

USEPA REGION 9 EMERGENCY RESPONSE GUIDE



LANDFILL FIRE RESPONSE

February 2010



USEPA REGION 9 EMERGENCY RESPONSE GUIDE

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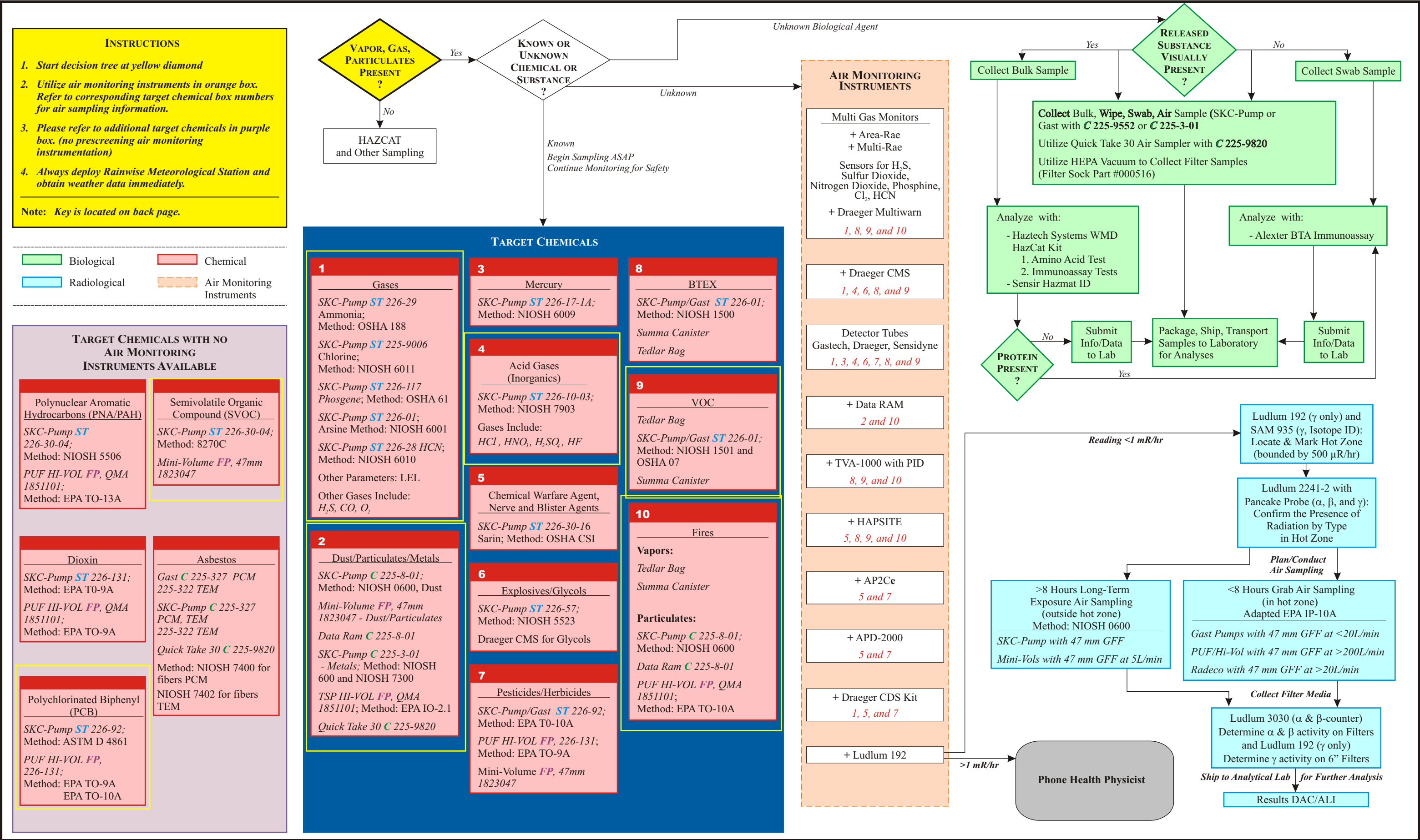
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AIR SAMPLING DECISION TREE - ERTG



Key:

+	Positive Result Above Background	HF	Hydrofluoric Acid
α	Alpha	Hi-Vol	High-Volume Sampler
β	Beta	HP	Health Physicist
γ	Gamma	LEL	Lower Explosive Limit
ALI	Airborne Limit Intake	L/Min	Liters/Minute
APD	Advanced Portable Detector	MCE	Methyl Cellulose Ester
ASTM	American Society for Testing and Materials	mR/hr	Millirem Per Hour
BTA	Bio Threat Analyzer	NH ₃	Ammonia
BTEX	Benzene, Toluene, Ethylbenzene, Xylene	NIOSH	National Institute of Occupational Safety and Health
C	Cassette Media for SKC Pumps	O ₂	Oxygen
CDS	Civil Defense System Draeger	OSHA	Occupational Safety and Health Administration
CGI	Combustible Gas Indicator	PCB	Polychlorinated Biphenyl
Cl	Chlorine	PCM	Phase Contrast Microscopy
CMS	Chip Measuring System Draeger	PDR	Personal Data Ram
CO	Carbon Monoxide	PID	Photoionization Detector
CWA	Chemical Warfare Agent	PNA and PAH	Polynuclear Aromatic Hydrocarbons
DAC	Data Chem	ppm	Parts Per Million
DoD	Department of Defense	PUF	Polyurethane Foam
FP	Filter Paper	SAM	Surveillance and Monitoring
FTIR	Hazmat Identification System	Saw MiniCad	Surface Acoustic Wave Mini Chemical Agent Detector
GC-MS	Gas Chromatograph Mass Spectrometer/HAPSITE	ST	Sorbent Tube Media for SKC Pumps
GFF	Glass Fiber Filter	START	Superfund Technical Assessment and Response Team
H ₂ S	Hydrogen Sulfide	SVOC	Semi Volatile Organic Compound
H ₂ SO ₄	Sulfuric Acid	TEM	Transmission Electron Microscopy
H ₃ PO ₄	Phosphoric Acid	TVA	Toxic Vapor Analyzer
HazCat TM	Hazardous Materials Categorization	µR/hr	Microrem Per Hour
HCl	Hydrochloric Acid	VOC	Volatile Organic Compound
HCN	Hydrogen Cyanide	WMD HazCat	Weapons of Mass Destruction Hazardous Materials Categorization
HEPA Filter	High Efficiency Particulate Air Filter		



Equipment Representatives:

Ahura – John Johnson (805) 300-1445
Alexeter – Todd Burke (877) 591-5571
Draeger - Tech Support – (800) 858-1739
HAPSITE Orders – Peggy Smith (315) 434-1100
HAPSITE Technical – Elizabeth Hembach (315) 434-1261
Hivolume Air Sampling Support – Jerry Winberry (919) 467-2785
Ludlum – (800) 622-0828
Lumex – Joseph Siperstein (888) 876-2611
Rae Systems – William Harrison (503) 502-3589
SKC Pump – Ken Walter (206) 979-8352
Scott – Shaun Endsley (208) 667-5915 or (800) 247-7257 (tech support)

Action Levels:

Oxygen Enriched/Deficient Environment

23.5% < O₂ < 19.5%

Flammable/Explosive Environment

CGI ≥ 10% LEL

Unknown Volatile Organic Compound

1ppm Sustained, Level-C

5ppm Sustained, Level-B

Radiation

≥1 mR/hr	Withdraw, Only Continue Monitoring with Health Physicist Advice
<1 mR/hr	Continue Monitoring for Radiation
.01 - .02 mR/hr	Typical Background Levels

Disclaimer

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Region 9 Action Levels and Exposure Limits – Landfill Fire Response

Contaminant	Exposure Limits						*Action Levels				
							Soil Screening Levels 2009		Air Screening Levels 2009		Water Screening Levels
	PEL (TWA)		REL (TWA)		TLV (TWA)		Residential Soil	Industrial Soil	Residential Air	Industrial Air	MCL
Gases	mg/m ³	ppm	mg/m ³	ppm	mg/m ³	ppm					
Hydrogen Chloride	7 mg/m ³	5 ppm	7 mg/m ³	5 ppm	2.78 mg/m ³	2 ppm	28,000,000 mg/kg	120,000,000 mg/kg	21.0 ug/m ³	88.0 ug/m ³	
Hydrogen Sulfide	28 mg/m ³	20 ppm	15 mg/m ³	10 ppm	14 mg/m ³	10 ppm	2,800,000 mg/kg	12,000,000 mg/kg	2.1 ug/m ³	8.8 ug/m ³	
Sulfur Dioxide	13 mg/m ³	5 ppm	5 mg/m ³	2 ppm	5.2 mg/m ³	2 ppm	NA	NA	NA	NA	NA
Carbon Monoxide	55 mg/m ³	50 ppm	40 mg/m ³	35 ppm	29 mg/m ³	25 ppm	NA	NA	NA	NA	NA
Hydrogen Cyanide	11 mg/m ³	10 ppm	ST - 5 mg/m ³	4.7 ppm	5 mg/m ³	4.7 ppm	1,600 mg/kg	20,000 mg/kg	3.1 ug/m ³	13 ug/m ³	
Nitrogen Dioxide	9 mg/m ³	5 ppm	ST – 1.8 mg/m ³	ST – 1 ppm	5.6 mg/m ³	3 ppm	NA	NA	NA	NA	NA
Metals											
Antimony	0.5 mg/m ³	0.1 ppm	0.5 mg/m ³	0.1 ppm	0.5 mg/m ³	0.1 ppm	31 mg/kg	410 mg/kg	NA	NA	0.006 mg/L
‡Arsenic	0.01 mg/m ³		0.002 mg/m ³				0.39 mg/kg	1.6 mg/kg	0.00057 ug/m ³	0.0029 ug/m ³	0.01 mg/L
Barium	0.5 mg/m ³		0.5 mg/m ³		0.5 mg/m ³		15,000 mg/kg	190,000 mg/kg	0.52 ug/m ³	2.2 ug/m ³	2.0 mg/L
‡Beryllium	0.002 mg/m ³		0.0005 mg/m ³		0.002 mg/m ³		160 mg/kg	2,000 mg/kg	0.001 ug/m ³	0.0051 ug/m ³	0.004 mg/L
‡Cadmium	0.005 mg/m ³				0.01 mg/m ³		70 mg/kg (diet)	800 mg/kg (diet)	.0014 ug/m ³ (water)	.0068 ug/m ³ (water)	0.005 mg/L
Chromium III & IV	1 mg/m ³		0.5 mg/m ³		0.5 mg/m ³		Cr III 120,000 mg/kg Cr VI 230 mg/kg	Cr III 1,500,000 mg/kg Cr VI 1,400 mg/kg	Cr III NA Cr VI 0.0002 ug/m ³	Cr III NA Cr VI 0.001 ug/m ³	Cr total 0.1 mg/L
Chromium, total	1 mg/m ³		0.5 mg/m ³		0.5 mg/m ³		280 mg/kg	1400 mg/kg	0.0002 ug/m ³	0.001 ug/m ³	0.1 mg/L

Region 9 Action Levels and Exposure Limits
April, 2009

Contaminant	Exposure Limits						*Action Levels				
							Soil Screening Levels 2009		Air Screening Levels 2009		Water Screening Levels
	PEL (TWA)		REL (TWA)		TLV (TWA)		Residential Soil	Industrial Soil	Residential Air	Industrial Air	MCL
Cobalt	0.1 mg/m ³		0.05 mg/m ³		0.02 mg/m ³		23 mg/kg	300 mg/kg	0.00027 ug/m ³	0.0014 ug/m ³	
Copper	1 mg/m ³		1 mg/m ³		1 mg/m ³		3,100 mg/kg	41,000 mg/kg	NA	NA	1.3 mg/L
Lead	0.050 mg/m ³		0.050 mg/m ³		0.050 mg/m ³		400 mg/kg	800 mg/kg	NA	NA	0.15 mg/L
Mercury	0.1 mg/m ³		0.05 mg/m ³		0.025 mg/m ³		4.3 mg/kg	24 mg/kg	0.31 ug/m ³	1.3 ug/m ³	0.002 mg/L
Molybdenum	15 mg/m ³						390 mg/kg	5,100 mg/kg	NA	NA	
‡Nickel (subsulfide)	1 mg/m ³		0.015 mg/m ³		0.1 mg/m ³		0.38 mg/kg	1.7 mg/kg	0.0051 ug/m ³	0.026 ug/m ³	NA
Selenium	0.2 mg/m ³		0.2 mg/m ³		0.2 mg/m ³		390 mg/kg	5,100 mg/kg	21 ug/m ³	88 ug/m ³	0.05 mg/L
Silver	0.01 mg/m ³		0.01 mg/m ³		0.1 mg/m ³		390 mg/kg	5,100 mg/kg	NA	NA	
Thallium	0.1 mg/m ³		0.1 mg/m ³		0.1 mg/m ³		510 mg/kg	66 mg/kg	NA	NA	0.002 mg/L
Vanadium	0.1 mg/m ³		0.05 mg/m ³		0.05 mg/m ³		550 mg/kg	7,200 mg/kg	NA	NA	
Zinc	15 mg/m ³		5 mg/m ³		10 mg/m ³		23,000 mg/kg	310,000 mg/kg	NA	NA	
VOCs											
‡Benzene	3.19 mg/m ³	1 ppm		0.1 ppm	1.5 mg/m ³	0.5 ppm	1.1 mg/kg	5.6 mg/kg	0.31 ug/m ³	1.6 ug/m ³	0.005 mg/L
‡1,3-Butadiene	2.21 mg/m ³	1 ppm			4.4 mg/m ³	2.0 ppm	0.054 mg/kg	0.26 mg/kg	0.081 ug/m ³	0.41 ug/m ³	
PAHs											
‡Benzo (a) pyrene	0.2 mg/m ³	0.02 ppm	0.1 mg/m ³	0.001 ppm			0.015 mg/kg	0.21 mg/kg	0.00087 ug/m ³	0.011 ug/m ³	0.0002 mg/L

Region 9 Action Levels and Exposure Limits
April, 2009

Contaminant	Exposure Limits						*Action Levels				
							Soil Screening Levels 2009		Air Screening Levels 2009		Water Screening Levels
	PEL (TWA)		REL (TWA)		TLV (TWA)		Residential Soil	Industrial Soil	Residential Air	Industrial Air	MCL
PARTICULATES**											
PM ₁₀	**150 ug/m ³										
PM _{2.5}	**35 ug/m ³										
PCBs											
‡Aroclor	0.5 mg/m ³	0.03 ppm	0.001 mg/m ³		0.5 mg/m ³	0.03 ppm	0.22 mg/kg	0.74 mg/kg	0.0043 ug/m ³	0.021 ug/m ³	
Dioxins & Furans											
‡Dioxin	-	-	0 mg/m ³	0 ppm	-	-	0.000094 mg/kg	.00039 mg/kg			.00003 mg/L
Furan	19.6 mg/m ³	5 ppm	0 mg/m ³	0 ppm	7.86 mg/m ³	2 ppm	78 mg/kg	1000 mg/kg	¥ 52 ug/m ³	¥ 220 ug/m ³	

Notes:

* EPA Region 9 Master Screening Level Table April, 2009

‡NIOSH Potential Occupational Carcinogens

** 24 Hour National Ambient Air Quality Standards (NAAQS) - Particulate Primary Standard

¥ as Furfural

TWA = Time weighted average concentration not to be exceeded during a 10 hour work day during a 40 hour work week.

PEL = OSHA Permissible Exposure Limit. The legally enforceable limit not to be exceeded at any time within a work day.

REL = NIOSH Recommended Exposure Limit. Limit recommended as protective of human health by the National Institute of Occupational Safety and Health.

TLV = Threshold Limit Value. The ACGIH limit not to be exceeded at any time during an 8 hour work day.

STEL or ST= Short Term Exposure Limit. The 15 minute TWA exposure that should not be exceeded at any time during a work day.

C = Ceiling REL. Limit should not be exceeded at any time.

MCL = Maximum Contaminant Level. Legally enforceable threshold limit set by the EPA for drinking water quality.

mg/m³ = milligrams per cubic meter

ug/m³ = micrograms per cubic meter

mg/L = milligrams per liter

mg/kg = milligrams per kilogram

ACGIH = American Congress of Government Industrial Hygienists

Land Fill Fire Response Guide
Air Monitoring Guidance

Target Compounds ¹	Instruments	Detection Levels	Intrinsically Safe (Yes/No)	Ionization Potential	PID Correction Factor	Occupational Action Levels		AEGL 1		PPE (PPE will be dependent on concentration of compound) (See NIOSH Pocket Guide website)
						Occupational Action Levels	Occupational (IDLH, NIOSH) ng/m ³	4-hour (ppm)	8-hour (ppm)	
Radiation ²										
Gamma Radiation	Ludlum Model 192	0-5,000 micro-R/hr	N	NA	NA	3 x background consult with HP	3 x background consult with HP	NA	NA	NA
Alpha, Beta, Gamma Radiation	Ludlum Model 2241-2 with Pancake Probe	0-9,999 R/hr or 999,000 cpm	N	NA	NA	3 x background consult with HP	3 x background consult with HP	NA	NA	NA

Notes:

¹ Does not include all compounds associated with tire fires, only the most common compounds with the lowest action levels. Depending on the chemical of concern, certain Draeger tubes and chips can be used. In addition, single gas instruments and sensors and/or a gas chromatography-mass spectroscopy instrument may be used.

² Standard U.S. EPA Emergency Response Protocol is to screen for radiation with a Micro-R at all Emergency Responses. If readings are three times background, responders consult with Health Physicist. Additional Radiation equipment is available to monitor for Alpha, Beta, and Gamma, but is not included in this table.

* AEGL 2 - There are no AEGLs 1 for this compound.

** MIRAN SapphIRE has problems with complex mixtures (e.g. distinguishing benzene from gasoline vapor)

AEGL - Acute Exposure Guideline Levels
cpm - counts per minute
eV - electron volt
IDLH - Immediately Dangerous to Life and Health
mg/m³ - milligrams per cubic meter
NA - Not Available

PEL - Permissible Exposure Limit
NIOSH - National Institute for Occupational Safety and Health
OSHA - Occupational Safety and Health Association
PAHs - Polyaromatic Hydrocarbons
PID - Photoionization Detector
PPE - Personal Protective Equipment

ppb - parts per billion
ppm - parts per million
R/hr - roentgen per hour
REL - Recommended Exposure Limit
VOCs - Volatile Organic Compounds

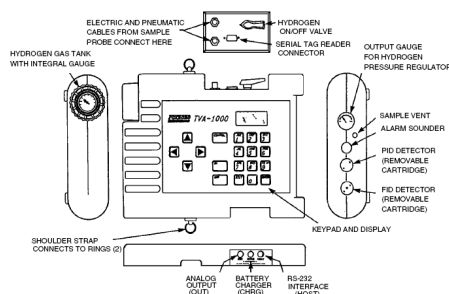
<http://www.epa.gov/oppt/aeql/pubs/chemlist.htm>

U.S. EPA website used to research AELGs using the chemical's name or Chemical Abstracts Service Registry Numbers (CAS)

TVA-1000B Toxic Vapor Analyzer (PID/FID)

GENERAL INFORMATION

Equipment Name:	TVA-1000 Toxic Vapor Analyzer
Model:	1000B
Manufacturer:	Thermo Fisher Scientific, Inc.
National Manufacturer Contact:	Telephone: 888-643-4968 E-mail: lori.gorski@thermofisher.com Website: http://www.thermofisher.com



NOTE: Guides are to be used by trained personnel only and DO NOT replace the manufacturer's operations or technical manuals. These guides were developed by field personnel for utilization by EPA and their contractors and are helpful in quick start-up and operations. Various limitations have been identified through the experience of the development group. Different makes, models, and updates to this equipment may change the limitations. It is recommended that calibration, maintenance, and use be recorded in a logbook. Additional product information may be found in the accompanying Equipment Operating Guide.

SPECIFICATIONS

Uses:	The TVA-1000 Toxic Vapor Analyzer, shown above, is an organic / inorganic vapor monitor for the gas survey industry. This analyzer uses either a flame ionization detector (FID), a photo-ionization detector (PID), or both. The vapor concentration may be read immediately on either of two displays — one mounted directly on the hand-held sample probe and the other on the instrument sidepack itself. Vapor concentration can be displayed on both displays in either parts per million (ppm), parts per billion (ppb), or percent concentration (%).
Limitations:	<ol style="list-style-type: none"> 1. The FID requires >16% oxygen to maintain the hydrogen flame. If there is not sufficient amount of oxygen, the flame will go out. 2. Neither detector is compound specific. PID is calibrated to isobutylene. The FID is calibrated to methane. Other compounds have different response factors for each detector. 3. Low oxygen can also effect the characteristics of the flame, causing false elevated readings. 4. If the ionization potential of a compound is higher than the lamp energy, the compound may not be detected. 5. PID has a smaller dynamic range, and is not the best choice for measuring high concentrations of vapors. 6. PID is susceptible to interference from water vapor more so than the FID. 7. As the unit ages, the PID lamp energy may decrease, so compounds with ionization energy near the lamp energy may not be detected. 8. PID lamp requires periodic cleaning depending on operating conditions. 9. Detection of chemical warfare agent vapors is unreliable, even if instrument is calibrated. 10. Must follow proper shipping instructions due to the hydrogen tank. The hydrogen storage tank needs to be shipped as dangerous goods. Air Cargo Only 1049 "Hydrogen, Compressed".
Response Range:	PID Instrument: 0.5 - 2,000 ppm isobutylene, accurate to 500 ppm isobutylene, Min.: 100 ppb benzene FID Instrument: 1.0 - 50,000 ppm methane, accurate to 10,000 ppm methane, Min: 300 ppb hexane

Alarm Level:	Set by user: High, Low, STEL.
Product Safety:	FM: Intrinsically safe for Class 1, Division 1, Groups A, B, C and D. Hydrogen cylinders require special shipping as dangerous goods, UN 1049.
Battery:	The TVA-1000B operates on a rechargeable nickel cadmium battery. When the battery is fully charged, it will last a minimum of eight hours of continuous use at 20°C. Extreme temperatures, hot or cold, and use of the backlight will shorten the run time. The battery does not need to be removed from the instrument to be charged. A fully discharged battery will take approximately 16 hours to recharge completely.
Calibration:	Annual Manufacturer Calibration, check calibration date on a tag or sticker. Capable of multipoint and multiple response factors/curves calibrations. Instrument alerts user if calibration is bad.

QUICK START GUIDE

Prior to Starting:	1.	Charge battery. Connect sample probe. Fill/install hydrogen tank.
	2.	Open the red hydrogen valve located on the side of the unit by turning the handle to the “ON” position. Let unit sit for approximately 5 minutes, so hydrogen can stabilize in unit.
Start-up	1.	Press “ON” button until unit beeps and “MAIN MENU” appears on screen.
	2.	Press “CONTROL”.
	3.	Press “3” to ignite FID. (unit should pause and two audible pops may be heard, indicating flame is lit) If ignition fails, wait 5 minutes, and then press “3” to ignite FID.
	4.	Press “1” to initiate run. Press and hold “EXIT” to stop run and return to the “MAIN MENU”.
Calibration:	<i>NOTE: Prior to performing calibration, the instrument must be on and warmed up for approximately 30 minutes. The pump must be ON, the PID lamp must be ON, and the FID must be ignited throughout the warm-up period.</i>	
	1.	Press “2” to enter Setup.
	2.	Press “1” to Calibrate.
	3.	Press “2” to enter span concentration. Enter the concentration of the span gas being used. (1=Both, 2=PID, 3=FID) Use the “▲ ▼” keys to select units of measurement. (ppm, ppb, %) and key in numbers using number keypad on unit. “”Press “ENTER” to accept.
	4.	Press “3” to zero the unit. (1=Both, 2=PID, 3=FID)
	5.	Press “1” to zero both the PID and the FID. Connect Zero Gas to probe or use ambient air. Press “ENTER” to start. Wait for readings to stabilize and press “ENTER” to accept, and follow the instructions on screen to save values.
	6.	Press “4” = Span.
	7.	Press “2” = PID, apply the appropriate span gas, 100 ppm Isobutylene to probe (using a clean and labeled Tedlar bag) and then press “ENTER”, wait for reading to stabilize and press “ENTER” to accept. Follow the instructions on screen to save values.
	8.	Repeat step 6 & 7 choosing “3”=FID and using 100ppm Methane span gas instead of Isobutylene.
	9.	Press “EXIT” 2 times to return to the “MAIN MENU”.
	10.	Press “1” = RUN, You are now in the “SURVEY MODE”.
	11.	Press and hold “EXIT” to stop run and return to the “MAIN MENU”.
Turn Off:	1.	Press and hold the “OFF” key until unit turns off.
	2.	With FID versions you must also shut off the hydrogen valve so the tank does not deplete. Removing hydrogen tank also reduces chances of hydrogen leaking from tank.

Multi Gas Monitor (Area RAE)

GENERAL INFORMATION

Equipment Name	Multi Gas Monitor (AreaRAE)
Model:	PGM50-5P
Manufacturer	RAE Systems, Inc.
Manufacturer Contact	Telephone 877-723-2878/ 408-752-0723 Fax 408-852-0724 Website www.RAEsystems.com 680 West Maude Avenue, #1 Sunnyvale, CA 94086



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SPECIFICATIONS

Uses:	To detect CO, H ₂ S, VOCs, O ₂ , and combustible gas (LEL).
Limitations:	VOCs as a lump sum. Concentration readings may not mean much if compounds are unknown. PID Lamps 10.6 eV (Installed) and 11.7 eV (Spare)
Response Range:	See Next Page.
Alarm Level:	See Next Page.
Product Safety:	Intrinsically safe.
Battery:	Rechargeable battery. Fully charged in 12 hours. Run Time 36 hours on full charge.
Calibration Gas:	Four-gas calibration: a 58-liter, 500 psig cylinder, containing CO: 50 ppm; H ₂ S: 25 ppm; LEL (methane): 50%; O ₂ : 19%; and balance N ₂ . VOC calibration: a 58-liter, 500 psig cylinder, containing 100 ppm isobutylene and balance air. Purchase from manufacturer or distributor.

Multi Gas Monitor (Area RAE)

QUICK OPERATIONS GUIDE		
Operation & Calibration:	1.	Guidelines for the Calibration and Operation of the individual AreaRAE units can be found in the Quick Start Guide for the MultiRAE.
	2.	Units should be Fresh Air Calibrated before deployment. Place pre-filter on inlet port, turn units on, when units are ready hold down the MODE and N/- buttons together until Enter Password= 0000 appears on the screen. Hold down the MODE button until Calibrate Monitor? appears on the screen. Press the Y/+ twice. After the calibration is done press the MODE button until the normal screen appears.
ER Truck and Repeater Computer Operation and Data Logging:	1.	Attach the Antenna to the <i>RAELink2 Host</i> found in the truck, then attach the RS-232 cable to the serial port on the ER Computer or any computer with the ProRAE Remote Software loaded on it (If your computer doesn't have a Serial Port use the USB converter located in the Host carrying case). Hold down the ON button located on the Host unit until the light is solid green.
	2.	Turn on the AreaRAE's and make sure that each unit's antenna is connected and that the LED light for Radio broadcasting is lit. Then take the AreaRAE Kit 1 of 2 and plug the extension cord(located inside case) into a power supply to the exterior adapter.
	3.	Open and turn on the computer. Remove the antenna from the case and place on top of vehicle or highest point available. Once the computer starts up the operating software will be displayed at full screen. If it is not displayed open the shortcut on the desktop (ProRAERemote V1.41).
	4.	To begin receiving data from the AreaRAEs press F9 . The computer will scan for the signals from the AreaRAEs and begin downloading information once connected. Once data is being received from all AreaRAEs, deploy AreaRAEs to appropriate locations for monitoring.
	5.	The panel view (F2) displays the four units with room for a total of 32 units. Set up (F3) can change various setting (more information is in the Manufacturer's Manual). Log View (F4) will display the data logged information from the AreaRAE's. The data can be shown in detail and graph form.
	6.	RAELink2 Repeater Operation: When the Host and AreaRAE are too far from each other to communicate the use of the <i>RAELink2 Repeater</i> may be necessary. The repeater can be found in the truck. To operate attach the antenna to the unit and turn on by holding down the ON button located on the Repeater until the light turns a solid green.
	7.	Place in a line of sight between the RAELink Host and the AreaRAE to establish a communication bridge.
Turning on/off the Alarms:	1.	Hold down the MODE and N/- buttons together until Enter Password= 0000 appears on the screen. Hold down the MODE button until Calibrate Monitor? appears on the screen. Press N/- button until Change Monitor Setup? appears on the screen then press Y/+ button. Press N/- until Change Light and Buzzer Mode? appears, press Y/+ button. Press N/- button to scroll through the options (Both On, Both Off and Light Only). Press Y/+ button to select option. Press MODE button until the default screen appears.
Switching	1.	First make sure that the AreaRAE Unit is off and unplugged. Then open the case using

Multi Gas Monitor (Area RAE)

Sensors:		the allen wrench and remove the four hex screws (2 on top and 2 on bottom). Be careful not to pull the electrical cords from the connections when opening the case.
	2.	Next remove the 3 screws from the silver metallic plate and remove the plate gently to avoid pulling the tubing from the inlet and outlet.
	3.	Once the cover is off and the sensors are exposed, remove the unnecessary sensor and replace with the desired sensor. Make sure that the black line on the sensor label is lined up with the white marker on the sensor. Replace the plate and screws then the case and the hex screws.
	4.	Once turned on the AreaRAE will recognize the sensors installed and configured. However the sensors will still need calibration.
Turn Off:	1.	Press and hold MODE key until the AreaRAE is OFF. Shutdown Computer.

ALARM LEVEL AND RESPONSE RANGE			
	LOW ALARM	HIGH ALARM	RESPONSE RANGE
O ₂	19.5%	23.5%	0 - 30% (volume)
LEL	10%	20%	0 - 100%
CO	35 ppm	200 ppm	0 - 500 ppm
H ₂ S	10 ppm	20 ppm	0 - 100 ppm
CH ₄	10% (%LEL)	20% (% LEL)	1 - 2,000 ppm

MultiRAE Plus

GENERAL INFORMATION	
Equipment Name	MultiRAE Plus
Model:	PGM50-5P
Manufacturer	RAE Systems, Inc.
Manufacturer Contact	Telephone (877) 723-2878 or (408) 752-0723 Fax (408) 852-0724 Website www.raesystems.com 680 West Maude Avenue #1, Sunnyvale, CA 94086



SPECIFICATIONS	
Uses:	To detect CO, H ₂ S, VOCs, O ₂ , and combustible gas (LEL).
Limitations:	VOCs as a lump sum. Concentration readings may not mean much if compounds are unknown.
Response Range:	See page 2.
Alarm Level:	See page 2.
Product Safety:	Intrinsically safe.
Battery:	Rechargeable battery. Fully charged in 10 hours. Or use 4-AA alkaline batteries.
Calibration Gas:	Four-gas calibration: a 58-liter, 500 psig cylinder, containing CO: 50 ppm; H ₂ S: 25 ppm; LEL (methane): 50%; O ₂ : 19%; and balance N ₂ . VOC calibration: a 58-liter, 500 psig cylinder, containing 100 ppm isobutylene and balance air. Purchase from the manufacturer or distributor.

