Box 424
Concord, MA 01742
(617) 969-0050

6. Beckman Instruments, Inc.
Process Instrument Division
2500 Harbor Boulevard
Fullerton, CA 92634

7. Bendix Corporation
Environmental and Process Instruments Division
P.O. Drawer 831
Ronceverte, WV 24970
(304) 647-4358

8. Cole Palmer
7425 North Oak Park Ave.
Chicago, Illinois 60648
(800) 323-4340

9. Curtin Matheson Scientific
Major Metropolitan Areas

10. Dosimeter Corporation of America
P.O. Box 42377
Cincinnati, OH 45242
(513) 489-8100

11. DuPont Company
Applied Technology Division
Concord Plaza - Clayton Bldg.
Wilmington, DE 19898
(302) 772-5989

12. Eberline Instruments
P.O. Box 2108
Santa Fe, NM 87501
(505) 471-3232

13. Energetics Science
Six Skyline Drive
Hawthorne, NY 10532

14. Environmental Measurements, Inc.
215 Leidesdorff Street
San Francisco, CA 94111
(415) 398-7664

15. Fisher Scientific
Major Metropolitan Areas

16. Gas Measurement Instruments Ltd.
Inchinnan Estate
RenfrewPA49RG
(041) 812-3211

17. GasTech Inc.
Johnson Instrument Division
331 Fairchild Drive
Mountain View, CA 94043
(415) 967-6794

18. General Metal Works Inc.
8368 Bridgetown Road
Village of Cleves, OH 45002
(513) 941-2229

19. Gilian Instrument Corp.
1275 Route 23
Wayne, NJ 07470
(201) 696-9244

20. Gulf Nuclear
202 Medical Center Boulevard
Webster, TX 77598
(713) 332-3581

21. Health Physics Instruments
124 San Felicia Drive
Goleta, CA 93117
(805) 685-2612

22. HNU Systems, Inc.
30 Ossipee Road
Newton Upper Falls, MA 02164
(617) 964-6690

23. Hydrolab Corporation
P.O. Box 9406
Austin, TX 78766
(512) 255-8841

24. ICN Dosimetry Service
26201 Niles Road
Cleveland, OH 44128
(216) 831-3000

25. Industrial and Environmental Analysts Inc.
P.O. Box 626
Essex Junction, VT 05452
(802) 878-5138

26. Johnson Division
UOP, Inc.
St. Paul, MN 55164
(612) 636-3900

27. Johnston Laboratories
P.O. Box 20086
383 Hillen Road
Towson, MD 21204
(301) 337-8700

28. Kurz Instruments Inc.
P.O. Box 849
Carmel Valley, CA 93924
(408) 659-3421

29. Leonard Mold and Die
960 West 48th Avenue
Denver, CO 80221
(303) 433-7101

30. Ludlum Measurements
P.O. Box 248
Sweetwater, TX 79556
(915) 235-5494

31. Matheson Safety Products
P.O. Box 85
932 Paterson Plank Road
East Rutherford, NJ 07073
(201) 933-2400

32. MDA Scientific, Inc.
1815 Elmdale Ave.
Glenview, IL 60025

33. Mine Safety Appliance Co.
600 Penn Center Boulevard
Pittsburgh, PA 15235

34. Nasco
901 Janesville Ave.
Fort Atkinson, WI 53538
(414) 563-2446

35. National Draeger, Inc.
101 Technology Drive
Pittsburgh, PA 15275
(412) 787-8383

36. National Mine Service Company
Industrial Safety Division
355 N. Old Steubenville Pike
Oakdale, PA 15071
(412) 788-4353

37. Photovac, Incorp.
134 Doncaster Ave.
Unit 2
Thornhill
Ontario, Canada L3T1L3

38. Powers Electric Products Company
P.O. Box 11591
Fresno, CA 93774

39. Research Appliance Company
Moose Lodge Road
Cambridge, MD 21613
(301) 228-9505

. Research Instrument Manufacturing Co. Ltd.
RR No. 2 Guelph
Ontario, Canada N1H6H8
(519) 822-1547

41. Rexnord Safety Products/Biomarine Ind.
45 Great Valley Parkway
Malvern, PA 19355
(215) 647-7200

42. R.S. Landauer Jr. Company
Division of Technical Operations, Inc.
Science Road
Glenwood, IL 60425
(312) 755-7000

43. Sensorex
9713 Bolsa Ave.
Westminster, CA 92683
(714) 554-7090

44. Sierra Instruments Inc.
P.O. Box 909
Carmel Valley, CA 93924
(408) 659-3177

. Soiltest, Inc
2205 Lee Street
Evanston, IL 60202
(312) 869-5500

46. Spectrex Corporation
3594 Haven Ave.
Redwood City, CA 94063
(415) 365-6567

47. Technical Associates
7051 Eton Avenue
Canoya Park, CA 91303
(213) 883-7043

48. Timco Manufacturing Company, Inc.
P.O. Box 35
Prairie Du Sac, WI 53578
(608)-643-8534

49. Victoreen, Inc.
10101 Woodland Ave.
Cleveland, OH 44104
(216) 795-8200

50. Wildco
301 Cass Street
Saginaw, MI 48602
(517) 799-8100

51. Yellow Springs Instrument Co.
Yellow Springs, OH 45387
(513) 767-7241

APPENDIX C

PACKING, MARKING, LABELING, AND SHIPPING OF HAZARDOUS MATERIAL SAMPLES

Portions of this Appendix have been taken,
by permission, from EPA/ERT
"Hazardous Materials Incident Response Operations"
Training Course Manual (165.1)

INTRODUCTION

Samples collected during a response to a hazardous material incident may have to be transported elsewhere for analysis. The Environmental Protection Agency (EPA) encourages compliance with Department of Transportation (DOT) regulations governing the shipment of hazardous materials. These regulations (49 CFR parts 171 through 179) describe proper marking, labeling, packaging and shipment of hazardous materials, substances and wastes. In particular, part 172.402(h) of 49 CFR is intended to cover shipment of samples of unknown materials destined for laboratory analysis.

ENVIRONMENTAL SAMPLES VERSUS HAZARDOUS MATERIAL SAMPLES

Samples collected at an incident should be classified as either environmental or hazardous material (or waste) samples. In general, environmental samples are collected offsite (for example from streams, ponds, or wells) and are not expected to be grossly contaminated with high levels of hazardous materials. Onsite samples (for example, soil, water, and materials from drums or bulk storage tanks, obviously contaminated ponds, lagoons, pools, and leachates from hazardous waste sites) are considered hazardous. A distinction must be made between the two types of samples in order to:

- Determine appropriate procedures for transportation of samples. If there is any doubt, a sample should be considered hazardous and shipped accordingly.
- Protect the health and safety of laboratory personnel receiving the samples. Special precautions are used at laboratories when samples other than environmental samples are received.