MultiRAE Plus

QUICK OPERATIONS GUIDE

Turn On:	1.	Press, hold, and release MODE key.
	2.	Wait for start-up sequence to complete (approximately 1 minute). The instrument will automatically go to real-time monitoring.
	3.	If H ₂ S, CO, and LEL read ZERO, and O ₂ reads 20.9, the instrument is ready to monitor. Otherwise go to ZERO step.
Zero:	1.	Hold both the N/- and MODE buttons for 3 seconds to enter Programming Menu. In the Programming Menu, always press MODE to back up one operational step.
	2.	Press Y/+ to “Calibrate Monitor?”
	3.	Press Y/+ to “Fresh Air Calibration?” You must be in a clean air environment.
	4.	The screen will prompt you when all sensors are zeroed.
	5.	The screen will prompt you to move to the next sub-menu “Multiple Sensor Calibration.”
	6.	To return to the monitoring mode, press MODE 2 times.
Calibration:	1.	From Program Mode press Y/+ at calibrate. Press N/- once to get to “Multiple Sensor Calibration.”
	2.	The screen will prompt “OK?” for fixed gas calibration.
	3.	Connect four gas calibration cylinder, turn on the valve of the gas bottle, and press Y/+ to accept multiple sensor calibration.
	4.	After multiple sensor calibration is complete, the screen will prompt “single sensor calibration?” Toggle to “VOC” using MODE button, then press Y/+.
	5.	Turn on calibration gas (isobutylene) valve, the instrument will calibrate VOC sensor.
	6.	Press MODE 2 times to return to real-time monitoring mode (may take a few minutes to zero out).
	7.	Calibration is recommended when a known concentration of gases is applied, and the readings are off by 10% or less.
Turn Off:	1.	Press and hold MODE key until OFF.

ALARM LEVEL AND RESPONSE RANGE

	LOW ALARM	HIGH ALARM	RESPONSE RANGE
O ₂	19.5%	23.5%	0 - 30% (volume)
LEL	10%	20%	0 - 100%
CO	35 ppm	200 ppm	0 - 500 ppm
H ₂ S	10 ppm	20 ppm	0 - 100 ppm
CH ₄	10% (%LEL)	20% (% LEL)	1 - 2,000 ppm

Dräger Chip Measuring System (CMS)

GENERAL INFORMATION

Equipment Name:	Chip Measuring System
Model:	6405050
Manufacturer:	Dräger Safety, Inc.
National Manufacturer Contact:	Telephone: 800-615-5503 E-mail: prodinfo@draeger.net Website: http://www.draeger.com



NOTE: Guides are to be used by trained personnel only and DO NOT replace the manufacturer's operations or technical manuals. These guides were developed by field personnel for utilization by EPA and their contractors and are helpful in quick start-up and operations. Various limitations have been identified through the experience of the development group. Different makes, models, and updates to this equipment may change the limitations. It is recommended that calibration, maintenance, and use be recorded in a logbook. Additional product information may be found in the accompanying Equipment Operating Guide.

SPECIFICATIONS

Uses:	Quantitatively measure hazardous gases and vapors.
Limitations:	<ol style="list-style-type: none"> 1. Limited shelf life for all chips. 2. Chips are subject to feed jamming. 3. Smaller subset of chips is available for CMS. 4. See manufacturer's technical specifications in each case of chips (cross interferences, quantitation, and etc.). 5. Limited to the chemicals that the chips are specific to. 6. One chemical is measured at a time. The chemical has to be known. Interference from other compounds may affect accuracy.
Response Range:	Various depending on individual chemicals.
Product Safety:	Intrinsically safe.
Battery:	Four alkaline AA batteries are required for operation. One set of batteries allows the analyzer to run for 450 minutes and perform more than 100 measurements.. Only use Varta LR64006; Energizer alkaline LR6 E91; or Panasonic AA, LR6 AM3 AA MN 1500 alkaline/foil (PMBC).
Calibration:	No calibration is required.

Additional Operational Information:	<ol style="list-style-type: none"> 1. One chip consists of 10 measurements capillaries filled with a substance-specific reagent system. 2. A printed bar code on the chip contains information about gas type, measuring range and time required for completing the analysis. 3. When ordering new chips, request chips with a 2-year shelf life. 4. The analyzer is able to perform 10 tests on one chip for the same chemical. 5. The internal data recorder stores up to fifty measurements with the time, date, contaminant, concentration, and sequential order of the measurement.
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QUICK START GUIDE

Prior to Starting:	1.	Select the appropriate chip for the gas or vapor to be analyzed. Each chip detects only one chemical. The measuring range and expiration date should be checked. On the chip, if the orange pin for a measurement channel is depressed, that channel has been used.
Turn On:	1.	Slide the blue switch to POSITION 1. The instrument will perform a self-test. If only one battery symbol is displayed, batteries must be changed before further measurements.
	2.	When “LOAD CHIP” message appears, insert the chip with arrow pointing toward the analyzer and barcode up, into the bottom port by pressing chip in upward direction lifting the blue gate. Slide chip evenly and <u>completely</u> into the chip inlet.
	3.	Gas to be measured and concentration range will be shown on the screen.
	4.	Following the prompt, slide the switch to POSITION 2 to check the chip. The number of available measurement channels is indicated on the right of the screen.
	5.	When “CHIP OK” is displayed, slide the switch to POSITION 3 to start measurement.
	6.	The analyzer displays “MEASURING”, and bars begin to fill in the space between “>” and “<”.
	7.	Once measurement is complete, the concentration will be displayed on the screen.
	8.	For the next measurement, slide the switch to POSITION 0, eject the chip, and reload again.
Zero:	1.	Not applicable.
Calibration:	1.	No calibration is required.
Turn Off:	1.	Slide the switch to POSITION 0, the chip will be ejected.

Dräger Multiwarn

GENERAL INFORMATION

Equipment Name:	Dräger MultiWarn
Model:	Dräger MultiWarn II
Manufacturer:	Dräger Safety, Inc.
National Manufacturer Contact:	Telephone: 888.794.3806 E-mail: prodinfo@draeger.net Website: http://www.draeger.com



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SPECIFICATIONS

Uses:	The Multiwarn II is a multi-gas sensor that combines catalytic oxidation and sensing technology for a total of up to 5 sensors. The instrument is also useful for measuring exposure in confined spaces.
Limitations:	<ol style="list-style-type: none"> 1. The Multiwarn is designed for continuous operation between -5 to 120°F (-20 to 40°C). For use outside of these parameters is possible, consult Multiwarn II and Sensor specifications for details. 2. Rapid or drastic changes in temperature, humidity, or pressure may cause slight fluctuations on the sensors. 3. At temperatures below 32°F (0°C), the humidity or pressure sensors may be slower to respond and battery life will be reduced. 4. The Multiwarn II is designed for continuous operation between 5 to 95% Relative Humidity. 5. Once readings have stabilized, use the Fresh Air Cal to adjust to the new ambient background. 6. Condensing water collecting on the sensor or filter may inhibit gas from entering the sensors. 7. The Multiwarn II is designed for continuous operation between pressures 20.7 to 38.4 inches of water. 8. If dust or mist is allowed to accumulate on the sensors, it can prevent gas from entering the sensors. 9. Some sensors are cross sensitive to many chemicals – see part numbers or manufacturer's data. 10. You must be in a clean environment to clean the sensor if you do not have the optional integrated pump.
Response Range:	Oxygen 0-25%; Percent methane 0-100 %; Lower explosive limit 0-100%; Chlorine 0-10 ppm; Ammonia 0-200 ppm; Hydrogen cyanide 0-50 ppm; Phosphine 0-1,000 ppm (PH ₃); Odorant (Mercaptane) 0-40 ppm; Amine 0-100 ppm.

Dräger Multiwarn

Alarms:	Combines loud audible and bright visual alarms to warn the user of conditions. A1 - A pre-alarm for Ex and TOX and oxygen deficiency. This alarm can be disregarded, except for the oxygen alarm. A2 - The main alarm for TOX or Ex or main alarm for oxygen excess. This alarm will continue until conditions are safe again. STEL, TWA, low battery & fault.	
	<u>PEL (A1):</u>	<u>STEV (STEL, A2):</u>
	Methane Vol%	5
	Methane %LEL	10
	Oxygen:	19.5%
	Chlorine ppm:	0.5
	Ammonia ppm:	25
	Hydrogen cyanide ppm:	2.5
	Phosphine ppm:	50
	Odorant-mercaptane ppm:	5
	Amine ppm:	5
		15
		20
		23.5%
		1.0
		50
		4.5
		100
		10
		n/a
Product Safety:	U I, Class 1, Division 1, Groups A-D, T4 C.S.A. ; Class 1, Division 1, Groups A-D, T4 CENELEC; EEX ib s IIC T4 (BVS) w/o IR Sensor CENELEC; EEX ibn d s IIB + H2 T4 (BVS) with IR Sensor MSHA	
Battery:	Rechargeable Ni-Cad battery capable of 10 hours of continuous use. The battery should be recharged after each use, and after the alarm has been triggered or after three weeks. The battery level may be checked by pressing the up arrow and the battery level is shown at the top of the screen. Low battery A1 alarm is activated when battery has less than 30 minutes of operation remaining. Low battery A2 alarm is activated when the battery is nearly dead. The instrument will automatically shut-down in 2 minutes to prevent damage to the battery. The alarm can be silenced by pressing the enter button. Batteries will take 8 hours to recharge.	
Calibration:	Calibrate instrument prior to each use. Each sensor has to be calibrated individually.	

Dräger Multiwarn

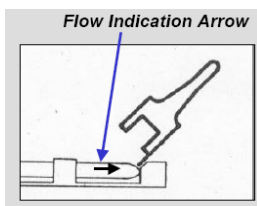
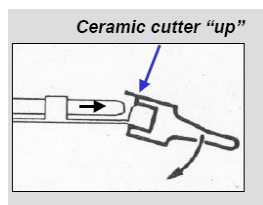
QUICK OPERATIONS GUIDE

Turn On:	1.	Press red ENTER button.
	2.	The instrument will go through start-up sequence, and return to real time monitoring.
	3.	Begin to monitor.
Fresh Air Calibration:	1.	Prior to initial use, sensors must be “warmed” in the monitoring unit or in the Bias Box (Warming box). Prior to any calibration, enter date and time (ENTER: Maintenance: Password 0001: Date and Time {dd.mm.yyyy}). Fresh air calibration should be done prior to use and only if the ambient air is clean. Press and hold red ENTER button until Menu comes up (3 seconds).
	2.	Scroll to Fresh Air Calibration and press ENTER.
	3.	Screen will state Fresh air adjust OK! when completed (about 10 seconds). Press ENTER to return to Menu. Scroll up to BACK and press ENTER.
	4.	Scroll to Measurement and press ENTER to return to monitoring or scroll to other options.
Calibration:	1.	Press and hold red ENTER button until “Menu” comes up (3 seconds).
	2.	Scroll to Maintenance and press ENTER
	3.	Scroll to Password and press ENTER. With the arrow and ENTER keys enter 0001. When complete, press ENTER twice.
	4.	Scroll to Span calibrate for individual gases and press ENTER.
	5.	Scroll to sensor (gas) to be calibrated and press ENTER.
	6.	Scroll to Span calibrate and press ENTER.
	7.	If the concentration is not identified or is different than identified, enter the value using the arrow and ENTER keys. When complete, scroll to forward and press ENTER.
	8.	In Supply gas mode, attach the calibration plate (double hose attachment plate) to red sensor protection plate with hose to calibration gas and turn on gas. Pump will automatically turn on. Scroll to forward and press ENTER.
	9.	Allow value to stabilize for a few seconds (possibly up to 20 seconds). Scroll to forward and press ENTER. If Calibration error is noted, value was probably not stabilized. Scroll back to Span calibrate and start from Step 4 again. If Calibration OK!, press ENTER and continue to calibrate the next sensor or return to Measurement.
Warming-Up Sensors and Sensor Exchange:	1.	Multiwarn sensors can be exchanged with the Pac III hand monitor sensors. Sensors can be warmed-up in the Multiwarn monitor unit itself or in the Bias Box. Sensors will take up to 24 hours for initial warm-up, depending on the sensor. The batteries in the Bias Box needs to be initially charged for 48 hours. Bias box charge will last up to 300 hours.
	2.	Take care when placing sensors into the sockets of the Bias Box, they are fragile. When the sensors are originally placed into the Bias Box, the LED lights to the right of the sensor socket will flash twice every three seconds showing the sensor is warming-up. After exchange, sensors will take approximately two minutes to re-warm.
Turn Off:	1.	Press up and down arrow keys simultaneously for three seconds to turn off unit.

Dräger Accuro 2000 Pump

GENERAL INFORMATION

Equipment Name:	Accuro 2000 Pump
Model:	2000
Manufacturer:	Dräger Safety, Inc.
National Manufacturer Contact:	Telephone: 800-615-5503 E-mail: prodinfo@draeger.net Website: http://www.draeger.com



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SPECIFICATIONS

Uses:	The Dräger Accuro 2000 is a battery-driven, electronically controlled instrument which uses the Accuro sampling pump to perform a pre-programmed number of strokes. It allows "hands-free" operation of the Draeger-Tube System for the measurement of specific gases and vapors in a complex ambient background for health and safety levels found in the measurement area. It is used for all applications except those in combustible atmospheres.
Limitations:	<ol style="list-style-type: none"> 1. Does not work with aerosols. 2. Tube shelf life limited and specific to individual tubes. 3. If the concentration of the agent is below the sensitivity of the tube, it will not be detected. Detector tubes are limited to specific agents. 4. A negative response does not guarantee that other harmful agents are not present. 5. Limited to the chemicals that the detector tubes are specific for. See manufacturer's technical specifications in each case of tubes (interferences, quantification, and etc.).
Response Range:	Depends on the targeted chemical and the reagent in the Dräger tube. Over 200 different Dräger-Tubes are available for measuring over 500 gases and vapors.
Color Change:	If the targeted chemical(s) is present, the reagent in the tube will change color. The length of the color change typically indicates the measured concentration.
Product Safety:	Intrinsically safe.
Battery:	Dräger-proprietary rechargeable lead acid battery A200 (6 volt/1 amp).
Additional Operational Information	Be sure to program the pump stroke count with the same number as indicated by the tube direction card, as the result is based on a specific volume of air. Approximate time interval to complete the test set will depend on the detector tube.

Dräger Accuro 2000 Pump

QUICK START GUIDE

Start-up:	1.	Break off both tips of the tube in the break-off eyelet or in the break-off husk.
	2.	Tightly insert the tube in the pump head with the arrow pointing towards the pump.
Operation:	1.	Insert the selected open ended Dräger tube into the Accuro 2000 pump's sockets
	2.	Turn the instrument on.
	3.	Program the number of strokes specific to the tube being used. The Accuro 2000 pump is programmable for up to 2000 strokes operation.
	4.	After completion of the operation, Observe the color change of the tube packing material.
	5.	Note: The stroke counter will stop the pump when required number of counts is complete. Each specific tube operates with specific number of strokes, please check the instructions card.
	6.	Color changes in tubes are used to determine the presence and concentration of a specific agent.
	7.	Refer to instructions included in tube box for color change interpretations.
		<i>Note: Information on cross sensitivity is important to detailed interpretation of the color change results. Information is provided in the specific test set instruction manual. Other harmful gases may be present even if a negative result is indicated.</i>

Dräger Quantimeter 1000 Pump

GENERAL INFORMATION

Equipment Name:	Quantimeter 1000 Pump
Model:	1000
Manufacturer:	Dräger Safety, Inc.
National Manufacturer Contact:	Telephone: 800-615-5503 E-mail: prodinfo@draeger.net Website: http://www.draeger.com

- 1 Battery pack
 - 2 Locking screw for battery pack
 - 3 Guide for test tube or extension hose
 - 4 Adjustment keys for nominal display
 - 5 Nominal value indication *
 - 6 Indicated value *
 - 7 On/Off key (main switch)
 - 8 START/STOP-key
 - 9 Test tube holder
 - 10 Breaking point
 - 11 Cap for blow-off valve
 - 12 Sealing cap for breaking facility
 - 13 Brief operating instructions
- * Symbol U = Undervoltage
Symbol F = Malfuction



Figure 1

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SPECIFICATIONS

Uses:	The Quantimeter 1000 is a battery powered gas detector pump that allows "hands-free" operation of the Dräger-Tube System for the measurement of specific gases and vapors in a complex ambient background for health and safety levels found in the measurement area.
Limitations:	<ol style="list-style-type: none"> 1. If the concentration of the agent is below the sensitivity of the tube, it will not be detected. 2. <u>A negative response does not guarantee other harmful agents aren't present.</u> 3. Detector tubes are limited to specific agents. 4. Battery lifespan.
Response Range:	Depends on the targeted chemical and the reagent in the Dräger tube. Over 200 different Dräger-Tubes are available for measuring over 500 gases and vapors.
Color Change:	If the targeted chemical(s) is/are present, the reagent in the tube changes color, and the length of the color change typically indicates the measured concentration.
Product Safety:	Intrinsically safe
Battery:	Dräger-property rechargeable lead acid battery A200 (6 volt/1 amp).
Pressure Test:	Not Applicable
Additional Operational Information	<ol style="list-style-type: none"> 1. Be sure to program the pump stroke count the same amount as indicated by the tube directions, as results are based on a specific volume of air. 2. Approximate time interval to complete the test set will depend on the detector tube.

Dräger Quantimeter 1000 Pump

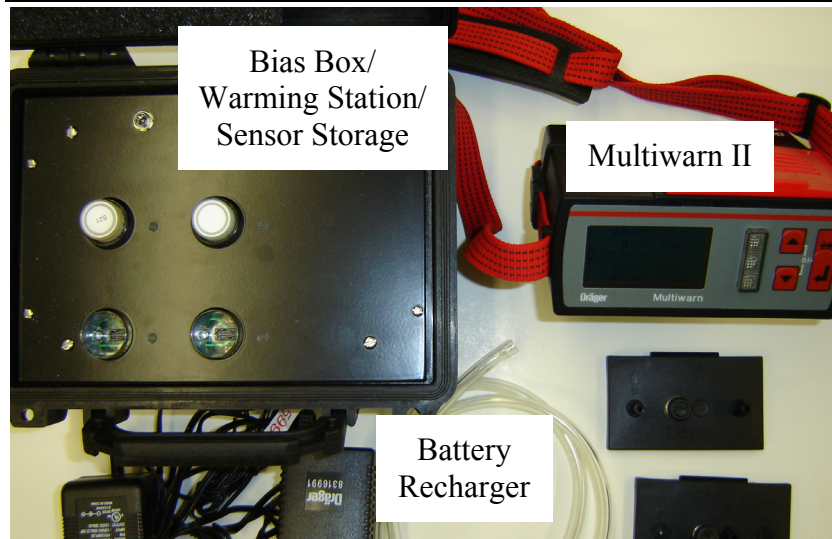
QUICK START GUIDE

Prior to Start-up:	1.	Install fully charged battery pack by inserting battery pack so that the contact pins of device fit into the sockets of the battery pack. Fasten socket in battery pack.
Leak Test Pump:	1.	<ul style="list-style-type: none"> -Switch pump on (#7 Fig. 1) and set the stroke preselection to “2” using the “+ or –” button. -Insert unopened tube gently into tube holder. (#9 Fig. 1) Push “START/STOP” key. (0 and 1 should alternately flash on counter) -Wait 15 minutes, making sure a second stroke does not commence. Pump is sufficiently gastight if a second stroke does not commence after 15 minutes. -Carefully remove tube from rubber sleeve and turn pump off.
Start-up:	1.	Choose tube in accordance with measurement task. Pay attention to relevant instructions for use!
	2.	Break off both tips of the tube in the break-off eyelet (#10 Fig. 1) or in the break-off husk.
	3.	Tightly insert the tube in the pump head with the arrow pointing towards the rubber sleeve. Use adapter for tubes in an upright position or when using the extension hose.
Operation:	1.	The Quantimeter 1000 pump is programmable for up to 1000 stroke operation.
	2.	Each specific tube operates with a specific number of strokes, please check the instructions included with tube.
	3.	Program the stroke count as per detector tube use instructions.
	4.	Turn on the pump by pressing the “START/STOP” key on top of the pump. The stroke counter will stop the pump when the requested number of counts are reached.
	5.	Color changes in tubes are used to determine the presence of an agent. Evaluate color length or color depth immediately afterwards. Refer to instructions included with tube.
	6.	Wash out pump with several strokes in a uncontaminated area.
	<p><i>Note: Information on cross sensitivity is important to detailed interpretation of the color change results. Information is provided in the specific test set instruction manual. Other harmful gases may be present even if a negative result is indicated.</i></p>	

Dräger Sensor Bias

GENERAL INFORMATION

Equipment Name:	Sensor Bias Box
Model:	2000
Manufacturer:	Dräger Safety, Inc.
National Manufacturer Contact:	Telephone: 800-615-5503 E-mail: prodinfo@draeger.net Website: http://www.draeger.com



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SPECIFICATIONS

Uses:	For the Dräger MultiWarn II and Dräger Pac-III detectors. Contains multiple sensors that can be exchanged with the MultiWarn and Pac-III in a short period of time. Those sensors include: (O ₂), percent methane (Vol% CH ₄), lower explosive limit (%LEL CH ₄), chlorine (ppm Cl ₂), ammonia (ppm NH ₄), hydrogen cyanide (ppm HCN), phosphine ppm (ppm PH ₃), odorant-mercaptane (ppm).
Limitations:	Sensors in the probe are delicate and easily damaged. Use gloves when replacing/ exchanging the sensors and do NOT touch the sensor filaments. Do NOT drop or allow to become wet. If oxygen concentrations exceed 23.5%, other sensors may read incorrectly (i.e. LEL and % CH ₄). Use extreme caution around oxygen-acetylene operations. Sensors may ignite oxygen enriched acetylene. Concentrations of hydrogen sulfide (H ₂ S) above 100 ppm may damage some of the sensors (CAT Ex). Cross-sensitivities may occur. No data logging capabilities. Temperatures of -5 - 120° F (-20 - 40 Celsius).
Response Range:	Oxygen 0-25%; Percent methane 0-100 %; Lower explosive limit 0-100%; Chlorine 0-10 ppm; Ammonia 0-200 ppm; Hydrogen cyanide 0-50 ppm; Phosphine 0-1,000 ppm (PH ₃); Odorant (Mercaptane) 0-40 ppm; Amine 0-100 ppm.
Product Safety:	Intrinsically safe in air-methane gas mixtures.
Battery:	One Ni-Cad T42, 4 Ah battery.
Calibration Gas:	Dräger brand or similar level calibration gas.

Dräger Sensor Bias

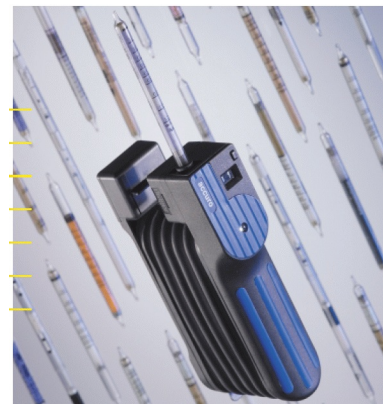
QUICK OPERATIONS GUIDE

Turn On:	1.	Insert power cord.
Fresh Air Calibration:	1.	Prior to initial use, sensors must be “warmed” in the monitoring unit or in the Bias Box.
Warming-Up Sensors and Sensor Exchange:	1.	Multiwarn sensors can be exchanged with the Pac III sensors. Sensors can be warmed-up in the Multiwarn instrument or in the Bias Box. Sensors will take up to 24 hours for initial warm-up, depending on the sensor. The batteries in the Bias Box needs to be initially charged for 48 hours. Bias box charge will last up to 300 hours.
	2.	Take care when placing sensors into the sockets of the Bias Box, they are fragile. When the sensors are originally placed into the Bias Box, the LED lights to the right of the sensor socket will flash twice every three seconds showing the sensor is warming-up. After exchange, sensors will take approximately two minutes to re-warm.
	3.	When the LED light flashes once every three seconds, the warming is complete. The sensor can now be placed into Multiwarn or Pac-III.
	4.	To exchange or replace the sensors in the Multiwarn monitoring unit, turn off the unit and unscrew the red sensor face plate. Unscrew the metal protective plate from the unit and remove carefully with the filter disk and rubber gasket. To replace the sensors in the Pac-III, unscrew the bottom two hex screws and separate the two halves of the sensor. Loosen the plastic center “key”, and gently remove the old sensor.
	5.	Use the short end of the allen wrench to hook under the sensor and gently pull upward to remove from the unit. Be careful to orient the new sensor properly into Multiwarn unit. Replace gasket, filter and red face plate on unit. For the Pac-III, retighten the plastic center “key”, connect the two halves of the sensor together, and tighten the two hex screws.
Turn Off:	1.	Press up and down arrow keys simultaneously for three seconds to turn off monitoring units. Unplug Bias Box to turn off.

Colorimetric Tubes

Dräger-Tubes® and Accuro® Pump EPA National Equipment List 02-07 Version 1 August 2005

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Note: Depending on the chemical to be screened, in certain cases such as suspected chemical warfare agents, a positive response is considered significant and would likely require follow-up action. In these cases evacuate the impacted area immediately.

Uses:

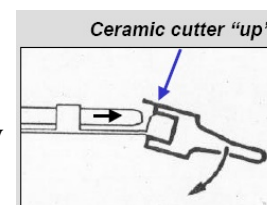
The Dräger-Tube® System is designed to provide a rapid identification of a chemical using specially designed and a calibrated detector tube sets. Dräger-Tubes® are glass vials filled with a chemical reagent that reacts to a specific chemical or family of chemicals. A calibrated 100 ml sample of air is drawn through the tube with the Dräger accuro® bellows pump. If the targeted chemical(s) is present, the reagent in the tube changes color and the length of the color change typically indicates the measured concentration.

Prior to Starting:

Each Dräger Kit contains specific information regarding the operational steps for that particular kit and the tubes for each specific chemical being monitored. You must read these instructions prior to starting.

Quick Start-up and Operation:

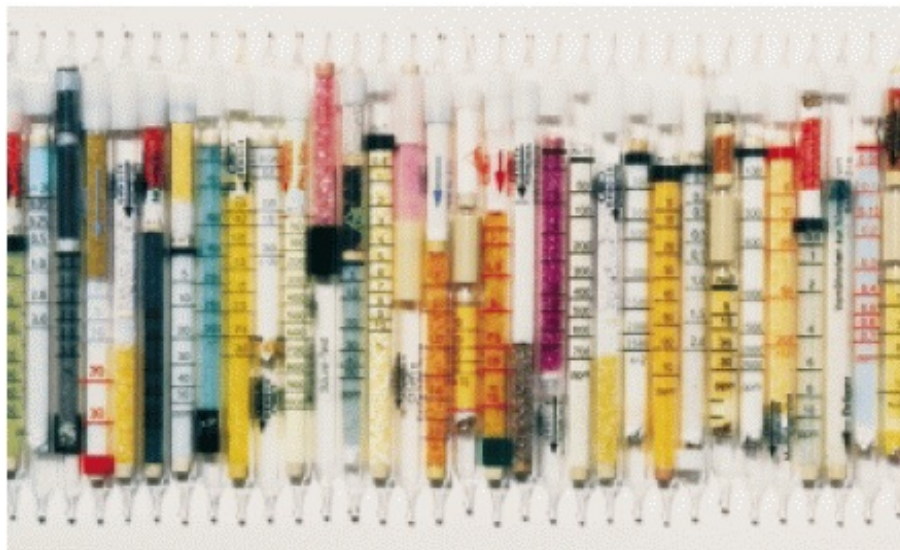
- Scrape the ceramic edge of the Simultest Set Opener multiple times to score the glass.
- Push opener completely over rubber block with ceramic cutter up and apply pressure down until all of the tips break off.
- Insert the tube set into the adapter (flow arrow pointing in) and then break the tips on the other side of the set.



- Connect the tube adapter to the pump.
- Grip the pump on the top and bottom. (As shown)
- Squeeze the pump until it will no longer compress.

Note: The stroke counter will advance when fully compressed. Insert pen tip on black button next to counter to zero.

- Allow the bellows to decompress by itself until the appearance of the white dot on top indicates the end of a stroke.
- Each specific tube operates with specific number of strokes, please check the instructions card.
- Color changes in tubes are used to determine the presence of an agent. (Refer to laminated instruction card for color change interpretations)



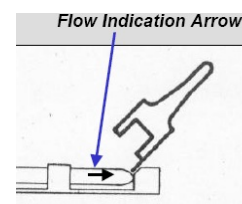
Note: Information on cross sensitivity is important to detailed interpretation of the color change results. Information is provided in the specific test set instruction manual. Other harmful gases may be present even if a negative result is indicated.

Additional Operation Information:

- Be sure to compress the pump the exact number of times as indicated by the tube directions, as the result is based on a specific volume of air.
- Approximately 2.5 minutes is needed to complete each test set.
- The Dräger Accuro® pump is the standard unit used for sampling with Dräger Tubes. It is calibrated to draw 100 cc of air through the Test Sets on each pump. Its design allows for easy one-hand operation.

Assembling the System

- After the detector tube is opened, insert opened Dräger tube into socket of pump with arrow pointing towards the pump socket. (See diagram)



Calibration

- No Calibration Necessary
- Tubes are pre-calibrated by the manufacturer.
- Pump calibrated to draw air in at 100 cc for each pump stroke



Principle of Operation:

There are two essential components of the Dräger- Tube® System, the detector tubes and the bellows pump. The specific kit includes detector tubes that are sensitive to specific agents. The tubes are connected to the pump via a socket. The pump is then compressed a set number of times to draw in a known volume of air. The pump simultaneously sucks in air and measures the volume of gas. The pump is built for simplicity and is pre-calibrated to pull in 100cc of air per stroke. As the bellows of the pump are compressed, the air in it escapes through the outlet valve, not through the detector tube, since the tube has a much higher resistance than the valve. Air flows through the detector tubes into the bellows while the pump returns to its original volume. As ambient air is drawn through the tube, it reacts with the substance packed inside the tube. The reaction between the agent and detector substance results in a color change. The color change is then carefully analyzed to determine if a specific chemical is present.

Applications:

To determine if specific chemical agents are present in the air.
Dräger- Tube® System kits allows for detection of hundreds of different chemical agents.

Limitations:

- Does not work with aerosols.
- Tube shelf life limited and specific to individual tubes.
- A negative response with the tube does not mean there are no other harmful chemicals present.
- Limited to the chemicals that the detector tubes are specific to. See manufacturer's technical specifications in each case of tubes (interferences, quantification, etc.).

Routine Maintenance:

Check the pump for leaks prior to use:

- Insert unopened Dräger tube into socket of pump
- Squeeze pump completely and release
- Pump is adequately leak-proof if the end stroke indicator has not appeared after 15 minutes
- Remove tube from socket
- Reset counter to zero
- Periodically clean the exhaust valve of the pump

- Clean metal screen located at pump head
- Flush pump with fresh air after each use to clear any remaining vapors from bellows

Health Effects:

Depending on the nature of screened chemical agents, any exposure is considered a health threat.

Action Levels:

Depending on the chemical to be screened, in certain cases such as chemical warfare agents, a positive response is considered significant and would likely require follow-up action. In these cases evacuate the impacted area immediately.

Battery Information:

No battery is required to operate the kit.

Main Inventory Items/Accessories:

Description	Quantity
CDS Set Opener	2
Tube Opener	1
Laminated Matrix/Re-order Card	1
Laminated Instruction Card	1
Indelible Marker	1
Carrying Case	1

Replacement of Auxiliary Equipment/Supplies:

Replacement detector tubes can be obtained from the manufacturer, or other distributing companies that carry Dräger products. Use only authentic Dräger parts for repair or replacement.

Shipping Information:

Precautions are to be made as not to break the detector tubes when shipping.

Contact Information (Technical Support):

<http://www.draeger.com>

Dräger Safety Inc
101 Technology Drive
Pittsburgh, Pa 15275
Phone: 412-787-8383

Description	Measuring Range
Acetaldehyde 100/a	100-1,000 ppm
Acetic Acid 5/a	5-80 ppm
Acetone 100/b	100-12,000 ppm
Acid Test	Qualitative
Acrylonitrile 0.5/a (5)	0.5-20 ppm
Air Current Tube Kit	
Air Current Tubes	
Alcohol 25/a	50-4,000 ppm Isopropanol 25-5,000 ppm Methanol
Alcohol 100/a	100-3,000 ppm
Amine Test	Qualitative
Ammonia 0.25/a	0.25-3 ppm
Ammonia 2/a	2-30 ppm
Ammonia 5/b	2.5-100 ppm
Ammonia 5/a	5-700 ppm
Ammonia 0.5%/a	0.05-10 Vol.%
Aniline 0.5/a	0.5-10 ppm
Aniline 5/a	1-20 ppm
Arsenic Trioxide 0.2/a	0.2 mg/m ³
Arsine 0.05/a	0.05-60 ppm
Benzene 0.5/a	0.5-10 ppm
Benzene 0.5/c (5) specific	0.5-10 ppm
Benzene 2/a (5)	2-60 ppm
Benzene 5/b	5-50 ppm
Benzene 15/a	15-420 ppm
Carbon Dioxide 100/a	100-3,000 ppm
Carbon Dioxide 0.1%/a	0.1-6 Vol.%
Carbon Dioxide 0.5%/a	0.5-10 Vol.%
Carbon Dioxide 1%/a	1-20 Vol.%
Carbon Dioxide 5%/A	5-60 Vol.%
Carbon Disulfide 3/a	3-95 ppm
Carbon Disulfide 30/a	32-3,200 ppm
Carbon Monoxide 2/a	2-300 ppm
Carbon Monoxide 5/c	5-700 ppm
Carbon Monoxide 8/a (only for CO in H ₂)	8-150 ppm
Carbon Monoxide 10/b	10-3,000 ppm
Carbon Monoxide 0.3%/b	0.3-7 Vol.%
Carbon Monoxide 200/a +	200-2,500 ppm CO
Carbon Dioxide 2%/a	2-12 Vol. % CO ₂
Carbon Pretubes	
Carbon Tetrachloride 0.2/b	0.2-70 ppm
Carbon Tetrachloride 1/a (5)	1-15 ppm
Carbon Tetrachloride 5/c	5-50 ppm
Chlorine 0.2/a	0.2-30 ppm

Description	Measuring Range
Chlorine 0.3/b	0.3-10 ppm
Chlorine 50/a	50-500 ppm
Chlorobenzene 5/a (5)	5-200 ppm
Chloroform 2/a (5)	2-10 ppm
Chloroformates 0.2/b	0.2-10 ppm
Chloroprene 5/a	5-60 ppm
Chromic Acid 0.1/a (9)	0.1-0.5 mg/m ³
Cyanide 2/a	2-15 mg/m ³
Cyanogen Chloride 0.25/a	0.25-5 ppm
Cyclohexane 100/a	100-1,500 ppm
Cyclohexylamine 2/a	2-30 ppm
Diethyl Ether 100/a	100-4,000 ppm
Dimethyl Formamide 10/b	10-40 ppm
Dimethyl Sulfate 0.005/c (9)	0.005-0.05 ppm
Dimethyl Sulfide 1/a (5)	1-15 ppm
Epichlorohydrin 5/b	5-50 ppm
Ethyl Acetate 200/a	200-3,000 ppm
Ethyl Benzene 30/a	30-600 ppm
Ethylene 0.1/a (5)	0.2-5 ppm
Ethylene 50/a	50-2,500 ppm
Ethylene Glycol 10 (5)	10-180 mg/m ³
Ethylene Oxide 1/a (5)	1-15 ppm
Ethylene Oxide 25/a	25-500 ppm
Ethyl Glycol Acetate 50/a	50-700 ppm
Fluorine 0.1/a	0.1-2 ppm
Formaldehyde 0.2/a	0.2-5 ppm
Formaldehyde Activation tube (for use only in conjunction with 0.2/a tube)	extend to 0.04 ppm
Formaldehyde 2/a	2-40 ppm
Formic Acid 1/a	1-15 ppm
Halogenated Hydrocarbons 100/a	100-2,800 ppm
Hexane 100/a	50-3,000 ppm
Hydrazine 0.2/a	0.2-10 ppm
Hydrazine 0.25/a	0.1-10 ppm
Hydrocarbons 0.1%/b	0.1-1.3 Vol. %
Hydrocarbons 2	3-23 mg/l
Hydrochloric Acid 1/a	1-10 ppm
Hydrochloric Acid 50/a	50-5,000 ppm
Hydrochloric Acid/Nitric Acid 1/a	1-10 ppm (HCL) 1-15 ppm (HNO ₃)
Hydrocyanic Acid 2/a	2-150 ppm
Hydrogen 0.2%/a	0.2-2 Vol. %
Hydrogen Fluoride 0.5/a	0.5-90 ppm
Hydrogen Peroxide 0.1/a	0.1-3 ppm

Description	Measuring Range
Hydrogen Sulfide 0.2/a	0.2-5 ppm
Hydrogen Sulfide 0.2/b	0.2-6 ppm
Hydrogen Sulfide 0.5/a	0.5-15 ppm
Hydrogen Sulfide 1/d	1-200 ppm
Hydrogen Sulfide 2/a	2-200 ppm
Hydrogen Sulfide 2/b	1-60 ppm
Hydrogen Sulfide 5/b	5-600 ppm
Hydrogen Sulfide 100/a	100-2,000 ppm
Hydrogen Sulfide 0.2%/A	0.2-7 Vol.%
Hydrogen Sulfide 2%/a	2-40 Vol.%
Hydrogen Sulfide + Sulfur Dioxide 0.2%/A	0.02-7 Vol.%
Mercaptan 0.1/a	0.1-2.5 ppm
Mercaptan 0.5/a	0.5-5 ppm
Mercaptan 20/a	20-100 ppm
Mercury Vapor 0.1/b	0.05-2 mg/m3
Methyl Acrylate 5/a	5-200 ppm
Methyl Bromide 0.5/a	0.5-30 ppm
Methyl Bromide 3/a	3-100 ppm
Methyl Bromide 5/b	5-50 ppm
Methylene Chloride 100/a	100-2,000 ppm
Natural Gas Test (Methane)(5)	Qualitative
Nickel Tetracarbonyl 0.1/a (9)	0.1-1 ppm
Nitric Acid 1/a	1-50 ppm
Nitrogen Dioxide 0.5/c	0.5-25 ppm
Nitrogen Dioxide 2/c	2-100 ppm
Nitroglycol 0.25/a	0.25 ppm
Nitrous Fumes 0.5/a	0.5-10 ppm
Nitrous Fumes 2/a	2-100 ppm
Nitrous Fumes 20/a	20-500 ppm
Nitrous Fumes 50/a	50-2,000 ppm
Nitrous Fumes 100/c	100-5,000 ppm
Oil Mist 1/a	1-10 mg/m3
Olefins 0.05%/a	0.06-3.2 Vol.% Propylene 0.04-2.4 Vol.% Butylene
Organic Arsenic Compounds and Arsine	3 mg org. arsenic/m3
Organic Basic Nitrogen Compounds	1 mg/m3
Oxygen 5%/C	5-23 Vol.%
Ozone 0.05/b	0.05-1.4 ppm
Ozone 10/a	10-300 ppm
Pentane 100/a	100-1,500 ppm
Perchloroethylene 0.1/a	0.1-4 ppm
Perchloroethylene 2/a	2-300 ppm

Description	Measuring Range
Perchloroethylene 10/b	10-500 ppm
Perchloroethylene 50/A	50-10,000 ppm
Petroleum Hydrocarbons 10/a	10-300 ppm (n-Octane)
Petroleum Hydrocarbons 100/a	100-2,500 ppm (n-Octane)
Phenol 1/b	1-20 ppm
Phosgene 0.02/a	0.02-1 ppm
Phosgene 0.25/c	0.25-15 ppm
Phosphine 0.01/a	0.01-1 ppm
Phosphine 0.1/a	0.1-4 ppm
Phosphine 1/a	1-100 ppm
Phosphine 25/a	25-10,000 ppm
Phosphine 50/a	15-1,000 ppm
Phosphoric Acid Esters 0.05/a (Dimethyldichlorovinylphosphate)	0.05 ppm
Polytest	Qualitative
Pyridine 5/A	5 ppm
Styrene 10/a	10-200 ppm
Styrene 10/b	10-250 ppm
Styrene 50/a	50-400 ppm
Sulfur Dioxide 0.1/a	0.1-3 ppm
Sulfur Dioxide 0.5/a	0.5-25 ppm
Sulfur Dioxide 1/a	1-25 ppm
Sulfur Dioxide 20/a	20-2,000 ppm
Sulfur Dioxide 50/b	50-8,000 ppm
Sulfuric Acid 1/a (9)	1-5 mg/m3
Tetrahydrothiophene 1/b (5)	1-10 ppm
Thioether	1 mg/m3
Toluene 5/b	5-300 ppm
Toluene 50a	50-400 ppm
Toluene 100/a	100-1,800 ppm
Toluene Diisocyanate 0.02/A (9)	0.02-0.2 ppm
o-Toluidine 1/a	1-30 ppm
Trichloroethane 50/d (5)	50-600 ppm
Trichloroethylene 2/a	2-250 ppm
Trichloroethylene 10/a	50-2,000 ppm
Triethylamine 5/a	5-60 ppm
Vinyl Chloride 0.5/b	0.5-30 ppm
Vinyl Chloride 1/a	1-50 ppm
Vinyl Chloride 100/a	100-3,000 ppm
Water Vapor 0.1/a	0.05-1 mg/L
Water Vapor 1/a	0.5-18 mg/L
Water Vapor 1/b	1-40 mg/L
Water Vapor 3/a	3-60 lbs/mmcf
Water Vapor 50/a	50-1,000 lbs/mmcf
Xylene 10/a	10-400 ppm

Landfill Fire Response

*Analytical Methods - Air, Soil & Water

Contaminant	Analytical Method	Matrix	Sampling Media	Holding Time
Acid Gases	NIOSH 7903	Air	SKC 226-10-03, 226-177, Sorbent Tubes	14 days
Methane	DET TB	Air	Colormetric Tube 800-20001	NA
Carbon Monoxide	ID 209	Air	Direct Reading Instrument w/datalogger	NA
Cyanides	NIOSH 7904	Air	SKC filter 225-2705 (1 um Teflon filter)	5 days
Toluene	NIOSH 2549	Air	SKC Pump/GAST ST 226-01, Summa Cannister	Consult Laboratory
PAHs*	EPA Method 8270C / 8310	Soil	8 oz glass jar	14 days
PAHs*	EPA Method 8270C	Water/Liquid	1L Amber glass jar	14 days
PAHs*	NIOSH 5506 EPA TO-13A	Air	SKC Filter PUF Hi Vol QMA #1851101, Sorbent Tube 226-30-04	Analyze sample ASAP
Total Metals	EPA Method 6010B/7471A (mercury)	Soil	8 oz glass jar	6 months (except mercury 28 days)
Total Metals	EPA Method 6010B/7470A (mercury)	Water/Liquid	500 mL poly preserved with HNO3	6 months (except mercury 28 days)
Total Metals	NIOSH 7300 NIOSH 0600	Air	Cellulose Filter 0.8 ug pores, or PVC Filter 5.0 ug pores SKC Pump 225-3-01	Consult Laboratory
pH	EPA Method 9040/9045	Soil/Sludge	8 oz glass jar	Analyze sample ASAP
pH	EPA Method 9040/9045	Water/Liquid	250 mL poly	24 hour
VOCs	EPA Method 8260	Soil	Encore	48 hours
VOCs	EPA Method 8260	Water/Liquid	40 ml VOA	14 days w/ preservative
VOCs	NIOSH 1501 OSHA 07	Air	SKC Pump/GAST ST 226-01, Summa Cannister	NIOSH 1501 = 30 days; OSHA 07 Contact Lab
Coal Tar Pitch Volatiles	NIOSH 5023 or TO-15	Air	Filter	Consult Laboratory
PCBs	EPA 8082 -8081	Soil		14 days
PCBs	EPA 8081	Water/Liquid		7 days

Landfill Fire Response

*Analytical Methods - Air, Soil & Water

Contaminant	Analytical Method	Matrix	Sampling Media	Holding Time
PCBs	EPA TO-9A, TO-10A ASTM-D-4861 NIOSH 5503	Air	PUF Hi Vol FP 226-131, SKC Pump 226-92, SKC Filter 225-16, SKC Filter Cassette 225-32, Florisil Sorbent Tube SKC 226-39	7 days
Particulates - Dust	NIOSH 0600	Air	Mini Vol FP 1823047, SKC Pump 225-8-01	Consult Laboratory
PCDDs, PCDFs (Dioxins & Furans)	EPA TO-9A	Air	SKC Pump ST 226-131, PUF Hi VOL FP QMA 1851101	Consult Laboratory

Notes:

*Analytical Methods compiled according to ERTG Air Sampling Decision Tree
SKC = SKC, Inc. See catalog and sampling guide included in Response Guide

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SUPERCEDES: SOP #2008; Revision 1.0; 01/03/94; U.S. EPA Contract 68-03-3482.



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1.0 SCOPE AND APPLICATION

This Standard Operating Procedure (SOP) provides guidance in developing and implementing sampling plans to assess the impact of hazardous waste sites on ambient air. It presents the United States Environmental Protection Agency/Environmental Response Team's (U.S. EPA/ERT's) approach to air sampling and monitoring and identifies equipment requirements. It is not within the scope of this SOP to provide a generic air sampling plan. Experience, objectives, site characteristics, and chemical characteristics will dictate sampling strategy. This SOP does not address indoor air sampling.

Two basic approaches can be used to assess ambient air (also referred to as air pathway assessments): modeling and measurements. The modeling approach initially estimates or measures the overall site emission rate(s) and pattern(s). These data are input into an appropriate air dispersion model, which predicts either the maximum or average air concentrations at selected locations or distances during the time period of concern. This overall modeling strategy is presented in the first three volumes of the Air Superfund National Technical Guidance Series on Air Pathway Assessments^(1,2,3). Specific applications of this strategy are presented in several additional Air Superfund Technical Guidance documents⁽⁴⁾.

The measurement approach involves actually measuring the air impact at selected locations during specific time periods. These measurements can be used to document actual air impacts during specific time intervals (i.e., during cleanup operations) or to extrapolate the probable "worst case" concentrations at that and similar locations over a longer time period than was sampled.

This SOP addresses issues associated with this second assessment strategy. This SOP also discusses the U.S. EPA/ERT's monitoring instruments, air sampling kits, and approach to air sampling and monitoring at hazardous waste sites.

These are standard (i.e., typically applicable) operating procedures which may be varied or changed as required, depending on site conditions, equipment limitations, or limitations imposed by the procedure. In all instances, the ultimate procedures employed should be documented and associated with the final report.

Mention of trade names or commercial products does not constitute U.S. EPA endorsement or recommendation for use.

2.0 METHOD SUMMARY

Air monitoring is defined as the use of direct-reading instruments and other screening or monitoring equipment and techniques that provide instantaneous (real-time) data on the levels of airborne contaminants. The U.S. EPA/ERT maintains numerous monitors for real-time measurements. Examples of air monitoring equipment are hand-held photoionization detectors (PID), flame ionization detectors (FID), oxygen/combustible gas detectors, and remote optical sensors.



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Air sampling is defined as those sampling and analytical techniques that require either off- or on-site laboratory analysis and therefore do not provide immediate results. Typically, air sampling occurs after use of real-time air monitoring equipment has narrowed the number of possible contaminants and has provided some qualitative measurement of contaminant concentration. Air sampling techniques are used to more accurately detect, identify and quantify specific chemical compounds relative to the majority of air monitoring technologies.

In the Superfund Removal Program, On-Scene Coordinators (OSCs) may request the U.S. EPA/ERT to conduct air monitoring and sampling during the following situations: emergency responses, site assessments, and removal activities. Each of these activities has a related air monitoring/sampling objective that is used to determine the potential hazards to workers and/or the community.

- Emergency Response

Emergency responses are immediate responses to a release or threatened release of hazardous substances presenting an imminent danger to public health, welfare, or the environment (i.e., chemical spills, fires, or chemical process failures resulting in a controlled release of hazardous substances). Generally these situations require rapid on-site investigation and response. A major part of this investigation consists of assessing the air impact of these releases.

- Removal Site Assessment

Removal site assessments (referred to as site assessments) are defined as any of several activities undertaken to determine the extent of contamination at a site and which help to formulate the appropriate response to a release or threatened release of hazardous substances. These activities may include a site inspection, multimedia sampling, and other data collection.

- Removal Actions

Removal actions clean up or remove hazardous substances released into the environment. Removal actions include any activity conducted to abate, prevent, minimize, stabilize, or eliminate a threat to public health or welfare, or to the environment.

Personal risk from airborne contaminants can be determined by comparing the results of on-site monitoring and sampling to health-based action levels such as the American Conference of Governmental Industrial Hygienists (ACGIH) Threshold Limit Values (TLVs) and the Occupational Safety and Health Administration (OSHA) Permissible Exposure Limits (PELs). Residential risk can be determined by comparing the results of off-site monitoring or sampling to health-based action levels such as those developed by the Agency for Toxic Substance and Disease Registry (ATSDR).

The extent to which valid inferences can be drawn from air monitoring/sampling depends on the degree to which the monitoring/sampling effort conforms to the objectives of the event. Meeting the project's objectives requires thorough planning of the monitoring/sampling activities, and implementation of the most appropriate monitoring/sampling and analytical procedures. These issues will be discussed in this SOP.



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3.0 SAMPLE PRESERVATION, CONTAINERS, HANDLING, AND STORAGE

Preservation, containers, handling and storage for air samples are discussed in the specific SOPs for the technique selected. In addition, the analytical method (i.e., U.S. EPA, National Institute for Occupational Safety and Health [NIOSH], and OSHA Methods) may be consulted for storage temperature, holding times and packaging requirements. After sample collection, the sampling media (i.e., cassettes or tubes) are immediately sealed. The samples are then placed into suitable containers (i.e., whirl bags, resealable bags or culture tubes) which are then placed into a shipping container.

Use bubble wrap or styrofoam peanuts when packing air samples for shipment. **DO NOT USE VERMICULITE.**

4.0 INTERFERENCES AND POTENTIAL PROBLEMS

Upwind sources can contribute to sample concentration. Natural sources, such as biological waste, can produce hydrogen sulfide and methane which may contribute to the overall contaminant level. Extraneous anthropogenic contaminants (i.e., burning of fossil fuels; emissions from vehicular traffic, especially diesel; and volatile compounds).

from petrochemical facilities; effluvia from smoke stacks) may also contribute. Air sampling stations should be strategically placed to identify contributing sources.

Photoreactivity or reaction of the parameters of concern may occur with nonrelated compounds [i.e., nitrogen compounds and polyaromatic hydrocarbons (PAHs)]. Some sorbent media/samples should not be exposed to light during or after sampling due to photochemical effects (i.e., PAHs).

Various environmental factors, including humidity, temperature and pressure, also impact the air sampling methodology, collection efficiency and detection limit. Since the determination of air contaminants is specifically dependent on the collection parameters and efficiencies, the collection procedure is an integral part of the analytical method.

Detection limits depend on the contaminants being investigated and the particular site situation. It is important to know why the data are needed and how the data will be used. Care should be taken to ensure the detection limits are adequate for the intended use of the final results.

Some equipment may be sensitive to humidity and temperature extremes.



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5.0 EQUIPMENT/APPARATUS

5.1 Direct Reading Instruments (Air Monitoring Instruments)

There are two general types of direct reading instruments: portable screening devices and specialized analytical instruments. Generally all these techniques involve acquiring, for a specific location or area, continuous or sequential direct air concentrations in either a real-time or semi-real-time mode. None of these instruments acquires true time-weighted average concentrations. In addition, these instruments are not capable of acquiring simultaneous concentration readings at multiple locations, although several are able to sequentially analyze samples taken remotely from different locations. The document, "Guide to Portable Instruments for Assessing Airborne Pollutants Arising from Hazardous Waste Sites⁽⁵⁾," provides additional information about air sampling and monitoring. The hazard levels for airborne contaminants vary. See the ACGIH TLVs and the OSHA PELs for safe working levels. Common screening devices and analytical instruments are described in Appendix A.

5.2 Air Sampling Equipment and Media/Devices

The U.S. EPA/ERT uses the following analytical methods for sampling: *NIOSH Manual of Analytical Methods*⁽⁶⁾, *American Society for Testing and Materials (ASTM) Methods*⁽⁷⁾, *U.S. EPA Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air*^(8,9), and *OSHA Methods*⁽¹⁰⁾.

Additional air sampling references include *Industrial Hygiene and Toxicology* (3rd Ed.)⁽¹¹⁾ and *Air Sampling Instruments for Evaluation of Atmospheric Contaminants*⁽¹²⁾. These methods typically specify equipment requirements for sampling. Since air sampling is such a diverse technology, no single method or reference is best for all applications. Common sampling equipment and media/devices are described in Appendix B.

5.3 Tools/Material and Equipment List

In addition to equipment and materials identified in Appendices A and B, the following equipment and materials may be required to conduct air sampling and monitoring at hazardous waste sites:

- Camera
- Site logbook
- Clipboard
- Chain of custody records
- Custody seals
- Air sampling worksheets
- Sample labels
- Small screwdriver set
- Aluminum foil



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- Extension cords
- Glass cracker
- Multiple plug outlet
- Whirl bags or culture tubes
- Teflon tape
- Calibration devices
- Tygon and/or Teflon® tubing
- Surgical gloves
- Lint-free gloves
- Ice
- Sample container

Use the following additional equipment when decontaminating glassware on site:

- Protective equipment (i.e., gloves, splash goggles, etc.)
- Appropriate solvent(s)
- Spray bottles
- Liquinox (soap)
- Paper towels
- Distilled/deionized water
- Five-gallon buckets
- Scrub brushes and bottle brushes

6.0 REAGENTS

Impinger sampling involves using reagents contained in a glass vial to absorb contaminants of concern (for example, NIOSH Method 3500 for formaldehyde uses 1% sodium bisulfite solution). Impinger solutions vary and are method-dependent.

Reagents such as acetone and hexane are required to decontaminate glassware and some air sampling equipment. Decontamination solutions are specified in ERT/REAC SOP #2006, Sampling Equipment Decontamination.

7.0 PROCEDURES

7.1 Air Monitoring Design

7.1.1 Initial Surveys

In general, the initial survey is considered to be a relatively rapid screening process for collecting preliminary data at hazardous waste sites. However, initial surveys may require many hours to complete and may consist of more than one entry.



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Some information is generally known about the site; therefore, real-time instrumentation for specific compounds (i.e., detector tubes and electrochemical sensors) can be used to identify hot spots. Sufficient data should be obtained with real-time instruments during the initial entry to screen the site for various contaminants. When warranted, intrinsically safe or explosion-proof instruments should be used. An organic vapor analyzer (OVA) is typically used during this survey. These gross measurements may be used on a preliminary basis to (1) determine levels of personal protection, (2) establish site work zones, and (3) map candidate areas for more thorough qualitative and quantitative studies involving air sampling.

In some situations, the information obtained may be sufficient to preclude additional monitoring. Materials detected during the initial survey may call for a more comprehensive evaluation of hazards and analyses for specific compounds. Since site activities and weather conditions change, a continuous program to monitor the ambient atmosphere must be established.

7.1.2 Off-Site Monitoring

Typically, perimeter monitoring with the same instruments employed for on-site monitoring is utilized to determine site boundaries. Because air is a dynamic matrix, physical boundaries like property lines and fences do not necessarily delineate the site boundary or area influenced by a release. Whenever possible, atmospheric hazards in the areas adjacent to the on-site zone should be monitored with direct-reading instruments. Monitoring at the fenceline or at varying locations off site provides useful information regarding pollutant migration. Three to four locations downwind of the source (i.e., plume) at breathing-zone height, provide a basic fingerprint of the plume. Negative instrument readings off site should not be interpreted as the complete absence of airborne toxic substances; rather, they should be considered another piece of information to assist in the preliminary evaluation. The interpretation of negative readings is instrument-dependent. The lack of instrument readings off site should not be interpreted as the complete absence of all airborne toxic substances; rather, it is possible that the particular compound or class of compounds to which the monitoring instrument responds is not present or that the concentration of the compound(s) is below the instrument's detection limit.

7.2 Air Sampling Design

7.2.1 Sampling Plan Design

The goal of air sampling is to accurately assess the impact of a contaminant source(s) on ambient air quality. This impact is expressed in terms of overall average and/or maximum air concentrations for the time period of concern and may be affected by the transport and release of pollutants from both on- and off-site sources. The location of these sources must be taken into account as they impact the selection of sampling locations. Unlike soil and



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groundwater concentrations, air concentrations at points of interest can easily vary by orders of magnitude over the period of concern. This variability plays a major role in designing an air sampling plan.

Downwind air concentration is determined by the amount of material being released from the site into the air (the emission rate) and by the degree that the contamination is diluted as it is transported. Local meteorology and topography govern downwind dilution. Contaminant emission rates can also be heavily influenced by on-site meteorology and on-site activities. All of these concerns must be incorporated into an air sampling plan.

A sampling strategy can be simple or complex, depending on the sampling program objectives. Programs involving characterization of the pollutant contribution from a single point source tend to be simple, whereas sampling programs investigating fate and transport characteristics of components from diverse sources require a more complex sampling strategy. In addition, resource constraints may affect the complexity of the sampling design.

An optimal sampling strategy accounts for the following site parameters:

- Location of stationary as well as mobile sources
- Analytes of concern
- Analytical detection limit to be achieved
- Rate of release and transport of pollutants from sources
- Availability of space and utilities for operating sampling equipment
- Meteorological monitoring data
- Meteorological conditions in which sampling is to be conducted

The sampling strategy typically requires that the concentration of contaminants at the source or area of concern as well as background contributions be quantified. It is important to establish background levels of contaminants in order to develop a reference point from which to evaluate the source data. Field blanks and lot blanks, as well as various other types of QA/QC samples, can be utilized to determine other sources. The impact of extraneous sources on sampling results can frequently be accounted for by placing samplers upwind, downwind and crosswind from the subject source. The analytical data from these different sampling locations may be compared to determine statistical differences.

7.2.2 Sampling Objectives

The objectives of the sampling must be determined prior to developing the sampling plan. Does the sampling plan verify adequate levels of protection for on-site personnel, or address potential off-site impacts associated with the site or with site activities? In addition, the assumptions associated with the sampling program must be defined. These assumptions include whether the sampling is to take place under "typical," "worst case," or "one-time" conditions. If the conditions present at the time of sampling are different from those



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assumed during the development of the sampling plan, then quality of the data collected may be affected. The following definitions have been established:

- Typical: routine daily sampling or routine scheduled sampling at pre-established locations.
- Worst case: sampling conducted under the worst meteorological and/or site conditions which would result in elevated ambient concentrations.
- One-time: only one chance is given to collect a sample without regard to time or conditions. Qualitative data acquired under these conditions are usually applicable only to the time period during which the data were collected and may not provide accurate information to be used in estimating the magnitude of an air impact during other periods or over a long time interval.

The sampling objectives also dictate the detection limits. Sampling methods for airborne contaminants will depend upon the nature and state (solid, liquid or gas) of the contaminant. Gases and vapors may be collected in aqueous media or adsorbents, in molecular sieves, or in suitable containers. Particulates are collected by filters or impactors. The volume of sample to be collected is dependent upon an estimate of the contaminant concentration in the air, the sensitivity of the analytical method, and the standard or desired detection limit. A sufficient amount of sample must be collected to achieve the desired detection limit without interference from other contaminants. In addition, the selected method must be able to detect the target compound(s).

7.2.3 Location and Number of Individual Sampling Points

Choose the number and location of sampling points according to the variability, or sensitivity, of the sampling and analytical methods being utilized, the variability of contaminant concentration over time at the site, the level of precision required and cost limitations. In addition, determine the number of locations and placement of samplers by considering the nature of the response, local terrain, meteorological conditions, location of the site (with respect to other conflicting background sources), size of the site, and the number, size, and relative proximity of separate on-site emission sources and upwind sources. The following are several considerations for sampler placement:

- Location of potential on-site emission sources, as identified from the review of site background information or from preliminary on-site inspections.
- Location of potential off-site emission sources upwind of the sampling location(s). Review local wind patterns to determine the location of off-site sources relative to wind direction.



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- Topographic features that affect the dispersion and transport of airborne toxic constituents. Avoid natural obstructions when choosing air sampling station locations, and account for channelization around those obstructions.
- Large water bodies, which affect atmospheric stability and the dispersion of air contaminants.
- Roadways (dirt or paved), which may generate dust that could mask site contaminants.
- Vegetation, such as trees and shrubs, which stabilizes soil and retards subsurface contaminants from becoming airborne. It also affects air flow and scrubs some contaminants from the air. Sometimes thick vegetation can make an otherwise ideal air monitoring location inaccessible.

Consider the duration of sampling activities when choosing the location and number of samples to be collected. For example, if the sampling period is limited to a few hours, one or two upwind and several downwind samples would typically be adequate, especially around major emission sources.

A short-term monitoring program ranges from several days to a few weeks and generally includes gathering data for site assessments, removal actions, and source determination data (for further modeling). Activities involved in a short-term sampling strategy must make the most of the limited possibilities for data collection. Consider moving upwind/downwind locations daily based on National Oceanic and Atmospheric Administration (NOAA) weather forecasts. Weather monitoring becomes critical where complex terrain and local meteorological effects frequently change wind direction. Often, a number of alternatives can fulfill the same objective.

Prevailing winds running the length of a valley usually require a minimum number of sampler locations; however, a complex valley may require more sampler locations to account for the wide variety of winds. Ocean/lake effects may require a radical plan to collect enough samples to reach a low detection limit. Two sets of samplers may be placed next to each other: one set would be activated during the sea breeze while the other set is turned off, and vice versa when there is no sea breeze. After the sampling event, the respective upwind and downwind samples would be combined. Another alternative for sampling near a large body of water may be to use automatic, wind-vector-operated samplers, which turn the sampler on only when the wind comes from a specified vector. At sites located on hillsides, wind will move down a valley and produce an upward fetch at the same time. Sampling locations may have to ring the site to measure the wind's impact.

Off-site sources may affect on-site monitoring. In this case, on-site meteorological data, concurrent with sampling data, is essential to interpreting the acquired data. Also, additional



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upwind sampling sites may be needed to fully characterize ambient background contaminant levels. Multiple off-site sources may require several monitoring locations, but if the sources are at a sufficient distance, only one monitoring location is needed.

Topography and weather are not the only factors in sampler location; the sampling sites must be secure from vandals and mishap. Secure all sampling locations to maintain chain of custody, and to prevent tampering with samples or loss of sampling units. High-volume sampling methods often require the use of 110 VAC electric power. When portable generators are used, the power quality may affect sampler operation. Also, be aware that the generators themselves could be a potential pollution source if their placement is not carefully considered.

Air quality dispersion models can be used to place samplers. The models incorporate source information, surrounding topography, and meteorological data to predict the general distance and directions of maximum ambient concentrations. Modeling results should be used to select sampling locations in areas of maximum pollutant concentrations.