The following section describes the packaging, labeling and shipping requirements for these two sample types. Specific DOT regulations for hazardous materials shipping papers and general marking requirements are presented as Attachments C-1 and C-2.

ENVIRONMENTAL SAMPLES

Environmental samples must be packaged and shipped according to the following procedures.

Packaging

Environmental samples may be packaged following the procedures outlined later for samples classified as "flammable liquids" or "flammable solids," but the requirements for marking, labeling, and shipping papers do not apply.

Environmental samples may also be packaged without being placed inside metal cans as required for flammable liquids or solids.

- Place sample container, properly identified and with a sealed lid, in a polyethylene bag, and seal bag.

- Place sample in a fiberboard container or metal picnic cooler which has been lined with a large polyethylene bag.

- Pack with enough noncombustible, absorbent, cushioning material to minimize the possibility of the container breaking.

- Seal large bag.

- Seal or close outside container.

Marking/Labeling

Sample containers must have a completed sample identification tag and the outside container must be marked "Environmental Sample." The appropriate side of the container must be marked "This End Up" and arrows placed accordingly. No DOT marking or labeling are required.

Shipping Papers

No DOT shipping papers are required.

Transportation

There are no DOT restrictions on mode of transportation.

ATIONALE: HAZARDOUS MATERIAL SAMPLES

Samples not determined to be environmental samples or samples known or expected to contain hazardous materials must be considered hazardous substance samples and transported according to the following requirements:

- If the substance in the sample is known or can be identified, package, mark, label, and ship according to the specific instructions for that material (if it is listed) in the DOT Hazardous Materials Table, 49 CFR 172.101.

- For samples of hazardous materials of unknown content, part 172.402 of 49 CFR allows the designation of hazard class based on the shipper's knowledge of the material and selection of the appropriate hazard class from part 173.2 (see Table C-1).

The correct shipping classification for an unknown sample is selected through a process of elimination, utilizing the DOT classification system (Table C-1). Unless known or demonstrated otherwise (through the use of radiation survey instruments), the sample is considered radioactive and appropriate shipping regulations for "radioactive material" followed. If radioactive material is eliminated, the sample is considered to contain "Poison A" materials (Table C-2), the next classification on the list. DOT defines "Poison A" as extremely dangerous poisonous gases or liquids of such a nature that a very small amount of gas, or vapor of the liquid, mixed with air s dangerous to life.

TABLE C-1. DOT PRIORITY RANKING OF HAZARDOUS MATERIALS

	Category	Definition	Application regulations
	General		49 CFR 173.1-173.34, 177
1	Radioactive Material	49 CFR 173.389	49 CFR 173.390-173.398
2	Poison A	49 CFR 173.326	49 CFR 173.327-173.337
3	Flammable Gas	49 CFR 173.300	49 CFR 173.300-173.316
4	Nonflammable Gas	49 CFR 173.300	49 CFR 173.300-173.316
5	Flammable Liquid	49 CFR 173.115	49 CFR 173.116-173.119, 173.121-173.149a
6	Oxidizer	49 CFR 173.151	49 CFR 173.152-173.239a
7	Flammable Solid	49 CFR 173.150	49 CFR 173.152-173.239a
8	Corrosive Material (Liquid)	49 CFR 173.240	49 CFR 173.241-173.299a
9	Poison B	49 CFR 173.343	49 CFR 173.344-173.379
10	Corrosive Material (Solid)	49 CFR 173.240	49 CFR 173.241-173.299a
11	Irritating Materials	49 CFR 173.381	49 CFR 173.381-173.385
12	Combustible Liquid (in containers exceeding 100 gal capacity)	49 CFR 173.115	49 CFR 173.116-173.118a, 173.121-173.149a
13	ORM-B	49 CFR 173.800	49 CFR 173.510, 173.800-173.862
14	ORM-A	49 CFR 163.605	49 CFR 173.510, 173.605-173.655
15	Combustible Liquid (in containers having capacities of 110 gal or less)	49 CFR 173.115	49 CFR 173.116-173.118a, 173.121-173.149a
16	ORM-E	49 CFR 173.1300	49 CFR 173.510

TABLE C-2. DOT LIST OF CLASS "A" POISONS (49 CFR 172.101)

Material	Physical state at standard temperature
Arsine	Gas
Bromoacetone	Liquid
Chloropicrin and methyl chloride mixture	Gas
Chloropicrin and nonflammable, nonliquified compressed gas mixture	Gas
Cyanogen chloride	Gas (13.1°C)
Cyanogen gas	Gas
Gas identification set	Gas
Germane	-
Grenade (with Poison "A" gas charge)	-
Hexaethyl tetraphosphate/compressed gas mixture	Gas
Hydrocyanic acid (prussic) solution	Liquid
Hydrocyanic acid, liquified	Gas
Insecticide liquified gas containing Poison "A" or Poison "B" material	Gas
Methyldichloroarsine	Liquid
Nitric oxide	Gas
Nitrogen peroxide	Gas
Nitrogen tetroxide	Gas
Nitrogen dioxide, liquid	Gas
Parathion/compressed gas mixture	Gas
Phosgene (diphosgene)	Liquid

Most poison A materials are gases or compressed gases and would not be found in drum-type containers. Liquid poison A's would be found only in closed containers. All samples taken from closed drums do not have to be shipped as poison A's, which provides for a "worst case" situation. Based upon information available, a judgment must be made whether a sample from a closed container is a poison A.

If poison A is eliminated as a shipment category, the next two classifications are "flammable" or "nonflammable" gases. Since few gas samples are collected, "flammable liquid" would be the next applicable category. With the elimination of radioactive material, poison A, flammable gas, and nonflammable gas, the sample can be classified as flammable liquid (or solid) and shipped accordingly. These procedures would also suffice for shipping any other samples classified below flammable liquids in the DOT classification table.

For samples containing unknown material, other categories listed below flammable liquids/solids on the table are generally not considered because eliminating other substances as flammable liquids requires flashpoint testing, which may be impractical and possibly dangerous at a site. Thus, unless the sample is known to consist of material listed below flammable liquid on the table, it is considered a flammable liquid (or solid) and shipped as such.

PROCEDURES: SAMPLES CLASSIFIED AS FLAMMABLE LIQUID (OR SOLID)

The following procedure is designed to meet the requirements for a "limited quantity" exclusion for shipment of flammable liquids and solids, as set forth in parts 173.118 and 173.153 of 49 CFR. By meeting these requirements, the DOT constraints on packaging are greatly reduced. Packaging according to the limited quantity exclusion requires notification on the shipping papers.