7.2.4 Time, Duration and Frequency of Sampling Events

After choosing appropriate sampling or monitoring locations, determine the sampling frequency and the number of samples to be collected. The time of day, duration and frequency of sampling events is governed by:

- The effects of site activities and meteorology on emission rates
- The diurnal effect of the meteorology on downwind dispersion
- The time period(s) of concern as defined by the objective
- The variability in the impact from other non-site-related sources
- If defined, the degree of confidence needed for either the mean or maximum downwind concentrations observed
- The precision requirements for single measurements
- Cost and other logistical considerations

The duration of the removal action and the number of hours per day that site work is conducted determine the time, duration, and frequency of samples. Short-term sampling programs may require daily sampling, while long-term programs may require 24-hour sampling every sixth or twelfth day. If the site will be undergoing removal activities 24 hours a day, continuous air sampling may be warranted. However, if the site activities will be conducted for only eight hours a day, and there are no emissions likely to occur during the remaining 16 hours, then sampling would be appropriate prior to the start of daily activities, would continue during operations, and end at the conclusion of the daily activities. An off-peak sample collection can ensure that emissions are not persisting after the conclusion of daily cleanup activities. For some sites, emissions are still a factor several hours after daily site activities have been completed. Because of the typically decreased



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downwind dispersion in the evening, higher downwind concentrations than were present during daytime site activities may be detected. For sites where this is possible, the sampling duration needs to be lengthened accordingly.

Sampling duration and flow rate dictate the volume of air collected, and to a major degree, the detection limit. The analytical method selected will provide a reference to flow rate and volume. Flow rates are limited to the capacity of the pumps being employed and the contact time required by the collection media.

The duration or period of air sampling is commonly divided into two categories (1) samples collected over a brief time period are referred to as "instantaneous" or "grab" samples and are usually collected in less than five minutes and (2) average or integrated samples are collected over a significantly longer period of time. Integrated samples provide an average concentration over the entire sampling period. Integrated samples are not suited to determining cyclical releases of contaminants because periodic or cyclical events are averaged out by the proportionally long sampling duration.

Air quality dispersion models can predict the maximum air contaminant concentration expected from a source. The meteorological and site conditions expected to cause the highest concentration are known as worst-case conditions and can be identified by analyzing the modeling results. Depending upon the objective, one may sample when the model predicts worst-case conditions will exist.

7.2.5 Meteorological and Physical/Chemical Considerations

A meteorological monitoring program is an integral part of site monitoring activities. Meteorological data, which define local terrain impacts on air flow paths, are needed to interpret air concentration data. Meteorological data may be available from an existing station located near the site (i.e., at a local airport), otherwise a station should be set up at the site. This data will document the degree that samples actually were downwind and verify whether other worst-case assumptions were met. Meteorological parameters to be monitored are, at a minimum, wind speed, wind direction, and sigma theta (which is the horizontal wind direction standard deviation and an indicator of atmospheric stability). The remaining parameters primarily affect the amount of a contaminant available in the air.

- Wind Speed

When the contaminant of concern is a particulate, wind speed is critical in determining whether the particulate will become airborne, the quantity of the particulate that becomes airborne, and the distance the particulate will travel from the source. Wind speed also contributes to the volatilization of contaminants from liquid sources.



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- Wind Direction

Wind direction highly influences the path of airborne contaminants. In addition, variations in wind direction increase the dispersion of pollutants from a given source.

- Atmospheric Stability

Atmospheric stability refers to the degree to which the atmosphere tends to dampen vertical and horizontal motion. Stable atmospheric conditions (i.e., evenings) result in low dispersion, and unstable atmospheric conditions (i.e., hot sunny days) result in higher dispersion.

- Temperature

Higher temperatures increase the rate of volatilization of organic and some inorganic compounds and affect the initial rise of gaseous or vapor contaminants. Therefore, worst-case emission of volatiles and semivolatiles occurs at the hottest time of day, or on the hottest day.

- Humidity

High humidity affects water-soluble chemicals and particulates. Humid conditions may dictate the sampling media used to collect the air sample, or limit the volume of air sampled and thereby increase the detection limit.

- Atmospheric Pressure

Migration of landfill gases through the landfill surface and through surrounding soils are governed by changes in atmospheric pressure. Atmospheric pressure will influence upward migration of gaseous contaminants from shallow aquifers into the basements of overlying structures.

In many cases, the transport and dispersion of air pollutants is complicated by local meteorology. Normal diurnal variations (i.e., temperature inversions) affect dispersion of airborne contaminants. Terrain features can enhance or create air inversions and can also influence the path and speed of air flow, complicating transport and dispersion patterns.

The chemical characteristics of a contaminant (i.e., molecular weight, physical state, vapor pressure, aerodynamic size, temperature, reactive compounds, and photodegradation) affects its behavior and can influence the method used to sample and analyze it.



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8.0 CALCULATIONS

Volume is obtained by multiplying the sample time in minutes by the flow rate. Sample volume should be indicated on the chain of custody record. Adjustments for temperature and pressure differences may be required.

Results are usually provided in parts per million (ppm), parts per billion (ppb), milligrams per cubic meter (mg/m^3) or micrograms per cubic meter ($\mu\text{g}/\text{m}^3$).

Refer to the analytical method or regulatory guidelines for other applicable calculations.

9.0 QUALITY ASSURANCE/QUALITY CONTROL

The manufacturer's instructions should be reviewed prior to instrument use. Instruments must be utilized in accordance with manufacturer's instructions. Equipment checkout and calibration activities must occur prior to and after monitoring and sampling and must be documented.

9.1 QA/QC Samples

QA/QC samples provide information on the variability and usability of environmental sample results. Various QA/QC samples may be collected to detect error. QA/QC samples are submitted with the field samples for analysis to aid in identifying the origin of analytical discrepancies; then a determination can be made as to how the analytical results should be used. Collocated samples, background samples, field blanks, and lot blanks are the most commonly collected QA/QC field samples. Performance evaluation (PE) samples and matrix spikes provide additional measures of data QA/QC control. QA/QC results may suggest the need for modifying sample collection, preparation, handling, or analytical procedures if the resultant data do not meet site-specific QA or data quality objectives. Refer to ERT/REAC SOP #2005, Quality Assurance/Quality Control Samples, for further details, and suggested frequencies for submittal of QA/QC samples.

9.2 Sample Documentation

All sample and monitoring activities should be documented legibly, in ink. Any corrections or revisions should be made by lining through the incorrect entry and by initialing the error. All samples must be recorded on an Air Sampling Worksheet. A chain of custody record must be maintained from the time a sample is taken to the final deposition of the sample. Custody seals demonstrate that a sample container has not been opened or tampered with during transport or storage of samples. Refer to ERT/REAC SOP #2002, Sample Documentation, for further information.

10.0 DATA VALIDATION

Results for QA/QC samples should be evaluated for contamination. This information should be utilized to qualify the environmental sample results accordingly with data quality objectives.



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11.0 HEALTH AND SAFETY

Personal protection equipment (PPE) requirements identified in federal and/or state regulations and 29 Code of Federal Regulations (CFR) 1910.120 for hazardous waste site work must be followed.

The majority of physical precautions involved in air sampling are related to the contaminant sampled. Attention should be given when sampling in potentially explosive, flammable or acidic atmospheres. On rare occasions, the collection media may be hazardous; for example, in the instance where an acidic or basic solution is utilized in an impinger.

When working with potentially hazardous materials, follow U.S. EPA, OSHA and corporate health and safety procedures.

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APPENDIX A

Portable Screening Devices and Specialized Analytical Instruments

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PORTABLE SCREENING DEVICES

Where possible, a datalogger should be used to minimize the length of time required for site personnel to be in a potentially contaminated area. Datalogger cable is available from manufacturers for linear output instruments and some nonlinear output instruments. U.S. EPA ERT/REAC has output cables for organic vapor analyzers (i.e., HNU and OVA), toxic gas analyzers (i.e., monitox) and real-time aerosol monitors (i.e., RAM and miniram).

- Total Hydrocarbon Analyzers

Total hydrocarbon analyzers used to detect a variety of volatile organic compounds (VOCs) at hazardous waste sites principally employ either a photoionization detector (PID) or a flame ionization detector (FID). Compounds are ionized by a flame or an ultraviolet lamp. PIDs depend on the ionization potential of the compounds. PIDs are sensitive to aromatic and olefinic (unsaturated) compounds such as benzene, toluene, styrene, xylenes, and acetylene. Greater selectivity is possible by using low-voltage lamps. The ionization potential of individual compounds can be found in the NIOSH Pocket Guide to Chemical Hazards. These instruments are not compound-specific and are typically used as screening instruments. FIDs are sensitive to volatile organic vapor compounds such as methane, propanol, benzene and toluene. They respond poorly to organic compounds lacking hydrocarbon characteristics.

- Oxygen and Combustible Gas Indicators

Combustible Gas Indicators (CGIs) provide efficient and reliable methods to test for potentially explosive atmospheres. CGI meters measure the concentration of a flammable vapor or gas in air and present these measurements as a percentage of the lower explosive limit (LEL). The measurements are temperature-dependent. The property of the calibration gas determines sensitivity. LELs for individual compounds can be found in the NIOSH Pocket Guide to Chemical Hazards. If readings approach or exceed 10% of the LEL, extreme caution should be exercised in continuing the investigation. If readings approach or exceed 25% LEL, personnel should be withdrawn immediately.

CGIs typically house an electrochemical sensor to determine the oxygen concentration in ambient air. Normally, air contains approximately 20.9% oxygen by volume. Oxygen measurements are of particular importance for work in enclosed spaces, low-lying areas, or in the vicinity of accidents that have produced heavier-than-air vapors which could displace ambient air. The meters are calibrated for sea level and may indicate a false negative (i.e., O₂ content) at higher altitudes. Since the air has been displaced by other substances, these oxygen-deficient areas are also prime locations for taking additional organic vapor and combustible gas measurements. Oxygen-enriched atmospheres increase the potential for fires by their ability to contribute to combustion or to chemically react with flammable compounds and promote auto-ignition.

- Toxic Atmosphere Analyzers

The toxic atmosphere analyzer is a compound-specific instrument, designed and calibrated to identify and quantify a specific compound or class of compounds in either gaseous or vapor form. Cross-sensitivity to air pollutants not of interest may lead to erroneous results.



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U.S. EPA/ERT has the following toxic atmosphere analyzers: carbon monoxide, phosgene, nitrous oxide, hydrogen cyanide, sulfur dioxide, hydrogen sulfide, and chlorine gas.

- Aerosol/Particulate Monitors

A Real-Time Aerosol/Particulate Monitor (RAM) displays readings for total particulates. The instrument employs a pulse light emitting diode which generates a narrow band emission in conjunction with a photovoltaic cell to detect light scattered from particulates.

The U.S. EPA/ERT uses the RAM when the contaminant of concern is associated with particulates, and when responding to fires involving hazardous materials, to identify plume levels. The instrument is very useful in determining the presence of a plume when it is not visible. The U.S. EPA/ERT typically uses RAMs on tripods to obtain particulate concentrations at the breathing zone level. Personal dataloggers are used with the RAMs to document minimum, average and maximum concentrations. This provides real-time data without requiring those in personal protective equipment to be constantly present in the plume.

- Chemical Detector Tubes (Colorimetric Tubes)

A chemical detector tube is a hollow, tube-shaped, glass body containing one or more layers of chemically impregnated inert material. To use, the fused ends are broken off and a manufacturer-specified volume of air is drawn through the tube with a pump to achieve a given detection limit. The chemicals contained within the packing material undergo a chemical reaction with the airborne pollutant present, producing a color change during the intake of each pump stroke. The concentration of a pollutant is indicated by the length of discoloration on a calibrated scale printed on the detector tube.

- Radiation Meters

Radiation meters determine the presence and level of radiation. The meters use a gas or solid ion detection media which becomes ionized when radiation is present. The meters are normally calibrated to one probe. Meters that detect alpha, beta, and gamma radiation are available.

- Gold Film (Hydrogen Sulfide and Mercury Vapor) Monitors

Hydrogen sulfide (H_2S) and Mercury (Hg) monitors operate on the principle that electric resistivity increases across a gold film as a function of H_2S and Hg concentration. The monitors provide rapid and relatively low detection limits for H_2S and Hg in air. After extensive sampling periods or high concentrations of H_2S and Hg , the gold film must be heated to remove contamination and return the monitor to its original sensitivity.

- Infrared Detectors

Infrared detectors such as the Miniature Infrared Analyzer (MIRAN) use infrared (IR) absorption as a function of specific compounds. MIRAN instruments apply to situations where the contaminants are identified but concentrations are not. MIRAN instruments generally require AC power.



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SPECIALIZED ANALYTICAL INSTRUMENTS

The continuous monitors described above provide qualitative measurement of air contaminants. Quantitative measurements in the field can be obtained using more sophisticated instruments, such as portable Gas Chromatographs, to analyze grab samples.

- Direct Air Sampling Portable Gas Chromatographs (GCs)

Portable GCs use gas chromatography to identify and quantify compounds. The time it takes for a compound to move through a chromatographic column is a function of that specific compound or group of compounds. A trained technician with knowledge of the range of expected concentrations of compounds can utilize a portable GC in the field to analyze grab samples. GCs generally require AC power and shelter to operate. This method is limited by its reliance on a short-term grab sample to be representative of the air quality at a site.

- Remote Optical Sensing

This technique, also referred to as long-path or open-path monitoring, involves transmitting either an infrared or ultraviolet light beam across a long open path and measuring the absorbance at specific wavelengths. The technique is capable of analyzing any preselected organic or inorganic volatile compound that can be resolved from compounds naturally occurring in ambient air. Current projected removal applications include perimeter monitoring during site cleanups and measurement of emission source strengths during site assessments.

- TAGA Direct Air Sampling Mass Spectrometer/Mass Spectrometer

The Trace Atmospheric Gas Analyzer (TAGA), which is operated by the U.S. EPA/ERT, is capable of real-time detection of preselected organic compounds at low parts-per-billion concentrations. The instrument has been successfully used by the U.S. EPA/ERT for isolating individual emission plumes and tracking those plumes back to their sources.



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APPENDIX B
Air Sampling Equipment and Media/Devices
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AIR SAMPLING EQUIPMENT

- High-Volume, Total Suspended Particulate (TSP) Samplers

High-volume TSP samplers collect all suspended particles by drawing air across an 8- by 10-inch glass-quartz filter. The sample rate is adjusted to 40 cubic feet per minute (CFM), or 1134 liters per minute (L/min), and it is held constant by a flow controller over the sample period. The mass of TSPs can be determined by weighing the filter before and after sampling. The composition of the filter varies according to the analytical method and the detection limit required.

- PM-10 Samplers

PM-10 samplers collect particulates with a diameter of 10 microns or less from ambient air. Particulates of this size represent the respirable fraction, and thus are of special significance. PM-10 samplers can be high-volume or low-volume. The high-volume sampler operates in the same manner as the TSP sampler at a constant flow rate of 40 CFM; it draws the sample through a special impactor head which collects particulates of 10 microns or less. The particulate is collected on an 8- by 10-inch filter. The low-volume sampler operates at a rate of approximately 17 L/min. The flow must remain constant through the impactor head to maintain the 10-micron cut-off point. The low-volume PM-10 collects the sample on 37-mm Teflon® filters.

- High-Volume PS-1 Samplers

High-volume PS-1 samplers draw a sample through polyurethane foam (PUF) or a combination foam and XAD-2 resin plug, and a glass quartz filter at a rate of 5-10 CFM (144 to 282 L/min). This system is excellent for measuring low concentrations of semivolatiles, PCBs, pesticides, or chlorinated dioxins in ambient air.

- Area Sampling Pumps

These pumps provide flow-rate ranges of 2-20 L/min and have a telescopic sampling mast with the sampling train. Because of the higher volume, this pump is suitable for sampling low concentrations of airborne contaminants (i.e., asbestos sampling). These pumps are also used for metals, pesticides and PAH sampling which require large sample volumes.

- Personal Sampling Pumps

Personal sampling pumps are reliable portable sampling devices that draw air samples through a number of sampling media including resin tubes, impingers, and filters. Flow rates are usually adjustable from 0.1 to 4 L/min (or 0.01 to .75 L/min with a restrictive orifice) and can remain constant for up to 8 hours on one battery charge or continuously with an AC charger/converter.



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GENERAL AIR SAMPLING GUIDELINES

- Canister Samplers

Evacuated canister sampling systems use the pressure differential between the evacuated canister and ambient pressure to bleed air into the canister. The sample is bled into the canister at a constant rate over the sampling period using a critical orifice, a mechanically compensated regulator, or a mass flow control device until the canister is near atmospheric pressure.

Pressure canister sampling systems use a pump to push air into the canister. To maintain a higher, more controlled flow, the pump typically controls the pressure differential across a critical orifice at the inlet of the canister, resulting in a pressurized canister at the completion of sampling.

AIR SAMPLING MEDIA/DEVICES

If possible, before employing a specific sampling method, consult the laboratory that will conduct the analyses. Many of the methods can be modified to provide better results or a wider range of results.

- Summa^R Canisters

Summa canisters are highly polished passivated stainless steel cylinders. The Summa polishing process brings chrome and nickel to the surface of the canisters, which results in an inert surface. This surface restricts adsorption or reactions that occur on the canister's inner surface after collection. At the site, the canister is either placed in a sampler to control sample collection rate, or opened to collect a grab sample. Samples can be collected by allowing air to bleed into or be pumped into the canister. U.S. EPA/ERT uses 6-liter Summa canisters for VOC and permanent gas analysis.

- Passive Dosimeters

Passive dosimeters are clip-on vapor monitors (samplers) in which the diffused contaminants are absorbed on specially prepared active surfaces. Industrial hygienists commonly use dosimeters to obtain time-weighted averages or concentrations of chemical vapors, as they can trap over 130 organic compounds. Selective dosimeters have also been developed for a number of chemicals including formaldehyde, ethylene oxide, hydrogen sulfide, mercury vapor, nitrogen dioxide, sulfur dioxide, and ozone. Dosimeters must be sent to a laboratory for analysis.

- Polyurethane Foam (PUF)

PUF is a sorbent used with a glass filter for the collection of semivolatile organic compounds such as pesticides, PCBs, chlorinated dioxins and furans, and PAHs. Fewer artifacts (chemical changes that occur to collected compounds) are produced than with some other solid sorbents. PUF is used with the PS-1 sampler and U.S. EPA Method TO13. PUF can also be used with personal sampling pumps when sampling for PAHs using the Lewis/McCloud method. Breakthrough of the more volatile PCBs and PAHs may occur when using PUF.



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- Sampling Bags (Tedlar[®])

Sampling bags, like canisters, transport air samples to the laboratory for analysis. Samples are generally pumped into the bags, but sometimes a lung system is used, in which a pump creates a vacuum around the bag in a vacuum box. Then the sample flows from a source into the bag. This method is used for VOCs, fixed gases (CO₂, O₂ and N₂) and methane.

- Impingers

An impinger allows an air sample to be bubbled through a solution, which collects a specific contaminant by either chemical reaction or absorption. For long sampling periods, the impinger may need to be kept in an ice bath to prevent the solution from evaporating during sampling. The sample is drawn through the impinger by using a sampling pump or more elaborate sampling trains with multiple impingers.

- Sorbent Tubes/Cartridges

A variety of sampling media are available in sorbent tubes, which are used primarily for industrial hygiene. A few examples are carbon cartridges, carbon molecular sieves, Tenax tubes and tube containing the XAD-2 polymer. Depending upon the sorbent material, tubes can be analyzed using either a solvent extraction or thermal desorption. The former technique uses standard laboratory equipment and allows for multiple analyses of the same sample. The latter technique requires special, but readily available, laboratory equipment and allows only one analysis per sample. In addition, thermal desorption typically allows for lower detection limits by two or more orders of magnitude. Whenever sorbent tubes are being used for thermal desorption, they should be certified as "clean" by the laboratory doing the analysis.

Thermally Desorbed Media

During thermal desorption, high-temperature gas streams are used to remove the compounds collected on a sorbent medium. The gas stream is injected and often cryofocused into an analytical instrument, such as a GC, for compound analysis:

- Tenax Tubes

Tenax tubes are made from commercially available polymer (p-phenylene oxide) packed in glass or stainless steel tubes through which air samples are drawn or sometimes pumped. These tubes are used in U.S. EPA Method TO1 and VOST for volatile nonpolar organic, some polar organic, and some of the more volatile semivolatile organics. Tenax is not appropriate for many of the highly volatile organics (with vapor pressure greater than approximately 200 mm Hg).

- Carbonized Polymers

The carbonized molecular sieve (CMS), a carbonized polymer, is a commercially available, carbon sorbent packed in stainless-steel sampling tubes through which air samples are drawn or sometimes



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pumped. These are used in U.S. EPA Method TO2 for highly volatile nonpolar compounds which have low-breakthrough volumes on other sorbents. When high-thermal desorption temperatures are used with CMS, more variability in analysis may occur than with other sorbents.

- **Mixed Sorbent Tubes**

Sorbent tubes can contain two type of sorbents. Combining the advantages of each sorbent into one tube increases the possible types of compounds to be sampled. The combination of two sorbents can also reduce the chance that highly volatile compounds will break through the sorbent media. An example of a mixed sorbent tube is the combination of Tenax and charcoal with a carbonized molecular sieve. A potential problem with mixed sorbent tubes is the breakthrough of a compound from an earlier sorbent to a later sorbent from which it cannot be desorbed.

Solvent-Extracted Media

Solvent-extracted media use the principle of chemical extraction to remove compounds collected on a sorbent media. The chemical solvent is injected into an instrument, such as a GC, for analysis of compounds. Examples of solvent-extracted media follow:

- **Chemically Treated Silica Gel**

Silica gel is a sorbent which can be treated with various chemicals. The chemically treated silica gel can then be used to sample for specific compounds in air. Examples include the DNPH-coated silica gel cartridge used with U.S. EPA Method TO11.

- **XAD-2 Polymers**

XAD-2 polymers usually are placed in tubes, custom-packed sandwich-style with polyurethane foam, and prepared for use with U.S. EPA Method TO13 or the semi-VOST method. The polymers are used for the collection of semivolatile polar and nonpolar organic compounds. The compounds collected on the XAD-2 polymer are chemically extracted for analysis.

- **Charcoal Cartridges**

Charcoal cartridges, consisting of primary and backup sections, trap compounds by adsorption. Ambient air is drawn through them so that the backup section verifies that breakthrough of the analytes on the first section did not occur, and the sample collection was therefore quantitative. Quantitative sample collection is evident by the presence of target chemicals on the first charcoal section and the absence on the second section. Next, the adsorbed compounds must be eluted, usually with a solvent extraction, and analyzed by GC with a detector, such as a Mass Spectrometer (MS).



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- Tenax Tubes

Cartridges are used in OSHA and NIOSH methods in a manner similar to charcoal cartridges but typically for less volatile compounds.

- Particulate Filters

Particulate filters are used by having a sampling pump pass air through them. The filter collects the particulates present in the air and is then analyzed for particulate mass or chemical or radiological composition. Particulate filters are made from different materials which are described below.

- Mixed Cellulose Ester (MCE)

MCE is manufactured from mixed esters of cellulose which are a blend of nitro-cellulose and cellulose acetate. MCE filters are used often for particulate sampling.

- Glass Fiber

Glass fiber is manufactured from glass fibers without a binder. Particulate filters with glass fiber provide high flow rates, wet strength, and high, solid holding capacity. Generally, the filters are used for gravimetric analysis of particulates.

- Polyvinyl Chloride

Particulate filters with polyvinyl chloride are resistant to concentrated acids and alkalis. Their low moisture pickup and light tare weight make them ideal for gravimetric analysis.

- Teflon®

Teflon is manufactured from polytetrafluorethylene (PTFE). Particulate filters with Teflon are easy to handle and exceptionally durable. Teflon filters are used for metal collection.

- Silver

Particulate filters manufactured from pure silver have high collection efficiency and uniform pore size. These filters are used for mercury collection and analysis.

- Cellulose

Particulate filters with cellulose contain less than 0.01% ash. These filters are used to collect particulates.



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AIR SAMPLING FOR METALS [NIOSH METHOD 7300, ELEMENTS]

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* These sections affected by Revision 0.0.

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AIR SAMPLING FOR METALS [NIOSH METHOD 7300, ELEMENTS]

1.0 SCOPE AND APPLICATION

The purpose of this standard operating procedure (SOP) is to define the proper sample collection technique for air sampling of elemental metals, as well as delineate the typical working range of the method and indicate potential interferences. Elements covered by this method include the metals listed in Table 1 (Appendix A).

These are standard (i.e., typically applicable) operating procedures which may be varied or changed as required, dependent upon site conditions, equipment limitations or limitations imposed by the procedure. In all instances, the ultimate procedures employed should be documented and associated with the final report.

Mention of trade names or commercial products does not constitute United States Environmental Protection Agency (U.S. EPA) endorsement or recommendation for use.

2.0 METHOD SUMMARY

Air sampling for elemental metals involves passing a known quantity of air across a mixed cellulose ester (MCE) filter. The particulate phase of the air, with a nominal size of greater than or equal to 0.8 microns (μm), is trapped in the filter.

This method requires air sampling using 37-millimeter (mm), 3-stage cassettes loaded with 0.8 μm MCE filters and support pads. The approximate minimum and maximum sample volumes required for detection of the metals of interest are listed in Table 1 (Appendix A).

3.0 SAMPLE PRESERVATION, CONTAINERS, HANDLING, AND STORAGE

No preservatives or special storage conditions are required. However, the samples should be stored with the filter upright and transported at or near ambient conditions to prevent significant deterioration of the samples. When transporting and handling the samples, prevent impact and vibrations which would dislodge particulates from the filters.

4.0 INTERFERENCES AND POTENTIAL PROBLEMS

A potential problem with the sampling method is overloading of the filter. This can disrupt flow, consequently producing analytical results that may be biased low. Periodic checking of the filter and pump during sampling can reduce this error and sample cassettes can be changed during the sampling period. In the event of heavy sample loading, multiple filters would be submitted and analyzed in the laboratory as a single sample. The total volume must be indicated on the Chain of Custody record.

5.0 EQUIPMENT/APPARATUS

The following equipment is required for air sampling for elements:



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- C Air pumps, low or medium volume
- C Tygon® tubing
- C 0.8µm MCE filters with support pads
- C 37-mm 3-stage cassettes
- C Hose-barb filter adapters
- C Calibrated rotameter or bubble meter
- C Screwdriver set
- C Sample collection documentation (air sampling worksheets, sample labels, logbooks, chain of custody records)
- C Particulate monitoring equipment (Real-time Aerosol Monitor [RAM])
- C Personal protection gear
- C Whirlpack bags

6.0 REAGENTS

This section is not applicable to this SOP.

7.0 PROCEDURE

7.1 Field Preparation

1. Determine the extent of the sampling effort, the sampling methods to be employed, and the types and amounts of equipment and supplies needed.
2. Obtain and organize the necessary sampling and monitoring equipment.
3. Decontaminate or pre-clean equipment, and ensure that it is in working order. Precalibrate sampling equipment, if possible.
4. Prepare scheduling and coordinate with staff, client, and regulatory agency, if appropriate.
5. Perform a general site survey prior to site entry in accordance with the site-specific Health and Safety Plan.
6. Use stakes, flagging tape, or other appropriate means to mark all sampling locations. If necessary, the proposed locations may be adjusted based on site access, property boundaries, surface obstructions and/or on-site activity.
7. Make an estimate of the airborne concentrations of the elements of concern. It may be possible to extrapolate the concentration of particulates by assuming similar percentages of



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metals are present in the airborne particulates as in the soils. However, it should be noted that this is only a rough estimate. If estimation of the airborne concentration of metals is not possible, then sample volumes should remain within the limits recommended in Table 1 (Appendix A).

8. Arrange for sample analysis by an appropriately certified laboratory and check with the laboratory for any special requirements (e.g., additional lot blanks).

7.2 Calibration

Calibrate the sampling pumps in the following manner:

1. Assemble the calibration train as shown in Figure 1 (Appendix A) using a representative 37-mm, 3-stage filter cassette loaded with a 0.8 μ m MCE filter and support pad (outlet plug removed), Tygon® tubing, hose-barb filter adapter, rotameter, and air sampling pump. Depending on the required flow rate, a low volume or a medium volume sampling pump may be required. Refer to Figure 2 (Appendix A) for an illustration of the components of the filter cassette.
2. Turn on the pump, allow to warm up, and adjust the flow using the flow adjust mechanism, until the float ball on the rotameter is aligned with the precalibrated flow rate value. A sticker on the rotameter should indicate this value. Refer to REAC SOP #2118, Rotameter Calibration, for calibration procedures. NOTE: Depending on the project's objectives, calibration of the rotameter to a higher flow rate may be required.
3. Affix a sticker to the pump indicating flow rate and media.

7.3 Sampling

1. Assemble the sampling trains with clean filter cassettes (Figures 3 and 4, Appendix A).
2. Verify the pump calibration by removing the inlet plug from the cassette, attaching a rotameter with Tygon® tubing and turning on the sampling pump. Ensure that all connections are tight. Record the actual flow rate on the Air Sampling Worksheet. Replace the inlet plug until ready to sample.
3. Set the sampling pump timer (low volume pumps) for the appropriate sampling time as determined by the Work Assignment Manager (WAM), or record the elapsed timer readings (medium volume pumps) on the Air Sampling Worksheet. This will be dictated by the type of sampling pump being utilized.



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4. Deploy the sampling pumps as indicated in the sampling plan, following site health and safety procedures.
5. Remove the cassette cap or inlet plug from the cassette. Sampling for elemental metals can be conducted with the cassettes open-faced (cassette cap removed) or closed-faced (only inlet port plug removed). Open-faced is preferred because it permits an even loading of the filter cassette and should be used whenever high particulate concentrations are expected. This allows greater particulate loading of the filter. However, either method is acceptable since the entire filter is used during sample analysis. Closed-faced sampling is typically performed when there is a possibility that the sample may be shaken and particulates may be lost.
6. Turn on the sampling pump and allow it to run for the sampling period determined by the WAM.

7.4 Post Sampling

1. Verify the sampling period by reading the sample run time (low volume pumps) or by checking the elapsed time on the counter (medium volume pumps). Record the sampling time on the Air Sampling Worksheet and turn off the pump.
2. Verify the pump calibration by attaching a rotameter with Tygon® tubing and turning on the sampling pump. Record the final flow rate on the Air Sampling Worksheet. Insert the inlet plug.
3. Remove the sampling cassette from the sampling train and insert the outlet plug.
4. Complete the Air Sampling Worksheet and calculate the sample volume (see Section 8.0 for calculations.)
5. Label the sample and place it in a Whirlpack bag for transport to the laboratory for analysis.
6. Prepare the samples (including QC samples) for transport by packing them in a shipping container with bubble wrap or styrofoam pieces. Complete a Chain of Custody record in accordance with REAC SOP #4005, Chain of Custody Procedures.

8.0 CALCULATIONS

The total volume of a sample is calculated by multiplying the total sample time by the average flow rate. The total volume for each sample must be indicated on the Chain of Custody Record.



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AIR SAMPLING FOR METALS [NIOSH METHOD 7300, ELEMENTS]

9.0 QUALITY ASSURANCE/QUALITY CONTROL

9.1 General QA Procedures

- All data must be documented on Air Sampling Worksheets or within site logbooks.
- All instrumentation must be operated in accordance with operating instructions as supplied by the manufacturer, unless otherwise specified in the work plan. Equipment checkout and calibration activities must occur prior to sampling/operation and must be documented.

9.2 Field Blanks

Provide one field blank per sampling event or per 20 samples, whichever is greater. The field blank should be handled in the same manner as the sampling cassette (remove/replace cap and plug, and transport) except that no air is drawn through it.

9.3 Collocated Sample

Collect one collocated sample per sampling event or per 20 samples, whichever is greater. Collocated samples are two samples collected from two adjacent pumps during the same time period at the same flow rates.

9.4 Lot Blank

Include a minimum of three lot blanks per lot of sampling cassettes utilized for a sampling event. Consult with the analytical laboratory to determine if additional lot blanks are required.

10.0 DATA VALIDATION

Results of the QA/QC samples will be evaluated for contamination during the data validation process. This information will be utilized to qualify the environmental sample results accordingly with the data quality objectives of the project.

11.0 HEALTH AND SAFETY

When working with potentially hazardous materials, follow U.S. EPA, Occupational Safety and Health Administration (OSHA), or corporate health and safety procedures.

12.0 REFERENCES

National Institute for Occupational Safety and Health. 1994. *NIOSH Manual of Analytical Methods*. Method



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SKC, Inc. Universal Sample Pump, Operating Instructions. Form #37711. Rev. 9912.

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13.0 APPENDICES

A - Table

B - Figures



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APPENDIX A

Table

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AIR SAMPLING FOR METALS [NIOSH METHOD 7300, ELEMENTS]

TABLE 1. Sampling Volumes

Element (Symbol)	Minimum Air Volume to be collected - Liters	Maximum Air Volume to be collected - Liters
Silver (Ag)	250	2000
Aluminum (Al)	5 ⁽¹⁾	100 ⁽¹⁾
Arsenic (As)	5	2000
Beryllium (Be)	1250	2000
Calcium (Ca)	5	200
Cadmium (Cd)	13	2000
Cobalt (Co)	25	2000
Chromium (Cr)	5	1000
Copper (Cu)	5	1000
Iron (Fe)	5	100
Lithium (Li) ⁽²⁾	100	2000
Magnesium (Mg)	5	67
Manganese (Mn)	5	200
Molybdenum (Mo) ⁽²⁾	5	67
Sodium (Na)	13	2000
Nickel (Ni)	5	1000
Phosphorus (P) ⁽²⁾	25 ⁽¹⁾	2000 ⁽¹⁾
Lead (Pb)	50	2000
Platinum (Pt) ⁽²⁾	1250	2000
Selenium (Se)	13	2000
Tin (Sn) ⁽²⁾	5	500
Tellurium (Te) ⁽²⁾	25	2000
Titanium (Ti) ⁽²⁾	5	100
Thallium (Tl)	25	2000
Vanadium (V)	5	2000
Tungsten (W) ⁽²⁾	5 ⁽¹⁾	200 ⁽¹⁾
Yttrium (Y) ⁽²⁾	5	200
Zinc (Zn)	5	200
Zirconium (Zr) ⁽²⁾	5	200

NOTE:

Do not exceed a filter loading of approximately 2mg total dust.

⁽¹⁾ Larger volumes may be required if the anticipated concentration is less than the ACGIH Threshold Limit Value (TLV).

⁽²⁾ Compound not on standard U.S. EPA Environmental Response Team analyte list.



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APPENDIX B

Figures

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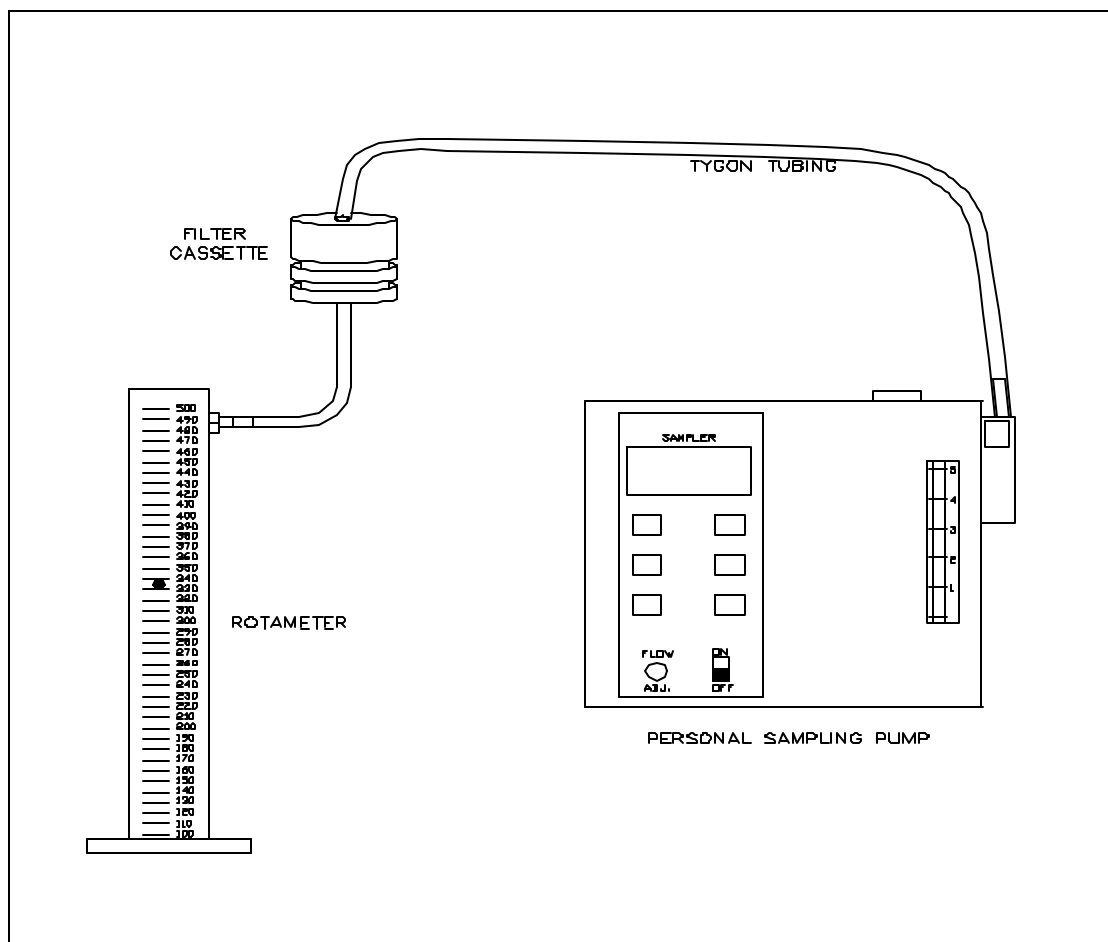


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AIR SAMPLING FOR METALS [NIOSH METHOD 7300, ELEMENTS]

FIGURE 1. Calibration Train with Low Volume Sampling Pump

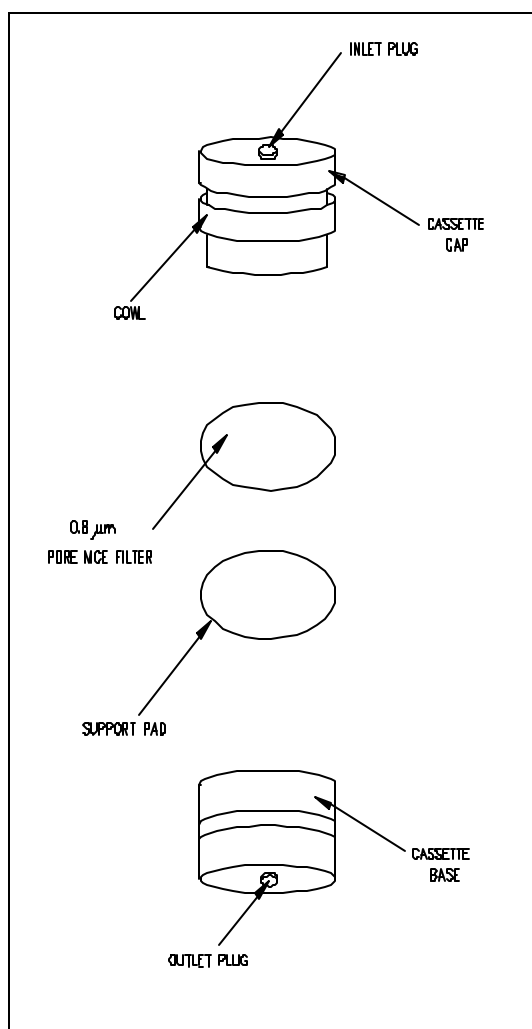


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FIGURE 2. Filter Cassette Assembly

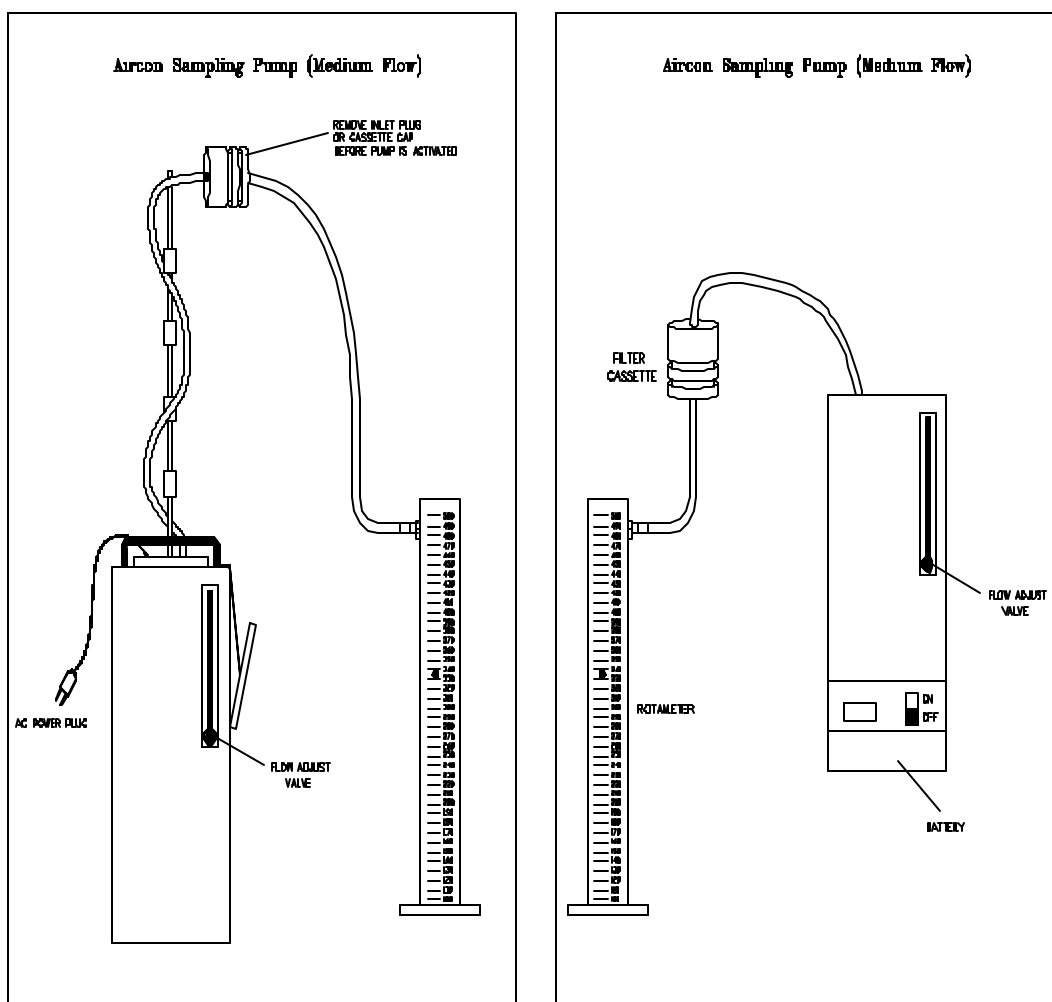


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FIGURE 3. Aircon Sampling Train



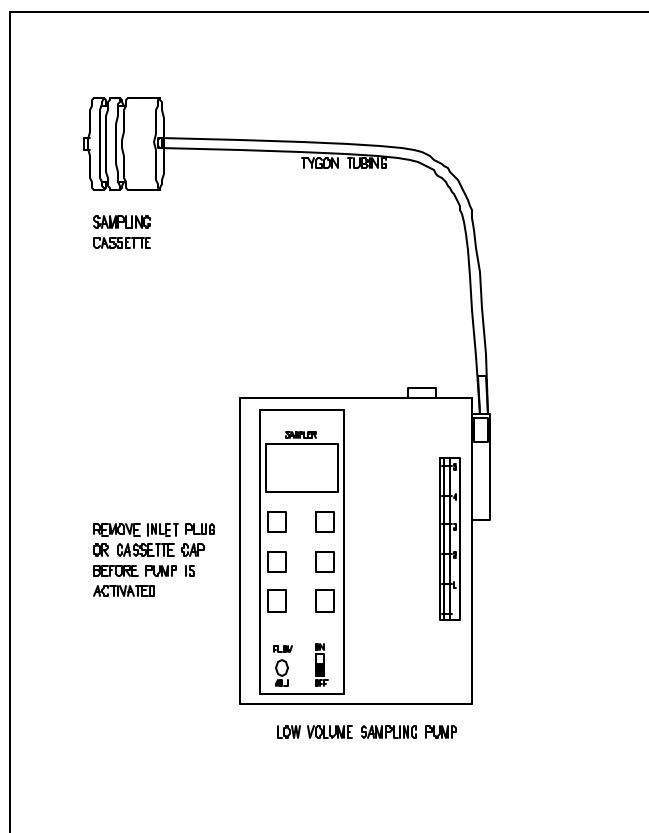


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FIGURE 4. Sampling Train with Low Volume Sampling Pump





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SUMMA CANISTER SAMPLING

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SUMMA CANISTER SAMPLING

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12.0 REFERENCES

13.0 APPENDICES

- A - Volatile Organic Compound Data Sheet
- B - Figure
- C - Canister Sampling Field Data Sheet*

* This section affected by Revision 0.1.

SUPERCEDES: SOP #1704; Revision 0.0; 09/12/94



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SUMMA CANISTER SAMPLING

1.0 SCOPE AND APPLICATION

The purpose of this standard operating procedure (SOP) is to describe a procedure for sampling of volatile organic compounds (VOCs) in ambient air. The method is based on samples collected as whole air samples in Summa passivated stainless steel canisters. The VOCs are subsequently separated by gas chromatography (GC) and measured by mass-selective detector or multidetector techniques. This method presents procedures for sampling into canisters at final pressures both above and below atmospheric pressure (respectively referred to as pressurized and subatmospheric pressure sampling).

This method is applicable to specific VOCs that have been tested and determined to be stable when stored in pressurized and subatmospheric pressure canisters. The organic compounds that have been successfully collected in pressurized canisters by this method are listed in the Volatile Organic Compound Data Sheet (Appendix A). These compounds have been measured at the parts per billion by volume (ppbv) level.

These are standard (i.e., typically applicable) operating procedures which may be varied or changed as required, dependent on site conditions, equipment limitations or limitations imposed by the procedure or other procedure limitations. In all instances, the ultimate procedures employed should be documented and associated with the final report.

Mention of trade names or commercial products does not constitute U.S. EPA endorsement or recommendation for use.

2.0 METHOD SUMMARY

Both subatmospheric pressure and pressurized sampling modes use an initially evacuated canister. Both modes may also use a mass flow controller/vacuum pump arrangement to regulate flow. With the above configuration, a sample of ambient air is drawn through a sampling train comprised of components that regulate the rate and duration of sampling into a pre-evacuated Summa passivated canister. Alternatively, subatmospheric pressure sampling may be performed using a fixed orifice, capillary, or adjustable micrometering valve in lieu of the mass flow controller/vacuum pump arrangement for taking grab samples or short duration time-integrated samples. Usually, the alternative types of flow controllers are appropriate only in situations where screening samples are taken to assess for future sampling activities.

3.0 SAMPLE PRESERVATION, CONTAINERS, HANDLING, AND STORAGE

After the air sample is collected, the canister valve is closed, an identification tag is attached to the canister, and the canister is transported to a laboratory for analysis. Upon receipt at the laboratory, the canister tag data is recorded. Sample holding times and expiration should be determined prior to initiating field activities.



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4.0 INTERFERENCES AND POTENTIAL PROBLEMS

Contamination may occur in the sampling system if canisters are not properly cleaned before use. Additionally, all other sampling equipment (e.g., pump and flow controllers) should be thoroughly cleaned. Instructions for cleaning the Summa canisters are described in ERT/REAC SOP #1703, Summa Canister Cleaning Procedures.

5.0 EQUIPMENT/APPARATUS

The following equipment/apparatus (Figure 1, Appendix B) is required:

5.1 Subatmospheric Pressure Sampling Equipment

1. VOC canister sampler - whole air sampler capable of filling an initially evacuated canister by action of the flow controlled pump from vacuum to near atmospheric pressure. (Andersen Samplers Inc., Model 87-100 or equivalent).
2. Sampling inlet line - stainless steel tubing to connect the sampler to the sample inlet.
3. Sample canister - leak-free stainless steel pressure vessels of desired volume with valve and Summa passivated interior surfaces (Scientific Instrumentation Specialist, Inc., ID 83843, Andersen Samplers, Inc., or equivalent).
4. Particulate matter filter - 2- μ m sintered stainless steel in-line filter (Nupro Co., Model SS-2F-K4-2, or equivalent).
5. Chromatographic grade stainless steel tubing and fittings - for interconnections (Alltech Associates, Cat. #8125, or equivalent). All materials in contact with sample, analyte, and support gases should be chromatographic grade stainless steel.
6. Fixed orifice, capillary, or adjustable micrometering valve - used in lieu of the electronic flow controller/vacuum pump for grab samples or short duration time-integrated samples.

5.2 Pressurized Sampling Equipment

1. VOC canister sampler - whole air sampler capable of filling an initially evacuated canister by action of the flow controlled pump from vacuum to near atmospheric pressure. (Andersen Samplers Inc., Model 87-100).
2. Sampling inlet line - stainless steel tubing to connect the sampler to the sample inlet.



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3. Sample canister - leak-free stainless steel pressure vessels of desired volume with valve and Summa passivated interior surfaces (Scientific Instrumentation Specialist, Inc., ID 83843, Andersen Samplers, Inc., or equivalent).
4. Particulate matter filter - 2- μ m sintered stainless steel in-line filter (Nupro Co., Model SS-2F-K4-2, or equivalent).
5. Chromatographic grade stainless steel tubing and fittings - for interconnections (Alltech Associates, Cat. #8125, or equivalent). All materials in contact with sample, analyte, and support gases should be chromatographic grade stainless steel.

6.0 REAGENTS

This section is not applicable to this SOP.

7.0 PROCEDURE

7.1 Subatmospheric Pressure Sampling

7.1.1 Sampling Using a Fixed Orifice, Capillary, or Adjustable Micrometering Valve

1. Prior to sample collection, the appropriate information is completed on the Canister Sampling Field Data Sheet (Appendix C).
2. A canister, which is evacuated to 0.05 mm Hg and fitted with a flow restricting device, is opened to the atmosphere containing the VOCs to be sampled.
3. The pressure differential causes the sample to flow into the canister.
4. This technique may be used to collect grab samples (duration of 10 to 30 seconds) or time-integrated samples (duration of 12 to 24 hours). The sampling duration depends on the degree to which the flow is restricted.
5. A critical orifice flow restrictor will have a decrease in the flow rate as the pressure approaches atmospheric.
6. Upon sample completion at the location, the appropriate information is recorded on the Canister Sampling Field Data Sheet.



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7.1.2 Sampling Using a Mass Flow Controller/Vacuum Pump Arrangement (Andersen Sampler Model 87-100)

1. Prior to sample collection the appropriate information is completed on the Canister Sampling Field Data Sheet (Appendix C).
2. A canister, which is evacuated to 0.05 mm Hg and connected in line with the sampler, is opened to the atmosphere containing the VOCs to be sampled.
3. A whole air sample is drawn into the system through a stainless steel inlet tube by a direct drive blower motor assembly.
4. A small portion of this whole air sample is pulled from the inlet tube by a specially modified inert vacuum pump in conjunction with a mass flow controller.
5. The initially evacuated canister is filled by action of the flow controlled pump to near atmospheric pressure.
6. A digital time-program is used to pre-select sample duration and start and stop times.
7. Upon sample completion at the location, the appropriate information is recorded on the Canister Sampling Field Data Sheet.

7.2 Pressurized Sampling

7.2.1 Sampling Using a Mass Flow Controller/Vacuum Pump Arrangement (Andersen Sampler Model 87-100)

1. Prior to sample commencement at the location, the appropriate information is completed on the Canister Sampling Field Data Sheet.
2. A canister, which is evacuated to 0.05 mm Hg and connected in line with the sampler, is opened to the atmosphere containing the VOCs to be sampled.
3. A whole air sample is drawn into the system through a stainless steel inlet tube by a direct drive blower motor assembly.
4. A small portion of this whole air sample is pulled from the inlet tube by a specially modified inert vacuum pump in conjunction with a mass flow controller.



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5. The initially evacuated canister is filled by action of the flow controlled pump to a positive pressure not to exceed 25 psig.
6. A digital time-programmer is used to pre-select sample duration and start and stop times.
7. Upon sample completion at the location, the appropriate information is recorded on the Canister Sampling Field Data Sheet.

8.0 CALCULATIONS

1. A flow control device is chosen to maintain a constant flow into the canister over the desired sample period. This flow rate is determined so the canister is filled to about 88.1 kPa for subatmospheric pressure sampling or to about one atmosphere above ambient pressure for pressurized sampling over the desired sample period. The flow rate can be calculated by:

$$F = \frac{(P)(V)}{(T)(60)}$$

where:

F = flow rate (cm³/min)
 P = final canister pressure, atmospheres absolute
 V = volume of the canister (cm³)
 T = sample period (hours)

For example, if a 6-L canister is to be filled to 202 kPa (two atmospheres) absolute pressure in 24 hours, the flow rate can be calculated by:

$$F = \frac{(2)(6000)}{(24)(60)} = 8.3 \text{ cm}^3/\text{min}$$



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2. If the canister pressure is increased, a dilution factor (DF) is calculated and recorded on the sampling data sheet.

$$DF = \frac{Y_a}{X_a}$$

where:

X_a = canister pressure (kPa, psia) absolute before dilution.
 Y_a = canister pressure (kPa, psia) absolute after dilution.

After sample analysis, detected VOC concentrations are multiplied by the dilution factor to determine concentration in the sampled air.

9.0 QUALITY ASSURANCE/QUALITY CONTROL

The following general quality assurance procedures apply:

1. All data must be documented on standard chain of custody records, field data sheets, or site logbooks.
2. All instrumentation must be operated in accordance with operating instructions as supplied by the manufacturer, unless otherwise specified in the work plan. Equipment checkout and calibration activities must occur prior to sampling/operation, and they must be documented.

10.0 DATA VALIDATION

This section is not applicable to this SOP.

11.0 HEALTH AND SAFETY

When working with potentially hazardous materials, follow U.S. EPA, OSHA, and corporate health and safety practices. Specifically, pressurizing of Summa canisters should be performed in a well ventilated room, or preferably under a fume hood. Care must be taken not to exceed 40 psi in the canisters. Canisters are under pressure, albeit only 20-30 psi, and should not be dented or punctured. They should be stored in a cool dry place and always be placed in their plastic shipping boxes during transport and storage.



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12.0 REFERENCES

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APPENDIX A
Volatile Organic Compound Data Sheet
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Volatile Organic Compound Data Sheet

TABLE 1. VOLATILE ORGANIC COMPOUND DATA SHEET

COMPOUND (SYNONYM)	FORMULA	MOLECULAR WEIGHT	BOILING POINT (°C)	MELTING POINT (°C)	CAS NUMBER
Freon 12 (Dichlorodifluoromethane)	Cl ₂ CF ₂	120.91	-29.8	-158.0	74-87-3
Methyl chloride (Chloromethane)	CH ₃ Cl	50.49	-24.2	-97.1	
Freon 114 (1,2-Dichloro-1,1,2,2-tetrafluoroethane)	ClCF ₂ CClF ₂	170.93	4.1	-94.0	
Vinyl chloride (Chloroethylene)	CH ₂ =CHCl	62.50	-13.4	-1538.0	75-01-4
Methyl bromide (Bromomethane)	CH ₃ Br	94.94	3.6	-93.6	74-83-9
Ethyl chloride (Chloroethane)	CH ₃ CH ₂ Cl	64.52	12.3	-136.4	75-00-3
Freon 11 (Trichlorofluoromethane)	CCl ₃ F	137.38	23.7	-111.0	75-35-4
Vinylidene chloride (1,1-Dichloroethene)	C ₂ H ₂ Cl ₂	96.95	31.7	-122.5	
Dichloromethane (Methylene chloride)	CH ₂ Cl ₂	84.94	39.8	-95.1	75-09-2
Freon 113 (1,1,2-Trichloro-1,2,2-trifluoroethane)	CF ₂ ClCCl ₂ F	187.38	47.7	-36.4	74-34-3
1,1-Dichloroethane (Ethylidene chloride)	CH ₃ CHCl ₂	98.96	57.3	-97.0	
cis-1,2-Dichloroethylene	CHCl=CHCl	96.94	60.3	-80.5	
Chloroform (Trichloromethane)	CHCl ₃	119.38	61.7	-63.5	67-66-3
1,2-Dichloroethane (Ethylene dichloride)	ClCH ₂ CH ₂ Cl	98.96	83.5	-35.3	107-06-2
Methyl chloroform (1,1,1-Trichloroethane)	CH ₃ CCl ₃	133.41	74.1	-30.4	71-55-6
Benzene (Cyclohexatriene)	C ₆ H ₆	78.12	80.1	5.5	71-43-2
Carbon tetrachloride (tetrachloromethane)	CCl ₄	153.82	76.5	-23.0	56-23-5
1,2-Dichloropropane (Propylene dichloride)	CH ₃ CHClCH ₂ Cl	112.99	96.4	-100.4	78-87-5
Trichloroethylene (Trichloroethene)	ClCH=CCl ₂	131.29	87	-73.0	79-01-6
cis-1,3-Dichloropropene (cis-1,3-dichloropropylene)	CH ₃ CCl=CHCl	110.97	76		
trans-1,3-Dichloropropene (cis-1,3-Dichloropropylene)	ClCH ₂ CH=CHCl	110.97	112.0		79-00-5
1,1,2-Trichloroethane (Vinyl trichloride)	CH ₂ ClCHCl ₂	133.41	113.8	-36.5	
Toluene (Methyl benzene)	C ₆ H ₅ CH ₃	92.15	110.6	-95.0	108-88-3
1,2-Dibromoethane (Ethylene dibromide)	BrCH ₂ CH ₂ Br	187.88	131.3	9.8	106-93-4
Tetrachloroethylene (Perchloroethylene)	Cl ₂ C=CCl ₂	165.83	121.1	-19.0	127-18-4
Chlorobenzene (Phenyl chloride)	C ₆ H ₅ Cl	112.56	132.0	-45.6	108-90-7
Ethylbenzene	C ₆ H ₅ C ₂ H ₅	106.17	136.2	-95.0	100-41-4
m-Xylene (1,3-Dimethylbenzene)	1,3-(CH ₃) ₂ C ₆ H ₄	106.17	139.1	-47.9	100-42-5
p-Xylene (1,4-Dimethylxylene)	1,4-(CH ₃) ₂ C ₆ H ₄	106.17	138.3	13.3	
Styrene (Vinyl benzene)	C ₆ H ₅ CH=CH ₂	104.16	145.2	-30.6	
1,1,2,2-Tetrachloroethane	CHCl ₂ CHCl ₂	167.85	146.2	-36.0	79-34-5
o-Xylene (1,2-Dimethylbenzene)	1,2-(CH ₃) ₂ C ₆ H ₄	106.17	144.4	-25.2	108-67-8
1,3,5-Trimethylbenzene (Mesitylene)	1,3,5-(CH ₃) ₃ C ₆ H ₃	120.20	164.7	-44.7	
1,2,4-Trimethylbenzene (Pseudocumene)	1,2,4-(CH ₃) ₃ C ₆ H ₃	120.20	169.3	-43.8	95-63-6
m-Dichlorobenzene (1,3-Dichlorobenzene)	1,3-Cl ₂ C ₆ H ₄	147.01	173.0	-24.7	541-73-1
Benzyl chloride (α-Chlorotoluene)	C ₆ H ₅ CH ₂ Cl	126.59	179.3	-39.0	100-44-7
o-Dichlorobenzene (1,2-Dichlorobenzene)	1,2-Cl ₂ C ₆ H ₄	147.01	180.5	-17.0	95-50-1
p-Dichlorobenzene (1,4-Dichlorobenzene)	1,4-Cl ₂ C ₆ H ₄	147.01	174.0	53.1	106-46-7
1,2,4-Trichlorobenzene	1,2,4-Cl ₃ C ₆ H ₃	181.45	213.5	17.0	120-82-1
Hexachlorobutadiene (1,1,2,3,4,4-Hexachloro-1,3-butadiene)					



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APPENDIX B

Figure
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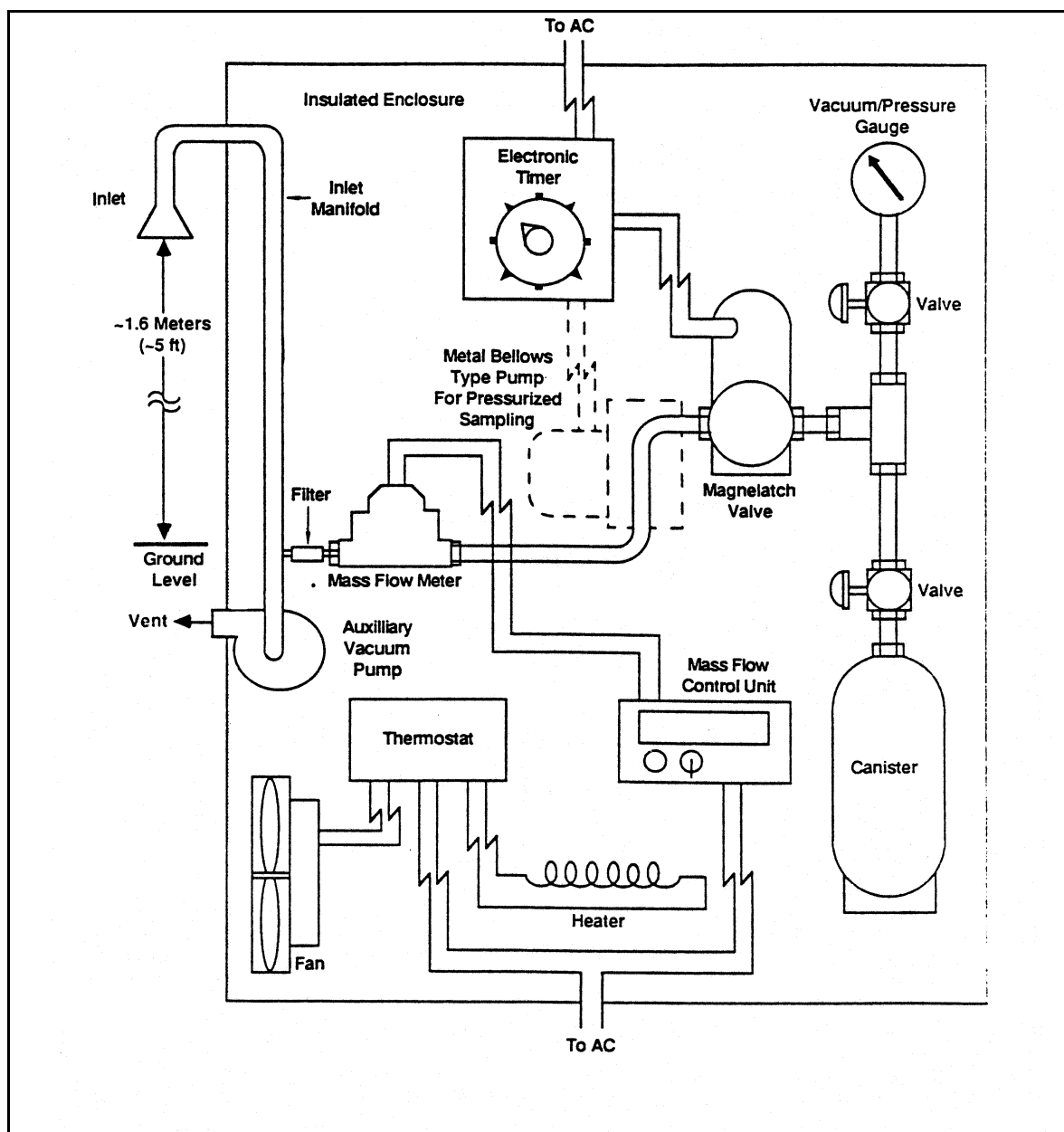
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FIGURE 1. Subatmospheric/Pressurized Sampling Equipment





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Canister Sampling Field Data Sheet
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Roy F. Weston, Inc.
REAC Project, Edison, NJ
EPA Contract No. 68-C4-0022

Site: _____
Samplers: _____
Date: _____

WA#: _____
EPA/ERT WAM: _____
REAC Task Leader: _____

Sample #					
Location					
SUMMA ID					
Orifice Used					
Analysis/Method					
Time (Start)					
Time (Stop)					
Total Time					
SUMMA WENT TO AMBIENT	YES/NO	YES/NO	YES/NO	YES/NO	YES/NO
Pressure Gauge Reading					
Pressure Gauge Reading					
Flow Rate (Pre)					
Flow Rate (Post)					
Flow Rate (Average)					
MET Station On-site? Y / N					
General Comments:					



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SOIL SAMPLING

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*These sections affected by Revision 1.0.