Packaging

1. Collect sample in a glass container (16 ounces or less) with a nonmetallic, teflon-lined screw cap. To prevent leakage, fill container no more than 90 percent full at 130°F. If an air space in the sample container would affect sample integrity, place that container within a second container to meet 90 percent requirement.

2. Complete sample identification tag and attach securely to sample container.

3. Seal container and place in 2-mil thick (or thicker) polyethylene bag, one sample per bag. Position identification tag so it can be read through bag. Seal bag.

4. Place sealed bag inside metal can and cushion it with enough noncombustible, absorbent material (for example, vermiculite or diatomaceous earth) between the bottom and sides of the can and bag

to prevent breakage and to absorb leakage. Pack one bag per can. Use clips, tape, or other positive means to hold can lid securely, tightly, and permanently.

5. Place one or more metal cans into a strong outside container, such as a metal picnic cooler or a DOT approved fiberboard box. Surround cans with noncombustible, absorbent, cushioning material for stability during transport.

6. Limited quantities of flammable liquids, for the purpose of the exclusion, are defined as one pint or less (49 CFR part 173.118(a)(2)).

7. Limited quantities of flammable solids, for the purpose of this exclusion, are defined as one pound net weight in inner containers and no greater than 25 pounds net weight in the outer container (49 CFR part 173.153(a)(1)).

Marking/Labeling

1. Use abbreviations only where specified.

2. Place following information, either hand printed or in label form, on the metal card.

- Laboratory Name and Address
- "Flammable Liquid, n.o.s. UN1993" or "Flammable Solid, n.o.s. UN1325."

Not otherwise specified (n.o.s.) is not used if the flammable liquid (or solid) is identified. Then the name of the specific material is listed before the category (for example, Acetone, Flammable Liquid) followed by its appropriate UN number found in the DOT hazardous materials table (172.101).

3. Place the following DOT labels (if applicable) on outside of can (or bottle).

- "Flammable Liquid" or "Flammable Solid."
- "Dangerous When Wet." Must be used with "Flammable Solid" label if material meets the definition of a water-reactive material.
- "Cargo Aircraft Only." Must be used if net quantity of sample in each outer container is greater than 1 quart (for "Flammable Liquid, n.o.s.") or 25 pounds (for "Flammable Solid, n.o.s.)."

4. Place all information on outside shipping container as on can (or bottle), specifically,

- Proper shipping name.
- UN or NA number.
- Proper label(s).
- Addressee and addressor.

(Note that the previous two steps (2 and 3) are EPA recommendations. Step 4 is a DOT requirement.

5. Print "Laboratory Samples and "This End Up" or "This Side Up" clearly on top of shipping container. Put upward pointing arrows on all four sides of container.

Shipping Papers

1. Use abbreviations only where specified.

   Complete carrier-provided bill of lading and sign certification statement (if carrier does not provide, use standard industry form). Provide the following information in the order listed. (One form may be used for more than one exterior container.)

   - "Flammable Liquid, n.o.s. UN1993" or "Flammable Solid, n.o.s. UN1325."
   - "Limited Quantity" (or "Ltd. Qty.").
   - Net weight or net volume (weight or volume may be abbreviated) just before or just after "Flammable Liquid, n.o.s. UN1325" or "Flammable Solid, n.o.s. UN1325"
   - Further descriptions such as "Laboratory Samples" or "Cargo Aircraft Only" (if applicable) are allowed if they do not contradict required information.

3. Include chain-of-custody record, properly executed, in outside container if legal use of samples is required or anticipated.

Transportation

1. Transport unknown hazardous substance samples classified as flammable liquids by rented or common carrier truck, railroad, or express overnight package services.

2. Do not transport by any passenger-carrying air transport system, even if they have cargo only aircraft. DOT regulations permit regular airline cargo only aircraft, but difficulties with most suggest avoiding them. Instead, ship by airlines that only carry cargo.

3. Transport by government-owned vehicle, including aircraft. DOT regulations do not apply, but EPA personnel will still use procedures described except for execution of the bill of lading with certification.

Other Considerations

1. Check with analytical laboratory for size of sample to be collected and if sample should be preserved or packed in ice.
2. For EPA employees, accompany shipping containers to carrier and, if required, open outside container(s) for inspection.
3. For overnight package services, determine weight restrictions--at least One service limits weight to 70 pounds per package.

PROCEDURES: SAMPLES CLASSIFIED AS POISON "A"

Packaging

1. Collect samples in a polyethylene or glass container with an outer diameter narrower than the valve hole on a DOT specification No. 3A1800 or No. 3AA1800 metal cylinder. To prevent leakage, fill container no more than 90 percent full (at 130°F).
2. Seal sample container.
3. Complete sample identification tag and attach securely to sample container.
4. Attach string or flexible wire to neck of the sample container; lower it into metal cylinder partially filled with noncombustible, absorbent cushioning material (for example, diatomaceous earth or vermiculite). Place only one container in a metal cylinder. Pack with enough absorbing material between the bottom and sides of the sample container and the metal cylinder to prevent breakage and absorb leakage. After the cushioning material is in place, drop the end of the string or wire into the cylinder valve hole.
5. Replace valve, torque to 250 ft/lb (for 1-inch opening), and replace valve protector on metal cylinder, using Teflon tape.
6. Place one or more cylinders in a sturdy outside container.

Marking/Labeling

1. Use abbreviations only where specified.
2. Place following information, either hand printed or in label form, on the side of the cylinder or on a tag wired to the cylinder valve protector.

- "Poisonous Liquid, n.o.s. NA1955" or "Poisonous Gas, n.o.s. NA1955."
- Laboratory name and address.
- DOT label "Poisonous Gas" (even if sample is liquid) on cylinder.

3. Put all information on metal cylinder on outside container.

4. Print "Laboratory Sample" and "Inside Packages Comply With Prescribed Specifications" on top and/or front of outside container. Mark "This Side Up" on top of contaner and upward-pointing arrows on all four sides.

<u>Shipping Papers</u>

1. Use abbreviations only as specified.

2. Complete carrier-provided bill of lading and sign certification statement (if carrier does not provide, use standard industry form). Provide following information in order listed. (One form may be used for more than one exterior container.)

   - "Poisonous Liquid, n.o.s. NA1955."
   - Net weight or net volume (weight or volume may be abbreviated), just before or just after "Poisonous Liquid, n.o.s. NA1955."

3. Include a chain-of-custody record, properly executed, in container or with cylinder if legal use of samples is required or anticipated.

4. For EPA employees, accompany shipping container to carrier and, if required, open outside container(s) for inspection.

<u>Transportation</u>

1. Transport unknown hazardous substance samples classified as poison A only by ground transport or Government-owned aircraft. Do not use air cargo, other common carrier aircraft, or rented aircraft.

SAMPLE IDENTIFICATION

The sample tag is the means for identifying and recording the sample and the pertinent information about it. The sample tag should be legibly written and completed with an indelible pencil or waterproof ink. The information should also be recorded in a logbook. The tag should be firmly affixed to the sample container. As a minimum, it should include:

- Exact location of sample.
- Time and date sample was collected.
- Name of sampler and witnesses (if necessary).
- Project codes, sample station, number, and identifying code (if applicable).
- Type of sample (if known).
- Hazardous substance or environmental sample.
- Tag number (if sequential tag system is used).
- Laboratory number (if applicable).
- Any other pertinent information.

APPENDIX D

DOCUMENT CONTROL/CHAIN-OF-CUSTODY PROCEDURES

GENERAL

Adherence to strict document control and chain-of-custody procedures is extremely important especially in relation to surveys at hazardous waste sites. The legal implications alone demand that accountability be given an utmost priority. The basic aspects of document control and chain-of-custody have therefore been included in this section. For additional information, the following publication, from which this section was developed, should be consulted.

- NEIC Policies and Procedures Manual, EPA-330-78-001R, May 1978 (revised December 1981), Section II

DOCUMENT CONTROL

The purpose of document control is to assure all project documents will be accounted for when the project is complete. Document control should include the use of serialized documents, a document inventory procedure and an adequate document filing system, all issued by, under the control of, and maintained by an appointed Document Control Officer (DCO). Table D-1 lists the principal items subject to document control during a specific project.

Serialized Documents

Sample collection and analytical tags, and chain-of-custody records should have preprinted serial numbers. It is not necessary that a sample tag number match a custody record number, however, it is necessary that all issued numbers be appropriately accounted for by the DCO. It is also necessary that in the event a tag or custody record is damaged, lost or destroyed prior to its use, its serial number and disposition are recorded.

Other Documents

Other documents used during the conduct of a project (e.g., field logbooks, laboratory notebooks, data sheets, etc.) should be appropriately coded with a unique identifier to ensure accountability. The project DCO will be responsible for development of the document identification system, paying particular attention to its utility and consistency for the specified program. An example of a document identification system is as follows:

Project Code	Subcontractor Code (if necessary)	Document Code	Serial Number
00-000-000-	-00-	-A-	-00001

In addition, a listing of suggested codes is shown in Table D-2.

TABLE D-1. DOCUMENTS SUBJECT TO CONTROL

Project Work Plan

Project Logbooks

Field Logbooks

Sample Data Sheets

Sample Tags

Chain-of-Custody Records

Laboratory Logbooks

Laboratory Data, Calculations, Graphs, etc.

Sample Checkout

Sample Inventory

Internal Memos

External Written Communication

Confidential Information

Photographs, Drawings, Maps

Quality Assurance Plan

Litigation Document

Final Report

TABLE D-2. SUGGESTED DOCUMENT CODES

Document	Code letter
Project Work Plans	A
Project Logbooks	B
Sampling Logbooks	C
Sampling Data Sheets	D1, D2 etc.
Sampling Coding Form	E
Laboratory Notebooks	G
Laboratory Data Sheets	H1, H2 etc.
Sample Logs	L1, L2 etc.
Internal Memos	M
External Written Communication	N
Confidential Information	O
Photos, Maps, Drawings	P
QA Plan	Q
Reports	R
Final Report	FR
Miscellaneous	X

CHAIN-OF-CUSTODY

The primary need for the implementation of chain-of-custody procedures stems from the possibility that a sample or a piece of data derived from the collection of a sample will be used as physical evidence in an enforcement action. The purpose of chain-of-custody in these instances is to trace the possession of a sample from the time of collection, until it or the derived data is introduced as evidence in legal proceedings. Custody records should, therefore, trace a sample from its collection, through all transfers of custody, until it is delivered to the analytical laboratory. At this point, internal laboratory records should document sample custody until its final disposition.

In order to establish that a sample is valid, it is also necessary to document the measures taken to prevent and/or detect tampering--either to the sample itself, the sampling equipment used or the environment sampled. This is done by the use of evidence tape, locks and custody seals, and documented entries noting their condition in field and laboratory log books. The custody record must document any tampering that may have occurred; the absence of any such comments indicates no tampering observed or noticed during the period of custody.

Since it may not always be possible to know ahead of time if a sample will be used as evidence in future legal actions, it is a good common sense practice to institute a proper chain-of-custody in all instances. Use of such practices as standard operating procedures on a project to project basis will contribute to the consistency and quality of the generated data.

Sample Identification

Preprinted, preserialized sample collection tags are recommended to identify samples collected for shipment to the analytical laboratory. Specific analysis tags may also be issued by the analytical laboratory after the sample has arrived. All collected samples, including duplicates and field blanks should be completely filled in with a minimum of the following information:

- Project Code
- Location Number

Assigned by the
Document Control Officer (DCO)

- Date of Collection
- Time of Collection
- Location Description
- Signature of Sampler

- Lab Sample Number--Assigned by the Analytical Laboratory
- Remarks Section

An example of an appropriate sample collection tag and analysis tag is shown in Figure D-1, respectively.

After sample analysis and appropriate quality assurance checks have been made, original sample collection tags are to be stored in a document file maintained by the DCO and the tag serial number is recorded in a master log for future reference. Maintaining such files and records is an important aspect of sample traceability and provides a needed cross referencing tool that can be used to correlate any one of the identifying numbers and sources (e.g., collection tag, laboratory number, master log, etc.) with a specific sample.