SUPERCEDES: SOP #2012; Revision 0.0; 2/18/00; U.S. EPA Contract 68-C99-223.



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SOIL SAMPLING

1.0 SCOPE AND APPLICATION

The purpose of this Standard Operating Procedure (SOP) is to describe procedures for the collection of representative surface soil samples. Sampling depths are assumed to be those that can be reached without the use of a drill rig, direct-push technology, or other mechanized equipment (except for a back-hoe). Sample depths typically extend up to 1-foot below ground surface. Analysis of soil samples may define the extent of contamination, determine whether concentrations of specific contaminants exceed established action levels, or if the concentrations of contaminants present a risk to public health, welfare, or the environment.

These are standard (i.e., typically applicable) operating procedures which may be varied or changed as required, dependent upon site conditions, equipment limitations, or limitations imposed by the procedure. In all instances, the ultimate procedures employed should be documented and associated with a final report.

Mention of trade names or commercial products does not constitute United States Environmental Protection Agency (U.S. EPA) endorsement or recommendation for use.

2.0 METHOD SUMMARY

Surface soil samples can be used to investigate contaminants that are persistent in the near surface environment. Contaminants that are detected in the near surface environment may extend to considerable depths, may migrate to the groundwater, surface water, the atmosphere, or may enter biological systems.

Soil samples may be collected using a variety of methods and equipment depending on the depth of the desired sample, the type of sample required (discrete or composite), and the soil type. Near-surface soils may be easily sampled using a spade, trowel, and/or scoop. Sampling at greater depths may be performed using a hand auger, continuous-flight auger, trier, split-spoon sampler, or, if required, a backhoe.

3.0 SAMPLE PRESERVATION, CONTAINERS, HANDLING, AND STORAGE

Samples must be cooled and maintained at 4°C and protected from sunlight immediately upon collection to minimize any potential reaction. The amount of sample to be collected, proper sample container type and handling requirements are discussed in the Response Engineering and Analytical Contract (REAC) SOP #2003, *Sample Storage, Preservation and Handling*.

4.0 INTERFERENCES AND POTENTIAL PROBLEMS

There are two primary problems associated with soil sampling: 1) cross contamination of samples, and 2) improper sample collection. Cross contamination problems can be eliminated or minimized through the use of dedicated sampling equipment. If this is not possible or practical, decontamination of sampling equipment is necessary. The guidelines for preventing, minimizing and limiting cross contamination of samples are discussed in the Environmental Response Team (ERT)/REAC SOP #2006, *Sampling Equipment Decontamination*. Improper sample collection procedures can disturb the sample matrix, resulting in volatilization of contaminants, compaction of the sample, or inadequate homogenization of the samples (when required), resulting in variable, non-



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representative results.

5.0 EQUIPMENT/APPARATUS

Soil sampling equipment includes the following:

- Site maps/plot plan
- Safety equipment, as specified in the site-specific Health and Safety Plan (HASP)
- Traditional survey equipment or global positioning system (GPS)
- Tape measure
- Survey stakes or flags
- Camera and image collection media
- Stainless steel, plastic*, or other appropriate homogenization bucket, bowl or pan
- Appropriate size sample containers
- Ziplock plastic bags
- Site logbook
- Labels
- Chain of Custody records and custody seals
- Field data sheets and sample labels
- Cooler(s)
- Ice
- Vermiculite
- Decontamination supplies/equipment
- Plastic sheeting
- Spade or shovel
- Spatula(s)
- Scoop(s)
- Plastic* or stainless steel spoons
- Trowel(s)
- Continuous flight (screw) auger
- Bucket auger
- Post hole auger
- Extension rods
- T-handle
- Sampling trier
- Thin wall tube sampler
- Split spoon sampler
- Soil core sampler
 - Tubes, points, drive head, drop hammer, puller jack and grip
- Photoionization detector (PID), Flame ionization detector (FID) and/or Respirable Aerosol Monitor (RAM)
- Backhoe (as required)



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- En Core® samplers

* Not used when sampling for semivolatile compounds.

6.0 REAGENTS

Decontamination solutions are specified in ERT/REAC SOP #2006, *Sampling Equipment Decontamination*, and the site specific work plan.

7.0 PROCEDURES

7.1 Preparation

1. Determine the extent of the sampling effort, the analytes to be determined, the sampling methods to be employed, and the types and amounts of equipment and supplies required to accomplish the assignment.
2. Obtain the necessary sampling and air monitoring equipment.
3. Prepare schedules and coordinate with staff, client, and regulatory agencies, as appropriate.
4. Perform a general site reconnaissance survey prior to site entry in accordance with the site specific HASP.
5. Use stakes or flags to identify and mark all sampling locations. Specific site factors, including extent and nature of contamination, should be considered when selecting sample locations. If required, the proposed locations may be adjusted based on site access, property boundaries, and surface obstructions. All staked locations should be utility-cleared prior to soil sampling; utility clearances must be confirmed before beginning intrusive work.
6. Pre-clean and decontaminate equipment in accordance with the site specific work plan, and ensure that it is in working order.

7.2 Sample Collection

7.2.1 Surface Soil Samples

The collection of samples from near-surface soil can be accomplished with tools such as spades, shovels, trowels, and scoops. The over-burden or over-lying surface material is removed to the required depth and a stainless steel or plastic scoop is used to collect the sample. Plastic utensils are not to be used when sampling for semivolatile compounds.

This method can be used in most soil types but is limited to sampling at or near the ground



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surface. Accurate, representative samples can be collected by this procedure depending on the care and precision demonstrated by the sample team member. A flat, pointed mason trowel to cut a block of the desired soil is helpful when undisturbed profiles are required. Tools plated with chrome or other materials must not be used.

The following procedure is used to collect surface soil samples:

1. If volatile organic compound (VOC) contamination is suspected, use a PID to monitor the sampler's breathing zone during soil sampling activities.
2. Using a pre-cleaned, stainless steel scoop, plastic spoon, or trowel, remove and discard sticks, rocks, vegetation and other debris from the sampling area.
3. Accumulate an adequate volume of soil, based on the type(s) of analyses to be performed, in a stainless, plastic or other appropriate container.
4. If volatile organic analysis is to be performed, immediately transfer the sample directly into an appropriate, labeled sample container with a stainless steel spoon, or equivalent, and secure the cap tightly to ensure that the volatile fraction is not compromised. Thoroughly mix the remainder of the soil to obtain a sample that is representative of the entire sampling interval. Then, either place the sample into appropriate, labeled containers and secure the caps tightly, or, if composite samples are to be collected, place a sample from another sampling interval or location into the homogenization container and mix thoroughly. When compositing is complete, place the sample into appropriate, labeled containers and secure the caps tightly.

7.2.2 Sampling at Depth with Augers and Thin Wall Tube Samplers

This system consists of an auger, head, a series of extensions, and a "T" handle (Figure 1, Appendix A). The auger is used to bore a hole to a desired sampling depth, and is then withdrawn. The sample may be collected directly from the auger head. If additional sample volume is required, multiple grabs at the same depth are made. If a core sample is to be collected, the auger head is then replaced with a tube auger. The system is then lowered down the borehole, and driven into the soil to the completion depth. The system is withdrawn and the core is collected.

Several types of augers are available; these include bucket or tube type, and continuous flight (screw) or post-hole augers. Bucket or tube type augers are better for direct sample recovery because a large volume of sample can be collected from a discrete area in a short period of time. When continuous flight or post-hole augers are used, the sample can be collected directly from the flights or from the borehole cuttings. The continuous flight or post-hole augers are satisfactory when a composite of the complete soil column is desired, but have limited utility for sample collection as they cannot be used to sample a discrete depth.



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SOIL SAMPLING

The following procedure is used for collecting soil samples with an auger:

1. Attach the auger head to an extension rod and attach the "T" handle.
2. Clear the area to be sampled of surface debris (e.g., twigs, rocks, litter). It may be advisable to remove a thin layer of surface soil for an area approximately six inches in radius around the sampling location.
3. Begin augering, periodically removing and depositing accumulated soils onto a plastic sheet spread near the hole. This prevents the accidental brushing of loose material back down the borehole when removing the auger or adding extension rods. It also facilitates refilling the hole, and avoids possible contamination of the surrounding area.
4. After reaching the desired depth, slowly and carefully remove the auger from the hole. When sampling directly from the auger head, proceed to Step 10.
5. Remove auger tip from the extension rods and replace with a tube sampler. Install the proper cutting tip.
6. Carefully lower the tube sampler down the borehole. Gradually force the tube sampler into the soil. Do not scrape the borehole sides. Avoid hammering the rods as the vibrations may cause the boring walls to collapse.
7. Remove the tube sampler and unscrew the extension rods.
8. Remove the cutting tip and the core from the device.
9. Discard the top of the core (approximately 1 inch), as this possibly represents material collected before penetration of the layer of concern. Place the core or a discrete portion of the core into the appropriate labeled sample container using a clean, decontaminated stainless steel spoon. If required, homogenize the sample as described in Step 10.
10. If VOC analysis is to be performed, transfer the sample directly from the auger head into an appropriate, labeled sample container with a stainless steel spoon, or equivalent and secure the cap tightly.
11. If another sample is to be collected in the same hole, but at a greater depth, reattach the auger head to the drill assembly, and follow steps 3 through 11, making sure to decontaminate the auger head and tube sampler between samples.
12. Abandon the hole according to applicable state regulations.



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SOIL SAMPLING

7.2.3 Sampling at Depth with a Trier

The system consists of a trier and a "T" handle. The auger is driven into the soil to be sampled and used to extract a core sample from the appropriate depth.

The following procedure is used to collect soil samples with a sampling trier:

1. Insert the trier (Figure 2, Appendix A) into the material to be sampled at a zero degree to forty-five degree (0° to 45°) angle from the soil surface plane. This orientation minimizes the spillage of sample.
2. Rotate the trier once or twice to cut a core of material.
3. Slowly withdraw the trier, making sure that the slot is facing upward.
4. If VOC analyses are required, transfer the sample directly from the trier into an appropriate, labeled sample container with a stainless steel spoon, or equivalent device and secure the cap tightly. Place the remainder of the sample into a stainless steel, plastic, or other appropriate homogenization container and mix thoroughly to obtain a sample that is representative of the entire sampling interval. Then, either place the sample into appropriate, labeled containers and secure the caps tightly; if composite samples are to be collected, place a sample from another sampling interval into the homogenization container and mix thoroughly. When compositing is complete, place the sample into appropriate, labeled containers and secure the caps tightly.

7.2.4 Sampling at Depth with a Split Spoon (Barrel) Sampler

Split spoon sampling is generally used to collect undisturbed soil cores of 18- or 24- inches in length. A series of consecutive cores may be extracted with a split spoon sampler to give a complete soil column profile, or an auger may be used to drill down to the desired depth for sampling. The split spoon is then driven to its sampling depth through the bottom of the augured hole and the core extracted.

When split spoon sampling is performed to gain geologic information, all work should be performed in accordance with American Society for Testing and Materials (ASTM) D1586-99, "*Standard Test Method for Penetration Test and Split-Barrel Sampling of Soils*".

The following procedures are used for collecting soil samples with a split spoon:

1. Assemble the sampler by aligning both sides of the barrel and then screwing the drive shoe on the bottom and the head piece on top.
2. Place the sampler at a 90 degree (90°) angle to the sample material.



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3. Using a well ring, drive the sampler. Do not drive past the bottom of the head piece or compression of the sample will result.
4. Record in the site logbook or on field data sheets the length of the tube used to penetrate the material being sampled, and the number of blows required to obtain the sample.
5. Withdraw the sampler, and open it by unscrewing the bit and head, and then splitting the barrel. The amount of recovery and soil type should be recorded on the boring log. If a split sample is desired, a cleaned, stainless steel knife should be used to divide the tube contents in half, longitudinally. This sampler is typically available in 2- and 3.5-inch diameter tubes. A larger barrel (diameter and/or length) may be necessary to obtain the required sample volume.
6. Without disturbing the core, transfer it to the appropriately labeled sample container(s) and seal tightly. Place the remainder of the sample into a stainless steel, plastic, or appropriate homogenization container, and mix thoroughly to obtain a sample that is representative of the entire sampling interval. Then, either place the sample into the appropriate, labeled containers and secure the caps tightly, or if composite samples are to be collected, place a sample from another sampling interval or location into the homogenization container and mix thoroughly. When compositing is complete, place the sample into the appropriate, labeled containers and secure the caps tightly.
7. Abandon the hole according to applicable state regulations.

7.2.5 Test Pit/Trench Excavation

A backhoe can be used to remove sections of soil when a detailed examination of stratigraphy and soil characteristics is required. The following procedures are used for collecting soil samples from test pits or trenches:

1. Prior to any excavation with a backhoe, it is imperative to ensure that all sampling locations are clear of overhead and buried utilities.
2. Review the site specific HASP and ensure that all safety precautions including appropriate monitoring equipment are installed as required.
3. Using the backhoe, excavate a trench approximately three feet wide and approximately one foot deep below the cleared sampling location. Place excavated soils on plastic sheets. Trenches greater than five feet deep must be sloped or protected by a shoring system, as required by Occupational Safety and Health Administration (OSHA) regulations.



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4. A shovel is used to remove a one to two inch layer of soil from the vertical face of the pit where sampling is to be done.
5. Samples are taken using a trowel, scoop, or coring device at the desired intervals. Be sure to scrape the vertical face at the point of sampling to remove any soil that may have fallen from above, and to expose fresh soil for sampling. In many instances, samples can be collected directly from the backhoe bucket.
6. If VOC analyses are required, transfer the sample into an appropriate, labeled sample container with a stainless steel spoon, or equivalent and secure the cap tightly. Place the remainder of the sample into a stainless steel, plastic, or other appropriate homogenization container, and mix thoroughly to obtain a sample representative of the entire sampling interval. Then, either place the sample into appropriate, labeled containers and secure the caps tightly; or, if composite samples are to be collected, place a sample from another sampling interval into the homogenization container and mix thoroughly. When compositing is complete, place the sample into the appropriate, labeled containers and secure the caps tightly.
7. Abandon the pit or excavation according to applicable state regulations.

7.2.6 Sampling for VOCs in Soil Using an En Core® Sampler

An En Core® sampler is a single-use device designed to collect and transport samples to the laboratory. The En Core® sampler is made of an inert composite polymer and reduces the open-air handling of soil samples in the field and in the laboratory; thereby, minimizing losses of VOCs.

1. Assemble the coring body, plunger rod and T-handle according to the instructions provided with the En Core® sampler.
2. Turn the T-handle with the T-up and the coring body down and push the sampler into the soil until the coring body is completely full. Remove the sampler from the soil. Wipe excess soil from the coring body exterior.
3. Cap the coring body while it is still on the T-handle. Push the cap over the flat area of the ridge. Be sure that the cap is seated properly to seal the sampler. Push and cap to lock arm in place.
4. Remove the capped sampler by depressing the locking lever on the T-handle while twisting and pulling the sampler from the T-handle.
5. Attach the label to the coring body cap, place in a plastic zippered bag, seal and put on ice.



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Generally, three En Core® samplers are required for each sample location. These samplers are shipped to the laboratory where the cap is removed and the soil samples are preserved with methanol or sodium bisulfate.

8.0 CALCULATIONS

This section is not applicable to this SOP.

9.0 QUALITY ASSURANCE/QUALITY CONTROL

There are no specific quality assurance (QA) activities that apply to the implementation of these procedures. However, the following general QA procedures apply:

2. All data must be documented in site logbooks or on field data sheets. At a minimum, the following data is recorded:

- Sampler's name and affiliation with project
- Sample number
- Sample location
- Sample depth
- Approximate volume of sample collected
- Type of analyses to be performed
- Sample description
- Date and time of sample collection
- Weather conditions at time of sampling
- Method of sample collection
- Sketch of sample location

2. All instrumentation must be operated in accordance with applicable SOPs and/or the manufacturer's operating instructions, unless otherwise specified in the work plan. Equipment checkout and calibration activities must occur prior to sampling/operation, and must be documented.
3. The types of quality control (QC) samples to be collected in the field shall be documented in the site-specific Work Plan.

10.0 DATA VALIDATION

This section is not applicable to this SOP.

11.0 HEALTH AND SAFETY

When working with potentially hazardous materials, follow U.S. EPA, OSHA and corporate health and safety



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procedures, in addition to the procedures specified in the site specific HASP.

12.0 REFERENCES

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U.S. Environmental Protection Agency. 1984. *Characterization of Hazardous Waste Sites - A Methods Manual: Volume II. Available Sampling Methods, Second Edition*. EPA-600/4-84-076.

de Vera, ER, B.P. Simmons, R.D. Stephen, and D.L. Storm. 1980. *Samplers and Sampling Procedures for Hazardous Waste Streams*. EPA-600/2-80-018.

American Society for Testing and Materials. *Standard Test Method for Penetration Test and Split-Barrel Sampling of Soils*. Method D 1586-99.

En Novative Technologies, Inc. 2001. *En Core® Sampler Sampling Procedures*. Web site access. March 13, 2001.



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APPENDIX A
Figures
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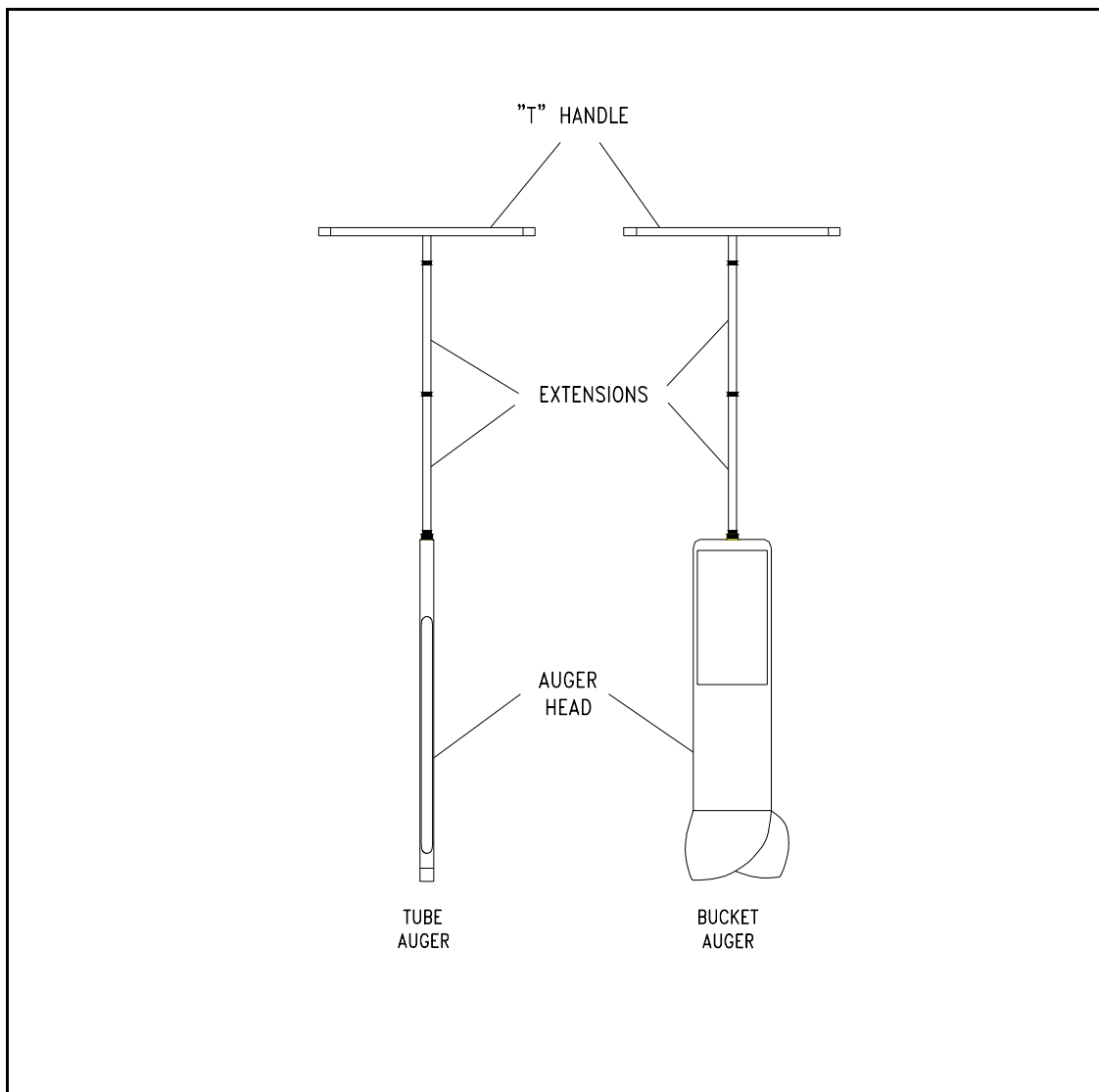
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FIGURE 1. Sampling Augers

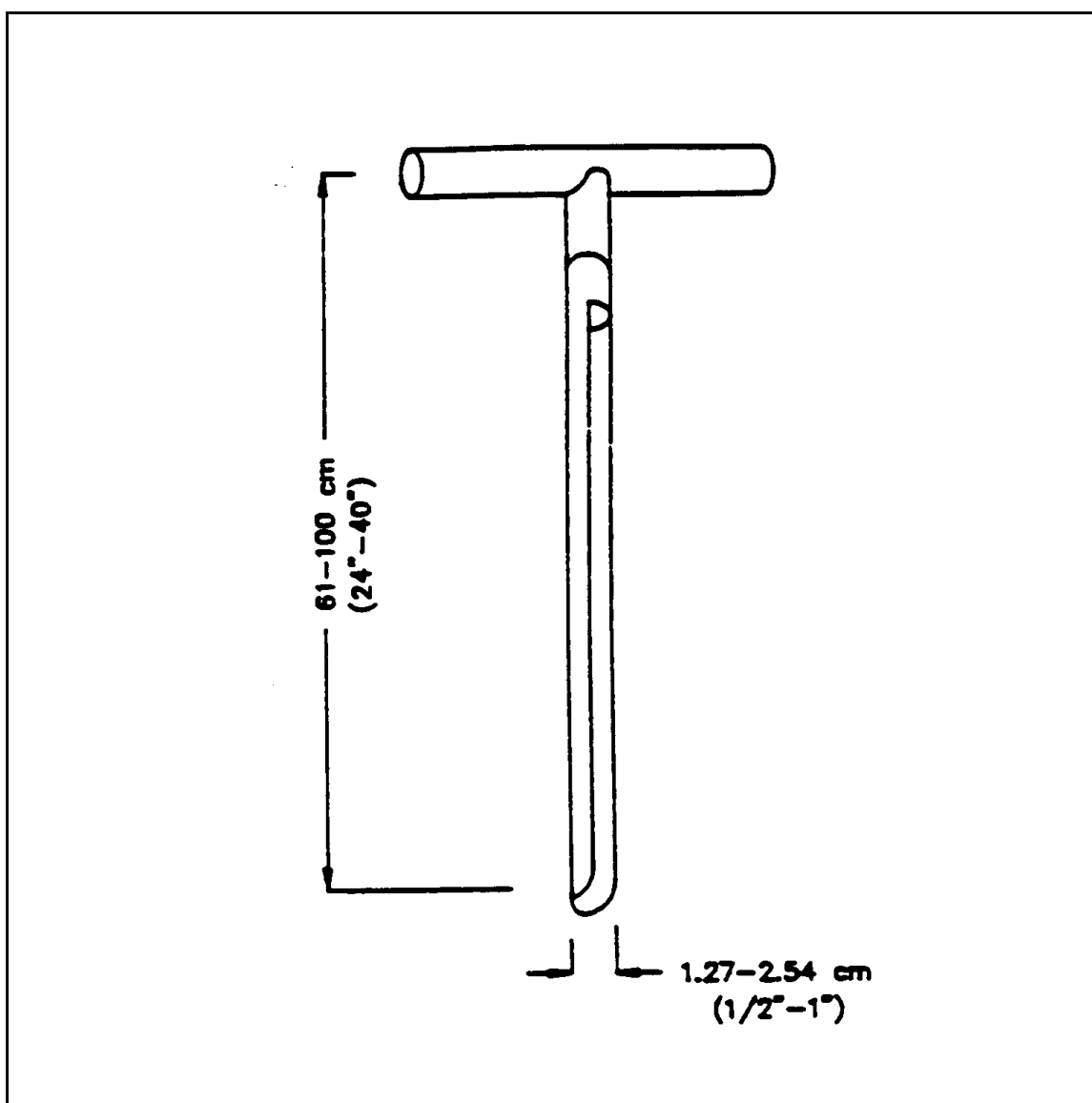


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FIGURE 2. Sampling Trier



FLY AWAY KITS START 3 ENE

Each START Office will have the following pre-packed ER equipment cache (Fly Away Kits).

Sampling Kit	Supply Kit
PPE Kit	ER Air Sampling Kit
Hazcat Kit (with Binder)	
ER Library (hard copy and disks): HASP, ER QASPs, NIOSH Pocket Guide, NA Emergency Response Guidebook, TLV Guide and a MERCK	

Sampling Kit

Item	Quantity
8 oz sample jars	24
4 oz sample jars (hazcat)	24
1 liter bottles poly/amber	8 (4/4)
VOA vials	1 case (40)
Sm box of acid preservatives	1- HNO ₃ , 1- HCl, 1-NaOH
Trowels/plastic scoops	6/6
Plastic bags	2 qt/2 gal
Paper paint buckets	4
Bailers, with rope	6
Coliwasas	1 box
Chain of Custody Forms	12
Chain of Custody Seals	1 roll

PPE Kit

Item	Quantity
Tyvek	8 Suits (2 M, 2 L, 2 XL, 2 XXL)
Saranex	8 Suits (2 M, 2 L, 2 XL, 2 XXL)
Nitrile inner gloves	2 boxes (M & XL)
Nitrile outer gloves	12 pairs (sizes 9, 10, 11)
Nitrile booties	5 pairs
Butyl Gloves	4 pairs
GME-P100 cartridges	6
Mersorb Cartridges	6
Duct Tape	2 rolls
Work Gloves	2 pairs
SCBA (tank, mask & harness)	2-M, 1-L
Extra filled SCBA tanks	3

Supply Kit

Item	Quantity
Spray Paint	2 cans
Caution Tape	1 roll
Strapping/Packaging Tape	2 rolls
Box cutter/Utility Knife	2
Flashlights, with extra batteries	2
Cable Ties	12
Binoculars	1
Trash bags/Drum Liners	1 box
Paper Towels	2 rolls
Visqueen	1 roll
Decon pool/pan	1
Decon Brush	1
Markers/Paint Pens	4/4
Pens and Med/Fine Point Sharpies	1 box of each
Log Books	2 small, 4 large
Inverter	1
Measuring Tape	1
Road Flares	4
First Aid Kit	1

ER Air Sampling Kit

Item	Quantity
Drager Tubes- NH ₃ , Cl, HCl, H ₂ NO ₃ , H ₂ SO ₄ & Vinyl Chloride	1 set of each
MCE Filters	1 box
Particulate Filters	1 box
Air Sampling Tubing	1 box
Air Sampling Tool Kit	1 set

**EPA Emergency Response Section (ERS)
and Superfund Technical Assessment and Response Team (START)**

**Emergency Response and Time Critical
Quality Assurance Sampling Plan
for
Air Sampling**

Response Location:
(Site Name)

Date:

Prepared by:

Reviewed by:

Approved by:

This sampling plan was prepared and delivered to the EPA OSC (select one):

☐ Prior to Sampling ☐ Post Sampling (within one month of sampling)

This emergency sampling plan is intended to be used in conjunction with the EPA's Region 9 Emergency Response Section's Generic Data Quality Objectives (DQOs) for Emergency Responses and Time Critical Evaluations. This sampling plan has been designed to assist field responders in their preparation for collecting, analyzing, shipping, storing and handling samples collected during an emergency response. The use of this generic sampling plan will involve forethought and planning that should help direct the sampling and analytical work. It is meant to be used in the case of emergency responses or time-critical responses when sampling teams may not have the opportunity to write a more thorough sampling plan. Sampling teams should always reference standard quality procedures, standard operations procedures, standard methods for sampling and analytical guidance.

The development of this generic plan will improve the documentation, communication, planning, and overall quality associated with the sampling and analysis by:

- 1) encouraging field teams to consider their goals and objectives before the generation of environmental data,
- 2) documenting predetermined information in a standardize format,
- 3) increasing the communication between sampling personnel and decision makers, and
- 4) detailing expectations and objective before samples are collected.

1.0 Introduction and Background. *Describe the site and specify the geographic boundaries for the site and any specific areas of concern. What is the problem, what precipitated the response, which agencies and other entities (e.g., contractors) are on site, who has taken the lead for the response and for environmental clean-up actions?*

2.0 Objectives. *Brief statement on the general project objective. What is the overall goal or objective? Specific objectives are summarized in Table D.*

2.1 Data Use Objectives. (How will the data be used?)

Data that are generated will be used: (Select Appropriate Boxes)

- 1 ☐ To compare with site-specific action levels or risk-based action levels (e.g., EPA PRGs) to determine if a chronic health threats exist.
- 2 ☐ To compare with site-specific action levels or risk-based action levels (e.g., RELs or MRLs) to determine if an acute health threats exist.
- 3 ☐ To compare to a established background level or with collected background sample(s).
- 4 ☐ To assist with determining the area of impact due to a hazardous material release.
- 5 ☐ To assist in the identification of the potential source of an airborne contaminant or odor.
- 6 ☐ To compare with federal or state occupational health limits (On-Site Health and Safety Assessment data).
- 7 ☐ As definitive confirmatory data for non-definitive (screening) data.
- 8 ☐ To assist in with an off-site acute exposure assessment.
- 9 ☐ Other objectives:

2.2 Sampling Objectives. (What are you proposing to do?)

- 1 ☐ Air monitoring (real-time) within the area of concern to determine contamination levels.
- 2 ☐ Air sampling within the area of concern to determine contamination levels.
- 3 ☐ Perimeter air sampling to determine contaminant concentration levels
- 4 ☐ Perimeter air monitoring (real-time) to determine contaminant concentration levels.
- 5 ☐ Personal air sampling of on-site personnel.
- 6 ☐ Personal air monitoring of on-site personnel.
- 7 ☐ Down-wind air monitoring
- 8 ☐ Down-wind air sampling
- 9 ☐ Other objectives:

2.3 Data Type

In general, data type and data needs should be decided prior to data generation. The data can be generally divided into three categories: definitive methodology data (generally data generated using standardize methods), non-definitive methodology data (also referred to as screening data) and screening data with at least 10% definitive conformation. The generation of definitive data is preferable, however in emergency and time critical situations where definitive data is not available, non-definitive data should be generated. Note that the data type is not an indicator of precision, accuracy or documentation completeness, or quality! Reported data should be verified (by a party other than the laboratory) as meeting specific quality control and data category requirements by following a verification or validation procedure. Refer to the START or ERS Quality Assurance Plans for specific quality parameters and requirements.

Check appropriate box(es):

- 1 ☐ Screening data will be generated. The data by itself may not be verifiable. **Due to the time critical situation, the data must be reported and may be used to make decisions.**
- 2a ☐ Screening data with at least 10 percent definitive data will be generated. Data using non-definitive analytical methodologies will be generated. **Due to the time critical situation, the data must be reported and may be used to make decisions prior to generation of definitive data.** The screening data by itself may not be verifiable. Screening data will be evaluated and reported with definitive data at a later time.
- 2b ☐ Screening data with 10 percent definitive data will be generated. Data using non-definitive analytical methodologies will be generated. **Data will not be reported until it is evaluated against definitive data.**
- 3a ☐ Definitive data will be generated. The sampling and analysis must be done on an emergency basis. **Due to the time critical situation, the preliminarily data must be reported and used for comparison without validation. Analytical data packages will be required. However, since the data was not used or intended for decision making, validation of the data package will not be performed.** (Document generic DQO deviation in Section 4.4)
- 3b ☐ Definitive data will be generated. The sampling must be done on an emergency basis. **Due to the time critical situation, preliminary data must be reported and may be used to make decisions without validation. The generated analytical documentation packages will be reviewed and validated. Qualified data will be reported after validation.**
- 3c ☐ Definitive data will be generated. **Full documentation will be required. Analytical data packages will be reviewed and validated prior to reporting.**

2.4 Contaminants of Concern

Potential contaminants of potential concern (COPC), proposed analytical method, proposed action levels and available reporting limit are summarized in Table A.

Table A Contaminants of Concern			
Potential COC	Proposed Analytical Method	Proposed Action Level	Available Reporting Limit
Other Data Collection Activity (non-chemical) (circle all that apply)	GPS Visual Other Geophysical	Interviews Modeling	Magnetometer Photography File Search

Add additional pages if necessary.

ERS/START**Emergency and Time Critical QASP
Air****3.0 Approach and Sampling Methodologies****3.1 Sampling Approach**

Indicate sampling approaches to be used (select approach)

- 1 ☐ Due to the lack of site information the approach will be determined in the field based on professional judgment of START.
- 2 ☐ Due to the lack of site information the approach will be determined in the field based on professional judgment of US EPA.
- 3 ☐ Due to the lack of site information the approach will be determined in the field based on professional judgment of local regulator.
- 4 ☐ Judgmental (Biased)
 - ☐ Near a point source
 - ☐ Down wind of a point source
 - ☐ Up wind of a point source
 - ☐ Other:
- 5 ☐ Random
- 6 ☐ Grid

3.2 Field Sampling**3.2.1 Sampling Collection Equipment**

Field equipment requirements are summarized in Table B.

ERS/START

Emergency and Time Critical QASP
Air

Table B Field Sampling Equipment					
Analyses	Sampling Equipment	Quantity	Dedicated or Reusable	Decon Solution	Resource/ Contractor
VOA	<input type="checkbox"/> SUMMAs or Equivalent				
	<input type="checkbox"/> Cartridges for VOAs				
	<input type="checkbox"/> Tedlar bags for VOAs.				
SVOAs.	<input type="checkbox"/> Cartridges of SVOAs.				
	<input type="checkbox"/> Cartridges of PAHs				
Pesticides	<input type="checkbox"/> Cartridges of Pesticides				
Acids	<input type="checkbox"/> Cartridges for Acid Gas samples				
Cyanide	<input type="checkbox"/> Cartridges for Cyanide samples				
Inorganic Particulate	<input type="checkbox"/> Cassettes for Total Inorganic samples.				
	<input type="checkbox"/> Cassettes for Inorganic samples (PM100 or 2.5).				
Other:	<input type="checkbox"/>				
	<input type="checkbox"/>				
	<input type="checkbox"/>				
	<input type="checkbox"/>				
ALL	<input type="checkbox"/> Hand Pumps and tubing				
	<input type="checkbox"/> Personal Sampling Pumps and tubing				
	<input type="checkbox"/> Vac-U-Chamber				
	<input type="checkbox"/> Pump Calibrator				

Add additional pages if necessary.

ERS/START**Emergency and Time Critical QASP
Air****3.2.2 Sample Locations**

Indicate the Sampling Location Name and describe the rationale for the each sample location chosen.

Sketch a map of the site and any areas of concern. Indicate sampling locations or sampling areas in Figure A and included names. Use a scale that is meaningful for the sampling work covered under this plan. Sketch out where the samples will be collected and include sampling location names. Attach a local map to this plan if it is available.

Figure A
Sample Location Map

Add additional maps if necessary.

3.2.3 Sample Containers and Preservatives

Containers and preservatives are summarized in Table C.

Table C Containers and Preservatives			
Analyses and Matrix	Container Type (per sample)	Preservation Method	Holding Time

Add additional pages if necessary.

3.2.4 Sample Labeling and DocumentationSample Collection Media Labels

Sample labels will clearly identify the particular sample and should include the following:

1. Site name
2. Time and date samples were taken
3. Sample preservation
4. Analysis requested
5. Sample location and/or identification number

Sample labels will be securely affixed to the sample container.

Chain of Custody Record

A chain of custody record will be maintained from the time the sample is taken to its final deposition. Every transfer of custody must be noted and signed for, and a copy of this record kept by each individual who has signed. When samples (or groups of samples) are not under direct control of the individual responsible for them, they must be stored in a secured container sealed with a custody seal.

The chain of custody record should include (at minimum) the following:

1. Sample identification number
2. Sample information
3. Sample location
4. Sample date and time

ERS/START**Emergency and Time Critical QASP
Air**

5. Names(s) and signature(s) of sampler(s)
6. Signature(s) of any individual(s) with control over samples

Custody Seals

Custody seals demonstrate that a sample container has not been tampered with or opened. The individual in possession of the sample(s) will sign and date the seal, affixing it in such a manner that the container cannot be opened without breaking the seal. The name of this individual, along with a description of the samples□ packaging, should be noted in the field book.

All sample documents will be completed legibly in ink. Any corrections or revisions will be made by lining through the incorrect entry and by initialing the error. These include the logbooks, the chain of custody forms, this field QASP and any other tracking forms.

Field Logbook

The field logbook is essentially a descriptive notebook detailing site activities and observations so that an accurate account of field procedures can be reconstructed in the writer's absence. All entries will be dated and signed by the individuals making the entries and will include the following:

1. Site name and project number
2. Names of sampling personnel
3. Dates and times of all entries (military time preferred)
4. Descriptions of all site activities, especially sampling start and ending times. Include site entry and exit times
5. Noteworthy events and discussions
6. Weather conditions
7. Site observations
8. Identification and description of samples and locations
9. Subcontractor information and names of on-site personnel
10. Date and time of sample collections, along with chain of custody information
11. Record of photographs
12. Site sketches
13. Exact times of various activities and occurrences related to sampling
14. Deviations from standard procedures or methods and the rationale for the deviations.

ERS/START**Emergency and Time Critical QASP
Air****3.3 Analysis****3.3.1 Monitoring Equipment**

Specify the monitoring equipment to be used. Check the appropriate boxes.

- | | | |
|---|--|--|
| <input type="checkbox"/> Organic Vapor Monitor (OVM with PID) | <input type="checkbox"/> Organic Vapor Analyzer (FID) | <input type="checkbox"/> HCN Monitor |
| <input type="checkbox"/> H ₂ S Monitor | <input type="checkbox"/> CO monitor | <input type="checkbox"/> SO ₂ Monitor |
| <input type="checkbox"/> Multiple Gas Analyzer | <input type="checkbox"/> O ₂ monitor | <input type="checkbox"/> Combustible Gas |
| <input type="checkbox"/> Combustible Gas Meter: | <input type="checkbox"/> Aerosol and Particulate Monitor | <input type="checkbox"/> Radiation Meter Monitor |
| <input type="checkbox"/> Other: | <input type="checkbox"/> Other: | <input type="checkbox"/> Other: |

☐ Drager sampling; check appropriate chemical tubes:

- | | | | |
|---|--|--|--|
| <input type="checkbox"/> acetic acid | <input type="checkbox"/> chloroform | <input type="checkbox"/> hydrocarbons, halogenated | <input type="checkbox"/> nitrous fumes |
| <input type="checkbox"/> acetone | <input type="checkbox"/> chromic acid | <input type="checkbox"/> hydrocarbons, petroleum | <input type="checkbox"/> perchloroethylene |
| <input type="checkbox"/> alcohol | <input type="checkbox"/> cyanide | <input type="checkbox"/> hydrochloric acid | <input type="checkbox"/> phenol |
| <input type="checkbox"/> ammonia | <input type="checkbox"/> ethyl benzene | <input type="checkbox"/> hydrogen peroxide | <input type="checkbox"/> sulfur dioxide |
| <input type="checkbox"/> benzene | <input type="checkbox"/> formaldehyde | <input type="checkbox"/> hydrogen sulfide | <input type="checkbox"/> trichloroethane |
| <input type="checkbox"/> carbon tetrachloride | <input type="checkbox"/> hexane | <input type="checkbox"/> methylene chloride | <input type="checkbox"/> vinyl chloride |
| <input type="checkbox"/> chlorine | <input type="checkbox"/> hydrocarbons | <input type="checkbox"/> nitric acid | |
| <input type="checkbox"/> other: _____ | | | |

3.3.2 Analysis Procedures and Summary

Check boxes of methods used for analysis. The analytical methods per sample and sample location are presented in Table D.

NIOSH Methods:

- | | | |
|---|---|---|
| <input type="checkbox"/> Acids, Inorganic [7903] | <input type="checkbox"/> Hydrocarbons, aromatic [1501] | <input type="checkbox"/> PAHs (HPLC) [5506] |
| <input type="checkbox"/> Chromium, hexavalent [7600] | <input type="checkbox"/> Hydrocarbons, halogenated [1003] | <input type="checkbox"/> PAHs (GC) [5515] |
| <input type="checkbox"/> Elements (ICP) [7300] | <input type="checkbox"/> Hydrogen cyanide [6010] | |
| <input type="checkbox"/> Asbestos & other fibers [7400] | <input type="checkbox"/> Trichloroethylene | |
| <input type="checkbox"/> other: _____ | | |

ERS/START**Emergency and Time Critical QASP
Air***EPA Toxic Organic Methods:*

☐ Volatile organic compounds (SUMMA Canisters, GC) [TO-14A/15]

☐ *other:* _____

3.4 Analytical Methods and Procedures

The analytical methods per sample and sample location are presented in Table D. General field QC considerations and requirements are presented in Table E.

ERS/START

Emergency and Time Critical QASP
Air

Table D Sample Locations and Data Objective Summary					
Sampling Locations and Identifiers should correspond to location indicated on Figure A					
Sample Location(s) (should match with 3.3.1 and Figure A)	Sample Identifiers	Analytical Method Refer to Table A	Data Use Objective(s) Refer to Section 2.1	Data Category Refer to Section 2.3	Samples Matrix (soil or water)

Add additional pages if necessary.

3.6 Quality Assurance and Quality Control

General field QA/QC considerations and requirements are presented in Table E.

Table E Quality Control Samples and Data Quality Indicator Goals			
QC Sample	Number/Frequency	Data Quality Indicator Goals & Evaluation Criteria	Comments/Exceptions
			Site specific remarks:
FIELD SPECIFIED QA/QC			
Background or reference sample	At least one sample should be collected from an area believed to be unaffected by source contamination.	Source samples should be at least 3 times background.	Surface soil: up-slope. Surface water: upstream. Ground water: up-gradient.
			:
Field Blanks	1 per SDG ¹ , per matrix, per method	Source samples should be at least 3 times the blank.	Water only.
			:
Sampling Media	1 per SDG, per matrix, per method	Source samples should be at least 3 times the blank.	Volatile analytes, water only.
			:
Equipment Blanks	1 per SDG, per matrix, per method	Source samples should be at least 3 times the blank.	Only when the use of decontaminated non-dedicated equipment is involved.
			:
Field Duplicates or Replicates	1 per SDG, per matrix, per method	35% RPD ²	As needed by sampling objectives. The procedure for collecting duplicate samples can greatly effect the reproducibility.
			:
SELECTED LABORATORY QA/AC			
Method Blank	1 per SDG, per matrix, per method	Std and samples should be at least 3 times the blank.	Mandatory.
Matrix Spike	1 per SDG, per matrix, per method on field designated sample.	75 -125 %R	Designate sample on COC.
Matrix Spike Duplicate or Replicate	1 per SDG, per matrix, per method on field designated sample.	≤50 RPD for organics; ≤20 RPD for metals	Designate sample on COC.
Reference Standards	1 per SDG, per matrix, per method	75 -125 %R	If available.
Internal Standards	All samples	50 -200 %R	All GC/MS and some GC analyses only.
Laboratory Control Standards	1 per SDG, per matrix, per method	75 - 125 %R	Per method for organic analyses.

¹ SDG = Sample Delivery Group (Maximum 20 samples)

² RPD = Relative Percent Difference

³ %R = Percent Recovery

ERS/START

Emergency and Time Critical QASP
Air**4.0 Project Organization and Responsibilities****4.1 Schedule of Sampling Activities**

Sampling activities are summarized in Table F.

Table F Proposed Schedule of Work For Soil/Water Sampling Activities		
Activity	Start Date	End Date

Add additional pages if necessary.

4.2 Project Laboratories

Laboratories used for this project are summarized in Table G.

Table G Laboratories	
Lab Name/ Location	Methods

Add additional pages if necessary.

4.3 Project Personnel and Responsibilities

Personnel and responsibilities are summarized in Table H.

Table H Sample Team(s) Personnel	
Personnel (Agency)	Responsibility

Add additional pages if necessary.

4.4 Modification or Additions to the Generic Data Quality Objective for Emergency and Time Critical Sampling

Project specific modification to the generic DQO statements for this are summarized in Table I. Also indicate which DQO step corresponds to the addition or modification.

Table I DQO Modifications and Additions	
Additions or Modifications to the Generic DQO Output Statements	DQO Step

Add additional pages if necessary.

**EPA Emergency Response Section (ERS)
And Superfund Technical Assessment and Response Team (START)**

**Emergency Response and Time Critical
Quality Assurance Sampling Plan
For
Soil, Water and Miscellaneous Matrix Sampling**

Response Location:
(Site Name and TDD#)

Date:

Prepared by:

Reviewed by:

Approved by:

This sampling plan was prepared and delivered to the EPA OSC (select one):

☐ Prior to Sampling ☐ Post Sampling (within one month of sampling)

This emergency sampling plan is intended to be used in conjunction with the EPA=s Region 9 Emergency Response Section=s Generic Data Quality Objectives (DQOs) for Emergency Responses and Time Critical Evaluations. This sampling plan has been designed to assist field responders in their preparation for collecting, analyzing, shipping, storing and handling samples collected during an emergency response. The use of this generic sampling plan will involve forethought and planning that should help direct the sampling and analytical work. It is meant to be used in the case of emergency responses or time-critical responses when sampling teams may not have the opportunity to write a more thorough sampling plan. Sampling teams should always reference standard quality procedures, standard operations procedures, standard methods for sampling and analytical guidance.

The development of this generic plan will improve the documentation, communication, planning, and overall quality associated with the sampling and analysis by:

- 1) encouraging field teams to consider their goals and objectives before the generation of environmental data,
- 2) documenting predetermined information in a standardize format,
- 3) increasing the communication between sampling personnel and decision makers, and
- 4) detailing expectations and objective before samples are collected.

1.0 Introduction and Background. *Describe the site and specify the geographic boundaries for the site and any specific areas of concern. What is the problem, what precipitated the response, which agencies and other entities (e.g., contractors) are on site, who has taken the lead for the response and for environmental clean-up actions?*

2.0 Objectives. *Brief statement on the general project objective. What is the overall goal or objective? Specific objectives are summarized in Table D.*

2.1 Data Use Objectives. (How will the data be used?)

Data that are generated will be used: (Select Appropriate Boxes)

- 1 ☐ To be compared with a background or reference sample(s).
- 2 ☐ To be compared with an available detection or quantification level.
- 3 ☐ To assist in determining the presence or absence of a hazardous material or substance at levels above an available detection or quantification level.
- 4 ☐ To assist with determining the area of impact due to a hazardous material release. (i.e., horizontal and lateral extent).
- 5 ☐ To be compared with site-specific action levels or risk-based action levels (e.g., EPA PRGs) to assist in determination if health threats exist.
- 6 ☐ As definitive confirmatory data for confirmation of non-definitive (screening) data.
- 7 ☐ Other objectives:

2.2 Sampling Objectives. (What are you proposing to do?)

- 1 ☐ Sampling to determine only the presence or absence of a hazardous substance within the area of concern.
- 2 ☐ Sampling to estimate:
G contamination levels within the area of concern.
G contamination area(s) within a site.
- 3 ☐ Sampling to determine the location of hot spots within the area of concern..
- 4 ☐ Surface soil sampling to estimate the lateral extent of contamination
G of specific source area(s) or areas of concern
G over entire site
- 5 ☐ Sub-surface sampling to estimate the vertical extent of contamination
G of specific source area(s) or areas of concern
G over entire site.
- 6 ☐ Sampling off site to determine:

ERS/START**Emergency and Time Critical QASP
Soil, Water and Miscellaneous Matrix****2.3 Sample Matrices**

- 1 ☐ Surface soils
- 2 ☐ Subsurface soil
Depth(s):
- 3 ☐ Surface water
- 4 ☐ Groundwater
Depth(s):
- 5 ☐ Other aqueous matrices
Please specify:
- 6 ☐ Wipe samples
- 7 ☐ Biota
Please specify:
- 8 ☐ Other matrices:

Please note: Please use other QASPs for air and containerized samples.

2.4 Data Type

In general, data type and data needs should be decided prior to data generation. The data can be generally divided into three categories: definitive methodology data (generally data generated using standardize methods), non-definitive methodology data (also referred to as screening data) and screening data with at least 10% definitive conformation. The generation of definitive data is preferable, however in emergency and time critical situations where definitive data is not available, non-definitive data should be generated. Note that the data type is not an indicator of precision, accuracy or documentation completeness, or quality! Reported data should be verified (by a party other than the laboratory) as meeting specific quality control and data category requirements by following a verification or validation procedure. Refer to the START or ERS Quality Assurance Plans for specific quality parameters and requirements.

Check appropriate box(es):

- 1 ☐ Screening data will be generated. The data by itself may not be verifiable. **Due to the time critical situation, the data must be reported and may be used to make decisions.**
- 2a ☐ Screening data with at least 10 percent definitive data will be generated. Data using non-definitive analytical methodologies will be generated. **Due to the time critical situation,**

the data must be reported and may be used to make decisions prior to generation of definitive data. The screening data by itself may not be verifiable. Screening data will be evaluated and reported with definitive data at a later time.

- 2b ☐ Screening data with 10 percent definitive data will be generated. Data using non-definitive analytical methodologies will be generated. **Data will not be reported until it is evaluated against definitive data.**
- 3a ☐ Definitive data will be generated. The sampling and analysis must be done on an emergency basis. **Due to the time critical situation, the preliminarily data must be reported and used for comparison without validation. Analytical data packages will be required. However, since the data was not used or intended for decision making, validation of the data package will not be performed.** (Document generic DQO deviation in Section 4.4)
- 3b ☐ Definitive data will be generated. The sampling must be done on an emergency basis. **Due to the time critical situation, preliminary data must be reported and may be used to make decisions without validation. The generated analytical documentation packages will be reviewed and validated. Qualified data will be reported after validation.**
- 3c ☐ Definitive data will be generated. **Full documentation will be required. Analytical data packages will be reviewed and validated prior to reporting.**

2.5 Contaminants of Concern

Potential contaminants of potential concern (COPC), proposed analytical method, proposed action levels and available reporting limit are summarized in Table A.

Table A Contaminants of Concern			
Potential COC	Proposed Analytical Method	Proposed Action Level	Available Reporting Limit
Other Data Collection	GPS	Visual	Interviews
			Magnetometer

ERS/START**Emergency and Time Critical QASP
Soil, Water and Miscellaneous Matrix**

Activity (non-chemical) (circle all that apply)	Other Geophysical	Modeling	Photography	File Search
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Add additional pages if necessary.

3.0 Approach and Sampling Methodologies**3.1 Sampling Approach**

Indicate sampling approaches to be used (select approach)

- 1 ☐ Due to the lack of site information the approach will be determined in the field based on professional judgment of START.
- 2 ☐ Due to the lack of site information the approach will be determined in the field based on professional judgment of US EPA.
- 3 ☐ Due to the lack of site information the approach will be determined in the field based on professional judgment of local regulator.
- 4 ☐ Judgmental (Biased)
- 5 ☐ Random
- 6 ☐ Systematic
- 7 ☐ Transects
- 8 ☐ Search-Grid

If a search-grid, specify grid type (circle one): Square Triangle Rectangle

Size of contamination hot-spot to be detected:

Shape of hot-spot (circle one): Circle Elliptical Elongated-Elliptical

Required Grid Spacing:

Acceptable probability of missing hot-spot (circle one): 5 % 10 % 20% 40%

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**Emergency and Time Critical QASP
Soil, Water and Miscellaneous Matrix**

ERS/START**Emergency and Time Critical QASP
Soil, Water and Miscellaneous Matrix****3.2 Field Analysis Equipment**

Field analysis equipment requirements are summarized in Table B1.

Table B1 Field Analytical Equipment				
Analysis Equipment Specify the field analytical procedures to be used. Select the appropriate boxes.	Model	Analyses	Matrix	Resource/Contractor
<input type="checkbox"/> X-Ray Fluorescence (XRF) Device [for metals]				
<input type="checkbox"/> Lumex (XRF) Mercury Instrument				
<input type="checkbox"/> Oil Analysis Kit [for oils]				
<input type="checkbox"/> Immunoassay Test Kits [pesticides, oils, chlorinated substances]				
<input type="checkbox"/> Chlor-N-Soil/Chlor-N-Oil test kits[PCBs, chlorinated substances]				
<input type="checkbox"/> pH Meter				
<input type="checkbox"/> Other field test kits [for pesticides]				
<input type="checkbox"/> Radiation Meter (such as Victoreen)				
<input type="checkbox"/>				

Revised: March 15, 2005

ERS/START**Emergency and Time Critical QASP
Soil, Water and Miscellaneous Matrix**

<input type="checkbox"/>				
<input type="checkbox"/>				

ERS/START**Emergency and Time Critical QASP
Soil, Water and Miscellaneous Matrix****3.3 Field Sampling Equipment**

Field equipment requirements are summarized in Table B2.

Table B2 Field Sampling and Decontamination Equipment				
Analyses and Matrix	Sampling Equipment	Dedicated or Reusable	Decontamination Solution	Resource/ Contractor

Add additional pages if necessary.

3.4 Field Methods and Procedures

3.4.1 Sample Locations. Indicate the sampling location name, describe location, and indicate rationale for each sample location chosen.

Add additional pages if necessary.

ERS/START**Emergency and Time Critical QASP
Soil, Water and Miscellaneous Matrix****3.4.2 Sample Labeling and Documentation**Sample Jar Labels

Sample labels will clearly identify the particular sample and should include the following:

1. Site name
2. Time and date samples were taken
3. Sample preservation
4. Analysis requested
5. Sample location and/or identification number

Sample labels will be securely affixed to the sample container.

Chain of Custody Record

A chain of custody record will be maintained from the time the sample is taken to its final deposition. Every transfer of custody must be noted and signed for, and a copy of this record kept by each individual who has signed. When samples (or groups of samples) are not under direct control of the individual responsible for them, they must be stored in a secured container sealed with a custody seal.

The chain of custody record should include (at minimum) the following:

1. Sample identification number
2. Sample information
3. Sample location
4. Sample date and time
5. Names(s) and signature(s) of sampler(s)
6. Signature(s) of any individual(s) with control over samples

Custody Seals

Custody seals demonstrate that a sample container has not been tampered with or opened. The individual in possession of the sample(s) will sign and date the seal, affixing it in such a manner that the container cannot be opened without breaking the seal. The name of this individual, along with a description of the samples= packaging, should be noted in the field book.

All sample documents will be completed legibly in ink. Any corrections or revisions will be made by lining through the incorrect entry and by initialing the error. These include the logbooks, the chain of custody forms, this field QASP and any other tracking forms.

ERS/START**Emergency and Time Critical QASP
Soil, Water and Miscellaneous Matrix****Field Logbook**

The field logbook is essentially a descriptive notebook detailing site activities and observations so that an accurate account of field procedures can be reconstructed in the writer's absence. All entries will be dated and signed by the individuals making the entries and will include the following:

1. Site name and project number
2. Names of sampling personnel
3. Dates and times of all entries (military time preferred)
4. Descriptions of all site activities, especially sampling start and ending times. Include site entry and exit times
5. Noteworthy events and discussions
6. Weather conditions
7. Site observations
8. Identification and description of samples and locations
9. Subcontractor information and names of on-site personnel
10. Date and time of sample collections, along with chain of custody information
11. Record of photographs
12. Site sketches
13. Exact times of various activities and occurrences related to sampling
14. Deviations from standard procedures or methods and the rational for the deviations.

3.4.3 Sample Containers and Preservatives

Containers and preservatives are summarized in Table C.

Table C Containers and Preservatives			
Analyses and Matrix	Container Type (per sample)	Preservation Method	Holding Time

Add additional pages if necessary.

3.5 Analytical Methods and Procedures

The analytical methods per sample and sample location are presented in Table D. General field QC considerations and requirements are presented in Table E.

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Emergency and Time Critical QASP
Soil, Water and Miscellaneous Matrix

Table D Sample Locations and Data Objective Summary					
Sampling Locations and Identifiers should correspond to location indicated on Figure A					
Sample Location(s) (should match with 3.3.1 and Figure A)	Sample Identifiers	Analytical Method Refer to Table A	Data Use Objective(s) Refer to Section 2.1	Data Category Refer to Section 2.3	Samples Matrix

Add additional pages if necessary.

ERS/START

Emergency and Time Critical QASP
Soil, Water and Miscellaneous Matrix

3.6 Quality Assurance and Quality Control

General field QA/QC considerations and requirements are presented in Table E.

Table E Quality Control Samples and Data Quality Indicator Goals			
QC Sample	Number/Frequency	Data Quality Indicator Goals & Evaluation Criteria	Comments/Exceptions <i>Site specific remarks:</i>
FIELD SPECIFIED QA/QC			
Background or reference sample	At least one sample should be collected from an area believed to be unaffected by source contamination.	Source samples should be at least 3 times background.	Surface soil: up-slope. Surface water: upstream. Ground water: up-gradient. :
Field Blanks	1 per SDG ¹ , per matrix, per method	Source samples should be at least 3 times the blank.	Water only. :
Travel Blanks	1 per SDG, per matrix, per method	Source samples should be at least 3 times the blank.	Volatile analytes, water only. :
Equipment Blanks	1 per SDG, per matrix, per method	Source samples should be at least 3 times the blank.	Only when the use of decontaminated non-dedicated equipment is involved. :
Field Duplicates or Replicates	1 per SDG, per matrix, per method	Water - 25% RPD ² Soil - 35% RPD ² Other - 35%	As needed by sampling objectives. The procedure for collecting duplicate samples can greatly effect the reproducibility. :
Performance Standards	1 per project, per matrix, per method	75 -125 %R ³	If available. :
SELECTED LABORATORY QA/AC			
Method Blank	1 per SDG, per matrix, per method	Stds and samples should be at least 3 times the blank.	Mandatory.
Matrix Spike	1 per SDG, per matrix, per method on field designated sample.	75 -125 %R	Designate sample on COC.
Matrix Spike Duplicate or Replicate	1 per SDG, per matrix, per method on field designated sample.	≤50 RPD for organics; ≤20 RPD for metals	Designate sample on COC.
Reference Standards	1 per SDG, per matrix, per method	75 -125 %R	If available.
Internal Standards	All samples	50 -200 %R	All GC/MS and some GC analyses only.
Laboratory Control Standards	1 per SDG, per matrix, per method	75 - 125 %R	Per method for organic analyses.

¹ SDG = Sample Delivery Group (Maximum 20 samples)

² RPD = Relative Percent Difference

³ %R = Percent Recovery

ERS/START**Emergency and Time Critical QASP
Soil, Water and Miscellaneous Matrix****4.0 Project Organization and Responsibilities****4.1 Schedule of Sampling Activities**

Sampling activities are summarized in Table F.

Table F Proposed Schedule of Work For Sampling Activities		
Activity	Start Date	End Date

Add additional pages if necessary.

4.2 Project Laboratories

Laboratories used for this project are summarized in Table G.

Table G Laboratories	
Lab Name/ Location	Methods

Add additional pages if necessary.

ERS/START**Emergency and Time Critical QASP
Soil, Water and Miscellaneous Matrix****4.3 Project Personnel and Responsibilities**

Personnel and responsibilities are summarized in Table H.

Table H Sample Team(s) Personnel	
Personnel (Agency)	Responsibility

Add additional pages if necessary.

4.4 Modification or Additions to the Generic Data Quality Objective for Emergency and Time Critical Sampling

Project specific modification to the generic DQO statements for this are summarized in Table I. Also indicate which DQO step corresponds to the addition or modification.

Table I DQO Modifications and Additions	
Additions or Modifications to the Generic DQO Output Statements	DQO Step

Add additional pages if necessary.

**United States Environmental Protection Agency, Region 9
Emergency Response Section
Generic Data Quality Objectives Process Document
for
Emergency Response
Air Sampling**

BACKGROUND

Requirements

The generic data quality objectives (DQOs) presented in this document are based on typical technical and project directives encountered by the United States Environmental Protection Agency, (EPA), Region 9, Emergency Response Section (ERS) and the Ecology and Environment, Inc., Superfund Technical Assessment and Response Team (START) in emergency responses that involve contaminants released to air. The ERS and START planning process for an emergency response involving air contamination is reflected in this DQO document. This document, coupled with site-specific output statements, as documented in an emergency response sampling plan, is intended to meet the EPA=s DQO process requirements as stated in the ERS quality management plan (QMP) and START=s quality assurance project plan (QAPP). The following requirements and preconditions must be fulfilled to effectively implement these DQOs:

- The emergency responders must be familiar with air modeling and all types of air sampling procedures, and possess sufficient emergency response experience and training to make emergency sampling design decisions.
- The emergency responders must be sufficiently prepared and organized for emergency response situations in order to implement the planning, mobilization, and communications necessary to support expeditious sampling, analyses, and decision making.
- The emergency responders must be familiar with the START QAPP and/or the ERS QMP.
- The emergency responders must be familiar with the EPA=s DQO process and the information and objectives indicated in this generic DQO document. The emergency responders must document any additional DQO information and DQO modifications.
- Before any sample collection, START and EPA emergency responders must determine site-specific assessment parameters as indicated in the emergency response sampling plan.
- All DQO-related information not specified in this DQO document or the emergency response sampling plan must be recorded in other project documentation (e.g., sampling plans, logbooks, action memos, or pollution reports).