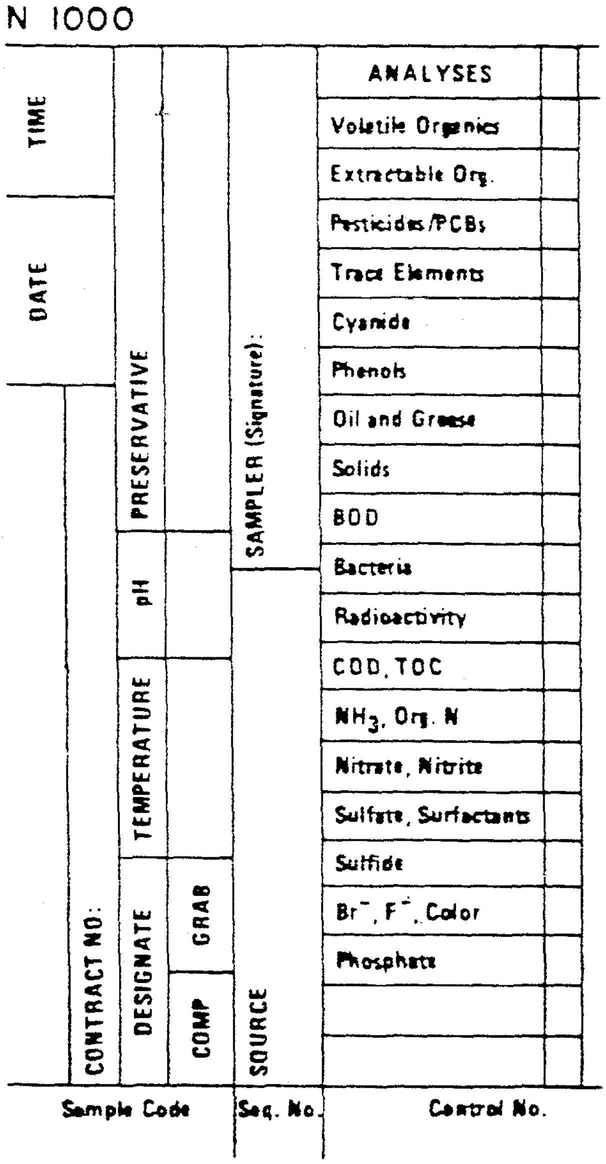
Chain-of-Custody Forms

There are many transfers of custody during the course of a sampling program, from time of collection through final sample disposition, and all samples should be accompanied by a Chain-of-Custody Record to document these transfers. In some instances, such as in the collection of air samples on solid sorbents, it becomes necessary to initiate custody procedures from collection media preparation on as the sorbent itself becomes part of the sample after collection is complete. Laboratories providing QC samples must also initiate a custody record. The use of a customized record sheet, such as the one shown in Figure D-2 fulfills these requirements by providing a convenient format for recording pertinent information.

The custody records are used for a packaged lot of samples; more than one sample will usually be recorded on one form. More than one custody record sheet may be used for one package, if necessary. Their purpose is to document the transfer of a group of samples traveling together; when the group of samples changes, a new custody record is initiated. The original of the custody record always travels with the samples; the initiator of the record keeps the copy. When custody of the same group of samples changes hands several times, some people will not have a copy of the custody record. This is acceptable as long as the original custody record shows that each person who had received custody has properly relinquished it.

In general, the following procedures should be followed when using the custody record sheets.

- The originator fills in all requested information from the sample tags (except in the case of air collection media and external QC samples which will be accompanied by custody forms from the originating facility).
- The person receiving custody checks the sample tag information against the custody record. He also checks sample condition and notes anything unusual under "Remarks" on the custody form.



N 1000

TIME

DATE

CONTRACT NO:

PRESERVATIVE

pH

TEMPERATURE

DESIGNATE

COMP

GRAB

SAMPLER (Signature):

SOURCE

ANALYSES
- Volatile Organics
- Extractable Org.
- Pesticides/PCBs
- Trace Elements
- Cyanide
- Phenols
- Oil and Grease
- Solids
- BOD
- Bacteria
- Radioactivity
- COD, TOC
- NH_3, Org. N
- Nitrate, Nitrite
- Sulfate, Surfactants
- Sulfide
- Br^-, F^-, Color
- Phosphate

Sample Code

Seq. No.

Control No.

Figure D-1. Sample Collection Tag.

CHAIN OF CUSTODY RECORD

Project Code	**Project Name**	REMARKS
SAMPLERS (Signature)		

Relinquished by: (Signature)	**Date/Time**	**Received by: (Signature)**	**Relinquished by: (Signature)**	**Date/Time**	**Received by: (Signature)**
Relinquished by: (Signature)	**Date/Time**	**Received by: (Signature)**	**Relinquished by: (Signature)**	**Date/Time**	**Received by: (Signature)**
Relinquished by: (Signature)	**Date/Time**	**Received for Laboratory by: (Signature)**	**Date/Time**	**Remarks**	

N 1000

Figure D-2. Chain-of-Custody Form.

- The originator signs in the top left "Relinquished by" box and keeps the copy.
- The person receiving custody signs in the adjacent "Received by" box and keeps the original.
- The Date/Time will be the same for both signatures since custody must be transferred to another person.
- When custody is transferred to the Sample Bank or an analytical laboratory, blank signature spaces may be left and the last "Received by" signature box used. Another approach is to run a line through the unused signature boxes.
- In all cases, it must be readily seen that the same person receiving custody has relinquished it to the next custodian.
- If samples are left unattended or a person refuses to sign, this must be documented and explained on the custody record.

Receipt for Samples Form

When it becomes necessary to split samples with another source, a parate receipt for samples from (Figure D-3) is prepared and marked to dicate with whom the samples have been split. The signature of the person receiving the samples is required and if this person refuses to sign, it should be noted in the "Received by" space.

This form also complies with requirements of both Section 3007(a)(2) of RCRA and Section 104 of the Comprehensive Environmental Response Compensation and Liability Act. These sections both state that "...If the officer, employee or representative obtains any samples prior to leaving the premises, he shall give to the owner, operator, or agent-in-charge a receipt describing the samples obtained and, if requested, a portion of such sample equal in volume or weight to the portion retained." A copy of the completed form must be given to one of the above described individuals, even if the offer for split samples is declined.

Custody Seals

Custody seals are narrow strips of adhesive paper used to demonstrate that no tampering has occurred. They may be used on sampling equipment or a house door, but they are intended for use on a sample transport container which is not secured by a padlock. They are not intended for use on individual sample containers.

RECEIPT FOR SAMPLES

PROJ NO

PROJECT NAME

Name of Facility

SAMPLERS *(Signature)*

Facility Location

Split Samples Offered

( ) Accepted ( ) Declined

STA NO	DATE	TIME	COMP	GRAB	SPLIT SAMPLES	TAG NUMBERS	STATION DESCRIPTION	NO OF CONTAINERS	REMARKS

Transferred by *(Signature)*

Received by *(Signature)*

Telephone

Date

Time

Title

Date

Time

Distribution: Original to Coordinator Field Files, Copy to Facility

Figure D-3. Receipt for Sample form.

Laboratory Custody Procedures

An onsite sample bank, the sampling laboratory area and any analytical laboratory used for analyses are considered to be working "laboratories" subject to laboratory custody procedures. Each laboratory should have a disignated sample custodian who implements a system to maintain control of the samples.

This includes accepting custody of arriving samples, verifying that information on the sample tags match the Chain-of-Custody Record, assigning unique laboratory numbers and laboratory sample tags and distributing the samples to the analyst.

The designated custodian is also responsible for retaining all original identifying tags, data sheets and laboratory records as part of the permanent project file.

Questions/Problems Concerning Custody Records

If a discrepancy between sample tag numbers and custody record listings if found, the person receiving custody should document this and properly store the samples. The samples should not be analyzed until the problem is resolved.

The responsible person receiving custody should attempt to resolve the problem by checking all available information (other markings on sample container, type of sample, etc.). He should then document the situation on the custody record and in his project logbook and notify the project QA Manager by the fastest available means, followed by written notification.

Changes may be written in the "Remarks" section of the Custody record and should be initialed and dated. A copy of this record should accompany the written notification to the QA Manager.

APPENDIX E

DECONTAMINATION PROCEDURES

Source: Interim Standard Operating Safety Guides
Revised September, 1982

Office of Emergency and Remedial Response

INTRODUCTION

Personnel responding to hazardous substance incidents may become contaminated in a number of ways, including:

- Contacting vapors, gases, mists, or particulates in the air.
- Being splashed by materials while sampling or opening containers.
- Walking through puddles of liquids or on contaminated soil.
- Using contaminated instruments or equipment.

Protective clothing and respirators help prevent the wearer from becoming contaminated or inhaling contaminants, while good work practices help reduce contamination on protective clothing, instruments, and equipment.

Even with these safeguards, contamination may occur. Harmful materials can be transferred into clean areas, exposing unprotected personnel. Or in removing contaminated clothing, personnel may contact contaminants on the clothing and/or inhale them. To prevent such occurrences, methods to reduce contamination and decontamination procedures must be developed and implemented before anyone enters a site and must continue (modified when necessary) throughout site operations.

Decontamination consists of physically removing contaminants and/or changing their chemical nature to innocuous substances. How extensive decontamination must be depends on a number of factors, the most important being the type of contaminants involved. The more harmful the contaminant, the more extensive and thorough decontamination must be. Less harmful contaminants may require less decontamination. Combining decontamination, the correct method of doffing personnel protective equipment, and the use of site work zones minimizes cross-contamination from protective clothing to wearer, equipment to personnel, and one area to another. Only general guidance can be given on methods and techniques for decontamination. The exact procedure to use must be determined after evaluating a number of factors specific to the incident. In addition, the decontamination procedures for sample equipment should be developed in conjunction with the analytical lab(s).

PRELIMINARY CONCERNS

Initial Planning

The initial decontamination plan assumes all personnel and equipment leaving the Exclusion Zone (area of potential contamination) are grossly contaminated. A system is then set up to wash and rinse, at least once, all the personnel protective equipment worn. This is done in combination with a sequential doffing of equipment, starting at the first station with the most heavily contaminated item and progressing to the last station with the least contaminated article. Each piece of clothing or operation requires a separate station. Figure E-1 diagrams a contamination control program showing the layout of the contamination reduction zone.

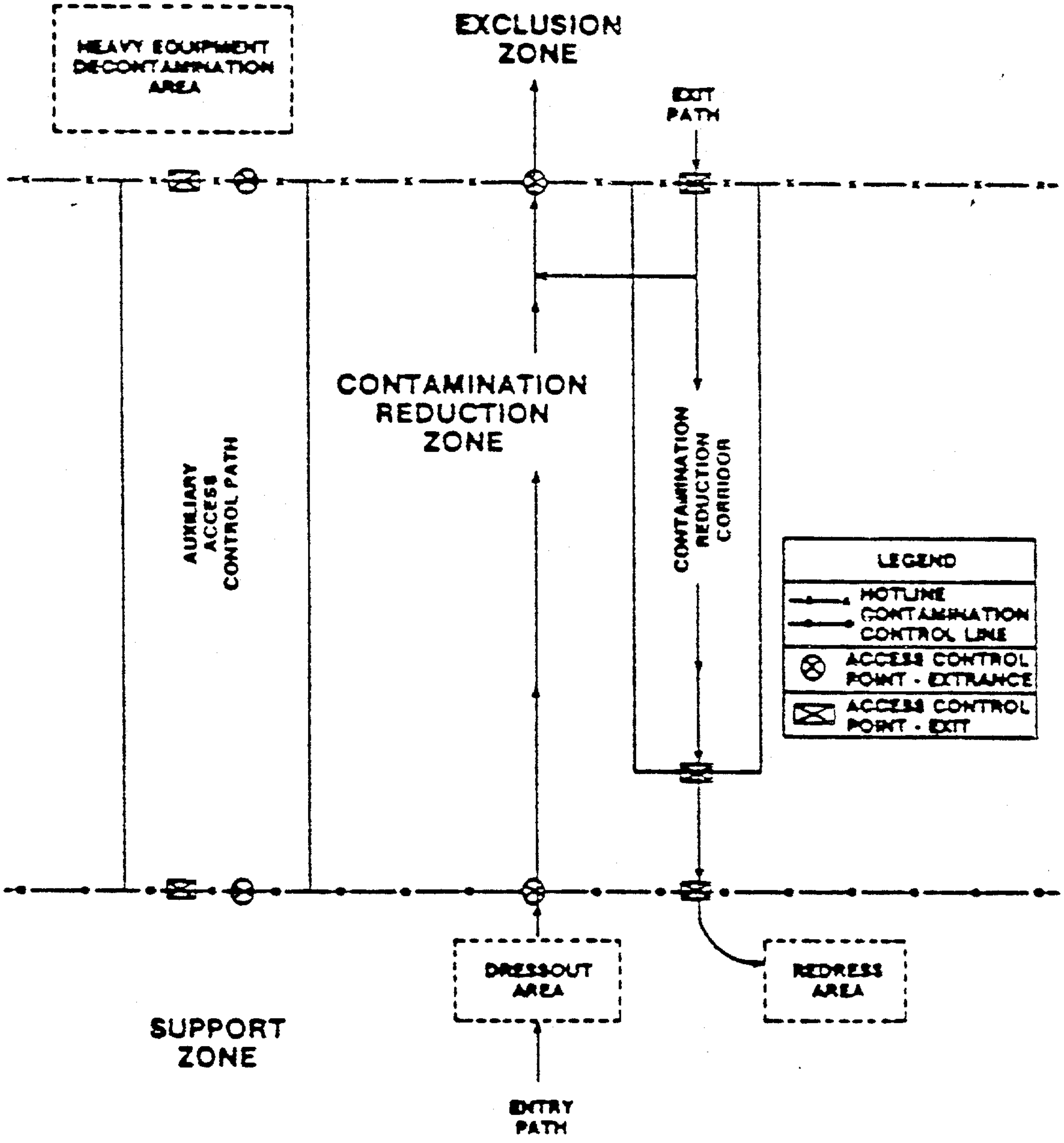


Figure E-1. Contamination reduction zone layout.

The spread of contaminants during the washing/doffing process is further reduced by separating each decontamination station by a minimum of 3 feet. Ideally, contamination should decrease as a person moves from one station to another farther along the line.

While planning site operations, methods should be developed to prevent the contamination of people and equipment. For example, using remote sampling techniques, not opening containers by hand, bagging monitoring instruments, using drum grapplers, watering down dusty areas, and not walking through areas of obvious contamination will reduce the probability of becoming contaminated which would require a less elaborate decontamination procedure.

The initial decontamination plan is based on a worst-case situation (if no information is available about the incident). Specific conditions at the site are then evaluated, including:

- Type of contaminant.
- The amount of contamination.
- Levels of protection required.
- Type of protective clothing worn.

The initial system is modified, eliminating unnecessary stations or otherwise adapting it to site conditions. For instance, the initial plan might require a complete wash and rinse of chemical protective garments. If disposable garments are worn, the wash/rinse step could be omitted. Wearing disposable boot covers and gloves could eliminate washing and rinsing both gloves and disposable boots and reduce the number of stations needed.

Contamination Reduction Corridor

An area within the Contamination Reduction Zone is designated the Contamination Reduction Corridor (CRC). The CRC controls access into and out of the Exclusion Zone and confines personnel decontamination activities to a limited area. The size of the corridor depends on the number of stations in the decontamination procedure, overall dimensions of work control zones, and amount of space available at the site. A corridor of 75 feet by 15 feet should be adequate for full decontamination. Whenever possible, it should be a straight path.

The CRC boundaries should be conspicuously marked, with entry and exit restricted. The far end is the hotline--the boundary between the Exclusion Zone and the Contamination Reduction Zone. Personnel exiting the Exclusion Zone must go through the CRC. Anyone in the CRC should be wearing the Level of Protection designated for the decontamination crew. Another corridor may be required for the entrance and exit of heavy equipment needing decontamination. Within the CRC, distinct areas are set aside for decontamination of personnel, portable field equipment, removed clothing, etc. All activities within the corridor are confined to decontamination.

Personnel protective clothing, respirators, monitoring equipment, sampling supplies, etc. are all maintained outside of the CRC. Personnel don their protective equipment away from the CRC and enter the Exclusion Zone through a separate access control point at the hotline.

EXTENT OF DECONTAMINATION REQUIRED

Modifications of Initial Plan

The original decontamination plan must be adapted to specific conditions found at incidents. These conditions may require more or less personnel decontamination than planned, depending on a number of factors.

Type of Contaminant--
The extent of personnel decontamination depends on the effects the contaminants have on the body. Contaminants do not all exhibit the same degree of toxicity (or other hazard). The more toxic a substance is the more extensive or thorough decontamination must be. Whenever it is known or suspected that personnel can become contaminated with highly toxic or skin-destructive substances, a full decontamination procedure should be followed. If less hazardous materials are involved, the procedure can be downgraded.

Amount of Contamination--
The amount of contamination on protective clothing is usually determined visually. If it is badly contaminated, a thorough decontamination is generally required. Gross material remaining on the protective clothing for any extended period of time may degrade or permeate it. This likelihood increases with higher air concentrations and greater amounts of liquid contamination. Gross contamination also increases the probability of personnel contact. Swipe tests may help determine the type and quantity of surface contaminants.

Level of Protection--
The Level of Protection and specific pieces of clothing worn determine on a preliminary basis the layout of the decontamination line. Each Level of Protection incorporates different problems in decontamination and doffing of the equipment. For example, decontamination of the harness straps and backpack assembly of the self-contained breathing apparatus is difficult. A butyl rubber apron worn over the harness makes decontamination easier. Clothing variations and different Levels of Protection may require adding or deleting stations in the original decontamination procedure.

Work Function--
The work each person does determines the potential for contact with hazardous materials. In turn, this dictates the layout of the decontamination line. Observers, photographers, operators of air samplers, or others in the Exclusion Zone performing tasks that will not bring them in contact with contaminants may not need, for example, to have their garments washed or rinsed. Others in the Exclusion Zone with a potential for direct contact with the hazardous material will require more thorough decontamination. Different decontamination lines could be set up for different job functions, or certain stations in a line could be omitted for personnel performing certain tasks.

Location of Contamination--

Contamination on the upper areas of protective clothing poses a greater risk to the worker because volatile compounds may generate a hazardous breathing concentration both for the worker and for the decontamination personnel. There is also an increased probability of contact with skin when doffing the upper part of clothing.

Reason for Leaving Site--

The reason for leaving the Exclusion Zone also determines the need and extent of decontamination. A worker leaving the Exclusion Zone to pick up or drop off tools or instruments and immediately return may not require decontamination. However, a worker leaving to get a new air cylinder or to change a respirator or canister may require some degree of decontamination. Individuals departing the CRC for a break, lunch, end of day, etc., must be thoroughly decontaminated.

Effectiveness of Decontamination

There is no method to immediately determine how effective decontamination is in removing contaminants. Discolorations, stains, corrosive effects, and substances adhering to objects may indicate contaminants have not been removed. However, observable effects only indicate surface contamination and not permeation (absorption) into clothing. Also many contaminants are not easily observed.

A method for determining effectiveness of surface decontamination is swipe testing. Cloth or paper patches--swipes--are wiped over predetermined surfaces of the suspect object and analyzed in a laboratory. Both the inner and outer surfaces of protective clothing should be swipe tested. Positive indications of both sets of swipes would indicate surface contamination has not been removed and substances have penetrated or permeated through the garment. Swipe tests can also be done on skin or inside clothing. Permeation of protective garments requires laboratory analysis of a piece of the material. Both swipe and permeation testing provide after-the-fact information. Along with visual observations, results of these tests can help evaluate the effectiveness of decontamination.

Equipment

Decontamination equipment, materials, and supplies are generally selected based on availability. Other considerations are ease of equipment decontamination or disposability. Most equipment and supplies can be easily procured. For example, soft-bristle scrub brushes or long-handle brushes are used to remove contaminants. Water in buckets or garden sprayers is used for rinsing. Large galvanized wash tubs or stock tanks can hold wash and rinse solutions. Children's wading pools can also be used. Large plastic garbage cans or other similar containers lined with plastic bags store contaminated clothing and equipment. Contaminated liquids can be stored temporarily in metal or plastic cans or drums. Other gear includes paper or cloth towels for drying protective clothing and equipment.

Decontamination Solution

Personnel protective equipment, sampling tools, and other equipment are usually decontaminated by scrubbing with detergent-water using a soft-bristle brush followed by rinsing with copious amounts of water. While this process may not be fully effective in removing some contaminants (or in a few cases, contaminants may react with water), it is a relatively safe option compared with using a chemical decontaminating solution. Using chemicals requires that the contaminant be identified. A decon chemical is then needed that will change the contaminant into a less harmful substance. Especially troublesome are unknown substances or mixtures from a variety of known or unknown substances. The appropriate decontamination solution must be selected in consultation with an experienced chemist.

Establishment of Procedures

Once decontamination procedures have been established, all personnel requiring decontamination must be given precise instructions (and practice, if necessary). Compliance must be frequently checked. The time it takes for decontamination must be ascertained. Personnel wearing SCBAs must leave their work area with sufficient air to walk to CRC and go through decontamination.

CONTAMINATION DURING MEDICAL EMERGENCIES

Basic Considerations

Part of overall planning for incident response is managing medical emergencies. The plan should provide for:

- Some response team members fully trained in first aid and CPR.
- Arrangements with the nearest medical facility for transportation and treatment of injured, and for treatment of personnel suffering from exposure to chemicals.
- Consultation services with a toxicologist.
- Emergency eye washes, showers, and/or wash stations.
- First aid kits, blankets, stretcher, and resuscitator.

In addition, the plan should have established methods for decontaminating personnel with medical problems and injuries. There is the possibility that the decontamination may aggravate or cause more serious health effects. If prompt life-saving first aid and/or medical treatment is required, decontamination procedures should be omitted. Whenever possible, response personnel should accompany contaminated victims to the medical facility to advise on matters involving decontamination.

Physical Injury

Physical injuries can range from a sprained ankle to a compound fracture, from a minor cut to massive bleeding. Depending on the seriousness of the injury, treatment may be given at the site by trained response personnel. For more serious injuries, additional assistance may be required at the site or the victim may have to be treated at a medical facility.

Life-saving care should be instituted immediately without considering decontamination. The outside garments can be removed (depending on the weather) if they do not cause delays, interfere with treatment, or aggravate the problem. Respiratory masks and backpack assemblies must always be removed. Fully encapsulating suits or chemical-resistant clothing can be cut away. If the outer contaminated garments cannot be safely removed, the individual should be wrapped in plastic, rubber, or blankets to help prevent contaminating the inside of ambulances and/or medical personnel. Outside garments are then removed at the medical facility. No attempt should be made to wash or rinse the victim. One exception would be if it is known that the individual has been contaminated with an extremely toxic or corrosive material which could also cause severe injury or loss of life. For minor medical problems or injuries, the normal decontamination procedure should be followed.

Heat Stress

Heat-related illnesses range from heat fatigue to heat stroke, the most serious. Heat stroke requires prompt treatment to prevent irreversible damage or death. Protective clothing may have to be cut off. Less serious forms of heat stress require prompt attention or they may lead to a heat stroke. Unless the victim is obviously contaminated, decontamination should be omitted or minimized and treatment begun immediately.

Chemical Exposure

Exposure to chemicals can be divided into two categories:

- Injuries from direct contact, such as acid burns or inhalation of toxic chemicals.
- Potential injury due to gross contamination on clothing or equipment.

For the contaminant inhaled, treatment can only be by qualified physicians. If the contaminant is on the skin or in the eyes, immediate measures must be taken to counteract the substance's effect. First aid treatment usually is flooding the affected area with water; however, for a few chemicals, water may cause more severe problems.

When protective clothing is grossly contaminated, contaminants may be transferred to treatment personnel or the wearer and cause injuries. Unless severe medical problems have occurred simultaneously with splashes, the protective clothing should be washed off as rapidly as possible and carefully removed.

PROTECTION FOR DECONTAMINATION WORKERS

The Level of Protection worn by decontamination workers is determined by:

- Expected or visible contamination on workers.
- Type of contaminant and associated respiratory and skin hazards.
- Total vapor/gas concentrations in the CRC.
- Particulates and specific inorganic or organic vapors in the CRC.
- Results of swipe tests.
- The presence (or suspected presence) of highly toxic or skin-destructive materials.

Level C Use

Level C includes a full-face, canister-type air-purifying respirator, hard hat with face shield (if splash is a problem), chemical-resistant boots and gloves, and protective clothing. The body covering recommended is chemical-resistant overalls with an apron, or chemical-resistant overalls and jacket.

A face shield is recommended to protect against splashes because respirators alone may not provide this protection. The respirator should have a canister approved for filtering any specific known contaminants such as ammonia, organic vapors, acid gases, and particulates.

Level B Use

In situations where site workers may be contaminated with unknowns, highly volatile liquids, or highly toxic materials, decontamination workers should wear Level B protection.

Level B protection includes SCBA, hard hat with face shield, chemical-resistant gloves, and protective covering. The clothing suggested is chemical-resistant overalls, jacket, and a rubber apron. The rubber apron protects the SCBA harness assembly and regulatory from becoming contaminated.

DECONTAMINATION OF EQUIPMENT

Insofar as possible, measures should be taken to prevent contamination of sampling and monitoring equipment. Sampling devices become contaminated, but monitoring instruments, unless they are splashed, usually do not. Once contaminated, instruments are difficult to clean without damaging them. Any delicate instrument which cannot be decontaminated easily should be protected while it is being used. It should be bagged, and the bag taped and secured around the instrument. Openings are made in the bag for sampling intake.

Decontamination Procedures

Sampling Devices--

Sampling devices required special cleaning. Decontamination procedures including solution and solvent selection must be developed in conjunction with the designated analytical laboratory.

Tools

Wooden tools are difficult to decontaminate because they absorb chemicals. They should be kept on site and handled only by protected workers. At the end of the response, wooden tools should be discarded. For decontaminating other tools, consult with the analytical laboratory and the site safety officer.

Heavy Equipment

Bulldozers, trucks, backhoes, bulking chambers, and other heavy equipment are difficult to decontaminate. The method generally used is to wash them with water under high pressure and/or to scrub accessible parts with detergent/water solution under pressure, if possible. In some cases, shovels, scoops, and lifts have been sandblasted or steam cleaned. Particular care must be given to those components in direct contact with contaminants such as tires and scoops. Swipe tests should be utilized to measure effectiveness.

Sanitizing of Personnel Protective Equipment

Respirators, reusable protective clothing, and other personal articles not only must be decontaminated before being reused, but also sanitized. The inside of masks and clothing becomes soiled due to exhalation, body oils, and perspiration. The manufacturer's instructions should be used to sanitize the respirator mask. If practical, protective clothing should be machine washed after a thorough decontamination; otherwise it must be cleaned by hand.

Persistent Contamination

In some instances, clothing and equipment will become contaminated with substances that cannot be removed by normal decontamination procedures. A solvent may be used to remove such contamination from equipment if it does not destroy or degrade the protective material. If persistent contamination is expected, disposable garments should be used. Testing for persistent contamination of protective clothing and appropriate decontamination must be done by qualified laboratory personnel.

Disposal of Contaminated Materials

All materials and equipment used for decontamination must be disposed of properly. Clothing, tools, buckets, brushes, and all other equipment that is contaminated must be secured in drums or other containers and labeled. Clothing not completely decontaminated onsite should be secured in plastic bags before being removed from the site.

Contaminated wash and rinse solutions should be contained by using step-in-containers (for example, child's wading pool) to hold spent solutions. Another containment method is to dig a trench about 4 inches deep and line it with plastic. In both cases the spent solutions are transferred to drums, which are labeled and disposed of with other substances onsite.