STEP 1. THE PROBLEM

Background for an Emergency Response Air Sampling Project

The EPA ERS was notified of a potential or actual contaminant release into air that may pose a significant imminent threat to human health and/or the environment. The location of the air release is within the EPA, Region 9. Because of the nature of the perceived threat, the investigation must proceed immediately. There may be no available data regarding the types of contaminants, or the specific location, extent, or magnitude of contamination.

Planning Team

Primary Decision Maker:	Responding EPA On-Scene Coordinator (OSC)
Plan Development:	START emergency responders and OSC
Plan Approval:	Responding OSC
On-Scene Assistance:	Local first responders
Supplemental Remote or On-Scene Support:	START response manager, START quality assurance (QA) coordinator, START analytical service provider, Emergency Rapid Response Services (ERRS) contractor, EPA Emergency Response Team (ERT), and Eagle Equipment Warehouse

The names and affiliations of the actual planning team will be documented in the field logbook or in the emergency response sampling plan.

Conceptual Site Model

- X A description of the release and a list of potential contaminants of concern (COCs) are provided in the site=s emergency response sampling plan.
- X The medium of concern is air. This medium will include ambient and indoor air.

Exposure Scenario

- X Air is being evaluated by the EPA, Region 9, to determine whether contamination poses an imminent threat to human health or the environment.
- X Concerns include direct exposure of airborne contaminants to human and environmental receptors; migration of air contaminants throughout a localized area; and, to a lesser degree, migration of contaminants from the air source to surface soil or water.

Resources

The planning and preparation for emergency response situations that involve environmental data collection in the EPA, Region 9, are administered and implemented by the EPA ERS and START, at the direction of the EPA OSC.

This is an emergency response under the technical direction of the EPA ERS. Labor resources include:

- X The responding OSC, who will typically oversee all data collection operations related to this project.
- X START personnel with a budget that will not typically exceed \$25,000.
- X Local first responders.
- X The EPA ERT air response group.
- X Federal, regional, state, or local responders.
- X The ERRS contractor.
- X EPA ERS personnel.

Analytical service resources include the following:

- X A START laboratory will be assigned upon request. Laboratory assignment will be based on site location or specific analytical requirements.
- X An EPA ERT air laboratory may be available.
- X The Air Resources Board and Regional Air Quality Controls Boards analytical resources may be available.

EPA-owned equipment resources are readily available and accessible for mobilization to an emergency response through the Eagle Warehouse, 888-447-5602 for the San Francisco office and 562-705-4900 for the Long Beach office. Use of EPA equipment can only be requested by EPA ERS personnel. This emergency equipment is accessible 24 hours per day, seven days per week. EPA emergency response equipment is continuously maintained in a response-ready condition. Sample collection media (jars, sorbent tubes, etc.) are available through the START.

Additional emergency air sampling equipment and air monitoring instruments may be available from the EPA ERT and its emergency response contractor in Edison, New Jersey.

Resource Constraints

The EPA, Region 9, QA Office resources, regional laboratory resources, and Contract Laboratory Program laboratory resources are typically not readily available for emergency response. Leased or rented equipment is not readily accessible for emergency response situations. The abilities and availability of resources other than EPA ERS and START resources will vary with the situation and location.

STEP 2. THE DECISION

Principal Study Questions

Primary Questions:

- #1 What are the COCs?
- #2 What is the point source for the air contamination?
- #3 What are the wind direction and speed?
- #4 Are there schools, hospitals, or other sensitive locations downwind of the release?
- #5 What are the contaminants and contaminant concentrations for specific samples that may be used as enforcement documentation?

Secondary Questions:

- #6 Based on the answers to the primary questions, what is an initial estimate of the level of the contamination above the action level?
- #7 Based on the answers to the primary questions, what are the contaminants of predominant concern?
- #8 Are there anticipated weather changes that could change airborne contamination migration?

Actions that Could Result from the Resolution of Study Questions

- 1) The EPA would initiate no further action on the site in relation to the air release.
- 2) The EPA would initiate a further investigation of the air release.
- 3) The EPA would initiate a removal action related to the air release.
- 4) The EPA would initiate legal action.
- 5) The EPA would supply information to local, regional, or state regulators, and defer any EPA action.
- 6) The EPA would supply information and technical support to local, regional, or state regulators, and defer any direct EPA action.

Decision Statements (Directives)

- X Determine the COCs and the action levels for the COCs.
- X Determine what sensitive receptors are located downwind of the release.
- X Estimate the areal extent and estimated concentrations of contamination.
- X Determine what contaminants are of predominant concern and whether an expeditious sampling and analysis protocol can be used to monitor and screen those contaminants.
- X Document contamination to support project decisions and future legal activities.
- X If warranted, determine potential migration of the contaminant plume.

STEP 3. DECISION INPUTS

Specific Data Required

- X Information regarding the types of hazardous substances that may have been released to the air.
- X Location of release point source.
- X Data capable of providing a rough estimate of the extent and concentrations of contamination.
- X Analytical data that are capable of legally documenting specific contamination.
- X Physical characteristics (e.g., clouds, temperature, and barometric pressure) of the relevant air body.
- X Chemical and physical properties and characteristics of COCs.
- X Analytical data for COCs that are capable of documenting and supporting emergency decisions.
- X Local meteorological data and predicted changes.
- X Data regarding the locations of schools, day care facilities, elder care facilities, hospitals, residential communities, and other sensitive locations.
- X Specific data needs will be indicated in the site=s emergency response sampling plan.

Sources for Study Information

- X Spill report information from first responders and responsible parties.
- X Material safety data sheets, chemical inventory information, manifest data, or local Toxic Release Inventory (TRI) database information relevant to the release. (TRI information is generally managed by local response agencies).
- X Verbal or written information from witnesses, first responders, and other on-scene personnel.
- X Chemical reference books and databases.
- X Site information collected during the emergency response.
- X Screening data generated during the emergency response.
- X Definitive analytical data generated during the emergency response.
- X Air dispersion models.
- X Weather reports.

Information Needed to Establish Action Level

- X Because a preliminary (emergency) action level may be based on the expected analytical reporting limits (of the laboratory providing the analysis), the analytical reporting limits for COCs are needed.
- X EPA, Region 9, ambient air preliminary remediation goals and National Institute of Occupational Safety and Health (NIOSH) exposure limits. If available, the local applicable or relevant and appropriate requirements for each COC.
- X Upwind data regarding contaminant concentration levels.

Confirm that Measurement Methods Exist to Provide Data

- X NIOSH sampling and analytical methods are used for emergency response measurements where definitive data are needed.
- X EPA Compendium of Methods for Determination of Toxic Organic in Ambient Air (TO), Inorganic in Ambient Air (IO), and Air Pollutants in Indoor Air (IP) methods can provide measurement data; however, only the TO methods for volatile sampling and analysis are routinely used for emergency response.
- X Real-time field monitoring instruments can be used as emergency response air contamination measurement tools.
- X Analytical methods used for this project are specified in the site=s emergency response sampling plan.

STEP 4. STUDY BOUNDARIES

Specify Characteristics that Define the Population Being Studied

- X The approximate contaminant concentrations in air within the area of concern (AOC).
- X The specific COC concentrations in selected enforcement samples.
- X Potential COCs are specified in the site=s emergency response sampling plan.

Geographic Boundary of Investigation

- X The geographic boundary of air sampling will be determined during the emergency response based on the professional judgment and experience of the responders.
- X Geographic boundaries are specified in the site=s emergency response sampling plan.

Temporal Boundary of Investigation

Data must be generated promptly to facilitate the on-scene emergency decision-making process. Unless otherwise specified and documented, the temporal boundaries are as follows:

- X Sample planning will take place just before sample collection.
- X Sample collection will generally take place immediately following verbal directives or approval from the OSC.
- X Analytical field data (i.e., data generated on scene using field-screening techniques or air monitoring instrumentation) that are needed to make on-scene emergency decisions must be generated and reported immediately.
- X Analytical data (definitive or non-definitive) used for on-scene emergency decisions must be generated within 24 to 48 hours after samples are collected.
- X Estimations derived from field-generated data that are used for on-scene emergency decisions must be generated and reported immediately.
- X All other preliminary definitive and non-definitive data will be reported within four weeks of sample collection.
- X Validated data will be reported approximately eight weeks after sample collection.

Other Constraints on Data Collection

- X It may not be possible to generate high-quality data that are thoroughly documented in an expeditious time frame.
- X The turn-around times for data are always estimated and cannot be ensured. Sample and system problems may indiscriminately increase data turn-around times.
- X Because some analytical data may be required immediately in order to facilitate the on-scene emergency decision-making process, it may be necessary to forgo some QA measures, including data review, in order to meet this requirement.
- X Definitive data will be validated before final reporting.
- X All other data used to make decisions will be reviewed before final reporting.
- X Physical constraints, such as bodies of water, rough terrain, barriers, lack of lighting, and poor weather conditions, may exist and will be addressed on site

- based on the professional judgment and experience of the responders.
- X Civil constraints, such as legal site access, permit requirements, and unfriendly neighborhoods, may exist and will be addressed on scene based on the situation.
 - X Because of the complex nature of ambient air sampling and the complications and costs of collecting and analyzing air samples, it may be necessary to implement alternatives to sampling, such as modeling. It is possible to answer most of the study questions without air sampling and analysis by using air dispersion modeling. Air dispersion modeling programs are used to estimate the extent of air contamination over large areas. These programs estimate dispersions without the use of analytical data from air sampling. However, the uncertainty associated with these estimations is large.

STEP 5. DECISION RULE

Statistical Parameter

Unless otherwise specified and documented, this investigation is interested in the worst-case values for each decisional unit. Unless otherwise specified and documented, the decisional unit for this investigation is the entire AOC.

Action Levels

The action levels are specified in the emergency response sampling plan. Unless otherwise specified in the site=s emergency response sampling plan or other project documents, the action levels for the site will be the laboratory=s analytical reporting limits.

Decision Rules

- X If the air contaminant concentrations at the sample locations are less than the action level, or if air release dispersion modeling data do not indicate that contamination is exceeding an action level, then the release may not be subject to removal action.

- X If the air contaminant concentrations at the sample locations exceed the action level, or if air dispersion modeling data indicate that contamination is exceeding an action level, then the release may be subject to additional investigations.

- X If the air contaminant concentrations at the sample locations exceed the action level, or if air dispersion modeling data indicate that contamination is exceeding an action level, then the release may be subject to an EPA removal action.

- X If the air contaminant concentrations at the sample locations exceed the action level, or if air dispersion modeling data indicate that contamination is exceeding an action level, then the EPA, Region 9, may defer additional action to regional, state, or local regulators.

- X If the air contaminant concentrations at the sample locations exceed the action level, or if air dispersion modeling data indicate that contamination is exceeding an action level, then the release may be subject to a removal or mitigating action by the responsible party. The EPA, Region 9, may oversee action or defer the oversight to regional, state, or local regulators.

- During an on-scene emergency response or before data reporting, the OSC could develop additional decision rules that could involve additional actions. Additional decision rules will be recorded with the project documentation (e.g., sampling plan, logbook, OSC action memo, or pollution report).

STEP 6. LIMITS ON DECISION ERRORS

Range of the Parameters of Interest

The COC concentrations may range from nondetect to several thousand times the action level. However, for emergency responses, concentrations above the action level that are of immediate danger to public health and the environment are of principal concern.

The Null Hypothesis or Baseline Condition

The COC concentration in air exceeds the action level.

Alternative Hypothesis

The COC concentration in air is less than the action level.

Decision Errors

<u>DECISION ERRORS</u> Air Emergency Response		
Decision Error	Deciding that COC concentrations in air <u>exceed</u> the action level when they do not.	Deciding that COC concentrations in air <u>do not exceed</u> the action level when they do.
True Nature of Decision Error	The sample concentration does not exceed the action level.	The sample concentration does exceed the action level.
The Consequence of Error	Air release will either undergo additional investigation or initiate a removal action. Each situation would cost the EPA, Region 9, additional resources of time, money, and manpower.	The COC concentrations in air could lead to direct exposure to the community and environment. Exposure would be an imminent threat to human health and/or the environment.
Which Decision Error Has More Severe Consequences near the Action Level?	LESS SEVERE	MORE SEVERE because the contaminated air may pose risks to human health and/or the environment.
Error Type Based on Consequences	False Negative Decision Decision that the air contaminant concentrations are greater than the action level when they actually are not.	False Positive Decision Decision that the air contaminant concentrations are less than the action level when they actually are not.
Definitions False Negative Decision = A false negative decision error occurs when the null hypothesis is not rejected when it is false. False Positive Decision = A false positive decision error occurs when the null hypothesis is rejected when it is true. See the EPA document titled, <i>Guidance for the Data Quality Objective Process</i> , Chapter 6, (EPA QA/G-4) for additional guidance regarding decision error.		

Decision Error Limits Goals

Decision Error Limits Goals for Emergency Responses		
True Concentration of Sample (% of Action Level)	Typical Decision Error Probability Goals (Based on Professional Judgment)	Type of Decision Error
0B50	Less than 5%	False negative
50B100	Gray area ¹	False negative
100B200	25 % ²	False positive
200B500	5%	False positive
500B1,000	Less than 1%	False positive
>500	Small	False positive
The goals in this table are based on professional judgment as relevant to a typical emergency response for air contamination. Specific project goals may vary with the situation.		
¹ <i>Gray area</i> is where relatively large decision errors are acceptable. ² Note that large decision errors are expected when the true contaminant concentrations are 100% to 200% of the action level.		

STEP 7. DESIGN FOR OBTAINING DATA

All sampling, analytical, and QA activities will proceed under the START QAPP and documents referenced therein. All site-specific planning and activities will be documented either in an emergency response sampling plan or within a bound field logbook. A record of sampling activities must also be documented in a bound field logbook.

START has developed an emergency response quality assurance sampling plan (ER-QASP) for emergency air sampling. This ER-QASP will be used for all emergency response situations that require air sampling and analysis. When possible, this sampling plan will be completed before the emergency response air sampling. In all cases, it will be completed within 30 days of the emergency response sampling event. The ER-QASP comprises four sections: ABackground,@ AObjectives,@ ASampling and Analysis Methodology,@ and AProject Organization and Responsibilities.@ The ER-QASP, the START QAPP, and the DQOs are intended to meet the EPA, Region 9, planning requirements for emergency response situations.

Before sample collection, the emergency responders should review sampling procedures and relevant QA/quality control (QC) requirements for selected analytical methods.

General Design

The collection of background/reference samples, replicates, and field blanks is recommended but not required. All analytical QA/QC and documentation specified in the START QAPP is recommended; however, such QA/QC and documentation may be considered secondary to the expeditious generation of data.

Based on emergency response goals and objectives, statistical measurement and determination of sampling error for emergency air sampling are not practical or necessary. However, where practicable, sampling and analytical measurement error will be estimated and reported with the data validation report.

Because of the emergency nature of the response, the specific sampling methodology and emergency response sampling design must be chosen in the field based on the experience, training, and professional judgment of the responders. However, unless otherwise justified, all air samples, other than point source samples, will be collected from the breathing zone.

Emergency response decisions will be made by the OSC based on professional judgment and training using analytical and non-analytical information. The analytical information initially generated by sampling will comprise discrete sample data and not statistical data. Concentrations of contaminants in unsampled areas will be estimated based on the professional judgment of the responders.

When possible, analytical measurement error will be minimized through the use of proper QA/QC practices and conformance to QA limits. Sampling error will be minimized when possible by increasing sampling locations, increasing sampling times, or reducing the AOC.

The OSC will consider data uncertainty when making decisions based on discrete sampling data and estimated values. For most standardized methods, the greatest uncertainty for discrete air sampling data is assumed to lie within reported ranges 50% to 100 % of the action level. For unqualified and validated definitive data, the range may be 70% to 100% of the action level. The uncertainty range for field-screening methods depends on the method and will be determined and considered before the data=s use for decisions. The uncertainty for estimated data (i.e., data based on extrapolations and interpolations) is typically greater than that for discrete data. The uncertainty for estimated data will be acknowledged and considered before the data=s use. Considerations of uncertainty will mitigate false positive decisions based on data values near the action level. The use of standard methods and procedures could mitigate all other false positive and false negative decisions.

Data validation, independent of the laboratory, will be performed on all enforcement data and all definitive data that are used in decision making. Data review, independent of project management, will be performed on all non-definitive and screening data used in the decision-making process. Because of the nature of emergency response activities, the validation will be performed after the decision making but before final reporting.

Biased and Judgmental Ambient Air Sampling

Because the primary objective of sample collection in an emergency response is to expeditiously identify the significant contamination threats, the sampling approach will initially concentrate on identifying and locating the highest or most significant levels of contamination. This sampling will be biased toward directly downwind locations from the suspected or known release. Additional sampling locations will be selected to monitor sensitive areas (schools, day care facilities, elder care facilities, and hospitals). Wind directions and speed information must be either collected using an on-scene meteorological station or inferred based on meteorological data from the closest accessible meteorological station. Because wind direction is unpredictable over time, time-composited samples should be collected at multiple locations away from the point source.

Air Dispersion Modeling Data

Meteorological and chemical release data must be collected in order to utilize air dispersion modeling. The on-scene use of modeling will depend on the situation and will be based on the professional judgment of the responders.

Indoor Air Sampling

Indoor AOCs will be sampled with a bias toward a point source location, high occupation areas, and areas where contaminants would tend to accumulate. A random sampling approach will be used for large indoor areas where no definitive point source is known.

Enforcement Sampling

Samples may be collected from selected locations and analyzed in order to document the presence and concentration of contamination at those locations for legal enforcement. This sampling would include complete documentation regarding the sampling and analysis performed. The samples would be analyzed in a non-time-critical manner to ensure maximum analytical quality and documentation.

Other Sampling Approaches

Other sampling approaches are typically not used during an emergency response. The data that these approaches generate are not needed to meet the emergency response objective. If physical information suggests that contaminants in the air may have precipitated to other media (e.g., particulate fall-out), then limited judgmental sampling of those media, when practicable, should be included.

**United States Environmental Protection Agency, Region 9
Emergency Response Section
Generic Data Quality Objectives Process Document
for
Emergency Response
Soil Sampling**

BACKGROUND

Requirements

The generic data quality objectives (DQOs) presented in this document are based on typical technical and project directives encountered by the United States Environmental Protection Agency, (EPA) Region 9, Emergency Response Section (ERS) and the Superfund Technical Assessment and Response Team (START) in emergency responses that involve releases to soil. The ERS and START planning process for an emergency response involving soil contamination is reflected in this DQO document. This document, coupled with site-specific output statements, as documented in an emergency response sampling plan, is intended to meet the EPA=s DQO process requirements as stated in the ERS quality management plan (QMP) and START=s quality assurance project plan (QAPP). The following requirements and preconditions must be fulfilled to effectively implement these DQOs:

- The emergency responders must be familiar with all types of soil sampling procedures and possess sufficient emergency response experience and training to make emergency sampling design decisions.
- The emergency responders must be sufficiently prepared and organized for emergency response situations in order to implement the planning, mobilization, and communications necessary to support expeditious sampling, analyses, and decision making.
- The emergency responders must be familiar with the START QAPP and/or the ERS QMP.
- The emergency responders must be familiar with the EPA=s DQO process and the information and objectives indicated in this generic DQO document. The emergency responders must document any additional DQO information and DQO modifications.
- Before any sample collection, the emergency responders must determine site-specific assessment parameters as indicated in the emergency response sampling plan.
- All DQO-related information not specified in this DQO document or the emergency response sampling plan must be recorded in other project documentation (e.g., sampling plans, logbooks, action memos, or pollution reports).

STEP 1. THE PROBLEM

Background for an Emergency Response Soil Sampling Project

The EPA ERS was notified that a release to soil that may pose a significant imminent threat to human health and/or the environment has been identified. The location of the contaminated soil is within the EPA, Region 9. Because of the nature of the perceived threat, the investigation must proceed immediately. There may be no available data regarding the types of contaminants, or the specific location, extent, or magnitude of soil contamination.

Planning Team

Primary Decision Maker:	Responding EPA On-Scene Coordinator (OSC)
Plan Development:	START emergency responders and OSC
Plan Approval:	Responding OSC
On-Scene Assistance:	Local first responders
Supplemental Remote or On-Scene Support:	START response manager, START quality assurance (QA) coordinator, START analytical service provider, Emergency Rapid Response Services (ERRS) contractor, EPA Emergency Response Team (ERT), and Eagle Equipment Warehouse

The names and affiliations of the actual planning team will be documented in the field logbook or in the emergency response sampling plan.

Conceptual Site Model

- X A description of the site and a list of the potential contaminants of concern (COCs) are provided in the site=s emergency response sampling plan.
- X The medium of concern is soil. This medium will include surface soil, subsurface soil, and sediments either in place or in piles.

Exposure Scenario

- X The site is being evaluated by the EPA, Region 9, to determine whether it poses an imminent threat to human health and/or the environment.
- X Concerns include migration of contaminants from soil to other media and direct exposure of human and/or environmental receptors to soil contaminants.

Resources

The planning and preparation for emergency response situations that involve environmental data collection in the EPA, Region 9, are administered and implemented by the EPA ERS and START, at the direction of the EPA OSC.

This is an emergency response under the technical direction of the EPA ERS. Labor resources include:

- X The responding OSC, who will typically oversee all data collection operations related to this project. A responding OSC must be capable of responding immediately.
- X START personnel with a budget that will not typically exceed \$25,000. START responders must be capable of responding immediately.
- X Local first responders.
- X Federal, regional, state, or local responders.
- X The ERRS contractor. The ERRS contractor must be capable of responding immediately.
- X EPA ERS personnel.

Analytical service resources include the following:

- X A START laboratory will be assigned upon request. Laboratory assignment will be based on site location or specific analytical requirements.

EPA-owned equipment resources are readily available and accessible for mobilization to an emergency response through the Eagle Warehouse, 888-447-5602 for the San Francisco office and 562-705-4900 for the Long Beach office. Use of EPA equipment can only be requested by EPA ERS personnel. This emergency equipment is accessible 24 hours per day, seven days per week. EPA emergency response equipment is continuously maintained in a response-ready condition. Sample collection media (jars, sorbent tubes, etc.) are available through the START.

Additional emergency sampling equipment and field analytical instruments may be available from the United States Coast Guard Pacific Strike Team in Novato, California, and from the EPA ERT and its emergency response contractor in Edison, New Jersey.

Resource Constraints

The EPA Region 9 QA Office resources, regional laboratory resources, and Contract Laboratory Program laboratory resources are typically not readily available for emergency response. Leased or rented equipment is not readily accessible for emergency response situations. The abilities and availability of resources other than EPA ERS and START resources will vary with the situation and location.

STEP 2. THE DECISION

Principal Study Questions

Primary Questions:

- #1 What are the COCs?
- #2 What is the general area (areal extent) of soil contamination?
- #3 Has contamination migrated laterally beyond the area of the release?
- #4 What are the estimated contaminant concentrations within the contaminated area?
- #5 What are the contaminants and contaminant concentrations for specific selected samples that may be used as enforcement documentation?

Secondary Questions:

- #6 Based on the answers to the primary questions, what is the rough estimated volume of soil with contamination that exceeds the action level?
- #7 Based on the answers to the primary questions, what is the contaminant(s) of predominant concern?

Actions that Could Result from the Resolution of Study Questions

- 1) The EPA would initiate no further action on the site in relation to the soil contamination.
- 2) The EPA would initiate a further investigation of the soil contamination.
- 3) The EPA would initiate a removal action to mitigate or remove the contaminated soil.
- 4) The EPA would initiate legal action.
- 5) The EPA would defer any direct EPA action to local or state regulators. The EPA would supply technical support and information to regulators.
- 6) The EPA would defer any direct EPA action and support to local, regional, or state regulators. The EPA would supply regulators with information collected during the response.

Decision Statements (Directives)

- X Determine the COCs and the action levels for the COCs.
- X Roughly estimate the lateral extent and concentrations of contamination.
- X Roughly estimate the volume of soil that might contain COCs above action levels.
- X Determine what contaminant(s) is of predominant concern and whether an expeditious sampling and analysis protocol can be used to screen for that contaminant(s).
- X Document contamination to support project decisions and future legal activities.
- X Visually determine whether COCs in soil might have migrated (or are migrating) to other media. Provide documentation to support determination.

STEP 3.

DECISION INPUTS

Specific Data Required

- X Information regarding the types of hazardous substances that may have been released to soil.
- X Action levels for potential COCs.
- X Analytical data capable of providing a rough estimate regarding the extent and concentration levels of contamination.
- X Analytical data that are capable of legally documenting specific contamination of selected samples.
- X Physical characteristics (e.g., topography and geology) of the site.
- X Chemical and physical properties and characteristics of COCs.
- X Analytical data for COCs that are capable of documenting and supporting emergency decisions.
- X Specific data needs will be indicated in the site=s emergency response sampling plan.

Sources for Study Information

- X Spill report information from first responders and responsible parties.
- X Material safety data sheets for the site, and site chemical inventory information or local Toxic Release Inventory (TRI) database information (TRI information is generally managed by local response agencies).
- X Chemical reference books and databases.
- X Verbal or written information from witnesses, first responders, and other on-scene personnel.
- X Site information collected during the emergency response.
- X Screening data generated during the emergency response.
- X Definitive analytical data generated during the emergency response.
- X Data collection activities specified in the site=s emergency response sampling plan.

Information Needed to Establish Action Level

- X Because a preliminary (emergency) action level may be based on the expected analytical reporting limits (of the laboratory providing the analysis), the analytical reporting limits for COCs are needed.
- X EPA, Region 9, soil preliminary remediation goals or soil screening levels are needed for COCs.
- X If available, the local applicable or relevant and appropriate requirements for each COC.

Confirm that Measurement Methods Exist to Provide Data

- X EPA SW-846 Methods are typically used for all measurements.
- X Analytical methods for this project are specified in the site=s emergency response sampling plan.

STEP 4. STUDY BOUNDARIES

Specify Characteristics that Define the Population Being Studied

- X The approximate COC concentrations in soil throughout the area of concern (AOC)
- X The specific COC concentrations of selected enforcement samples.
- X Potential COCs are specified in the site=s emergency response sampling plan.

Geographic Boundary of Investigation

- X The geographic boundary of sampling will be determined during the emergency response based on professional judgment and experience of the responders.
- X Geographic boundaries are specified in the site=s emergency response sampling plan and referenced as the AOC.

Temporal Boundary of Investigation

Data must be generated promptly to facilitate the on-scene emergency decision-making process. Unless otherwise specified and documented, the temporal boundaries are as follows:

- X Sample planning will take place just before sample collection.
- X Sample collection will generally take place immediately following verbal directives or approval from the OSC.
- X Analytical field data (i.e., data generated on scene using field-screening techniques) that are needed to make on-scene emergency decisions must be generated and reported immediately.
- X Analytical data (definitive or non-definitive) used for on-scene emergency decisions must be generated within 24 to 48 hours after samples are collected.
- X Estimations derived from field-generated data that are used for on-scene emergency decisions must be generated and reported immediately.
- X All other preliminary definitive and non-definitive data will be reported within four weeks of sample collection.
- X Validated data will be reported approximately eight weeks after sample collection.

Other Constraints on Data Collection

- X It may not be possible to generate high-quality data that are thoroughly documented in an expeditious time frame.
- X The turn-around times for data are always estimated and cannot be ensured. Sample and system problems may indiscriminately increase data turn-around times.
- X Because some analytical data may be required immediately in order to facilitate the on-scene emergency decision-making process, it may be necessary to forgo some QA measures, including data review, in order to meet this requirement.
- X Definitive data will be validated before final reporting.
- X All other data used to make decisions will be reviewed before final reporting.
- X Physical constraints, such as rough terrain, bodies of water, barriers, lack of lighting, and poor weather conditions, may exist and will be addressed on scene based on the experience and professional judgment of the responders.
- X Civil constraints, such as legal site access, permit requirements, and unfriendly

neighborhoods, may exist and will be addressed on scene based on the situation.

STEP 5. DECISION RULE

Statistical Parameter

Unless otherwise specified and documented, this investigation is interested in the worst-case values for each decisional unit. Unless otherwise specified and documented, the decisional unit for this investigation is the entire AOC.

Action Levels

The action levels are specified in the emergency response sampling plan. Unless otherwise specified in the site's emergency response sampling plan or other project documents, the action levels for the site will be the laboratory's achieved analytical reporting limits.

Decision Rules

- X If the COC concentration at a sample location is less than the action level, then soil represented by that sample will not be considered contaminated and may not be subject to any removal action.
- X If the COC concentration at a sample location exceeds the action level, then soil represented by that sample will be considered contaminated and may be subject to additional investigations.
- X If the COC concentration at a sample location exceeds the action level, then soil represented by that sample will be considered contaminated and may be subject to an EPA removal action.
- X If the COC concentration at a sample location exceeds the action level, then soil represented by that sample will be considered contaminated and the EPA may defer additional action to regional, state, or local regulators.
- X If the COC concentration at a sample location exceeds the action level, then soil represented by that sample will be considered contaminated and may be subject to a removal action by the responsible party. The EPA, Region 9, may oversee removal or defer the oversight to regional, state, or local regulators.

During an on-scene emergency response or before data reporting, the OSC could develop additional decision rules that could involve additional actions. Additional decision rules will be recorded with the project documentation (e.g., sampling plan, logbook, OSC action memo, or pollution report).

STEP 6.

LIMITS ON DECISION ERRORS

Range of the Parameters of Interest

The COC concentrations may range from nondetect to several thousand times the action level. However, for emergency responses, concentrations above the action level that are of immediate danger to public health and the environment are of principal concern.

The Null Hypothesis or Baseline Condition

The COC concentration in soil exceeds the action level.

Alternative Hypothesis

The COC concentration in soil is less than the action level.

Decision Errors

<u>DECISION ERRORS</u> Soil Emergency Response		
Decision Error	Deciding that the sample concentration <u>exceeds</u> the action level when it does not.	Deciding that the sample concentration <u>does not exceed</u> the action level when it does.
True Nature of Decision Error	The sample concentration does not exceed the action level.	The sample concentration does exceed the action level.
The Consequence of Error	Areas of soil represented by the sample will undergo additional investigation or may be immediately excavated or treated. Each situation would cost the EPA, Region 9, additional resources of time, money, and manpower.	1) The community could be directly exposed to COCs in areas of contaminated soil. Exposure would be an imminent threat to human health and the environment. 2) The COCs in areas of contaminated soil could migrate from the soil to a drinking or agricultural water source. Exposure would be an imminent threat to human health. 3) The COCs in soil could migrate from soil to air. Exposure would be an imminent threat to human health and the environment. 4) The COCs in areas of contaminated soil could migrate from soil to sensitive environments. Exposure would be an imminent threat to the environment.
Which Decision Error Has More Severe Consequences near the Action Level?	LESS SEVERE	MORE SEVERE because the contaminated soil may pose risks to human health and/or the environment.
Error Type Based on Consequences	False Negative Decision A decision that the soil contaminant concentrations are greater than the action level when they actually are not.	False Positive Decision A decision that the soil contaminant concentrations are less than the action level when they actually are greater.
Definitions False Negative Decision = A false negative decision error occurs when the null hypothesis is not rejected when it is false. False Positive Decision = A false positive decision error occurs when the null hypothesis is rejected when it is true. See the EPA document titled, <i>Guidance for the Data Quality Objective Process</i> , Chapter 6, (EPA QA/G-4) for additional guidance regarding decision error.		

Decision Error Limits Goals

Decision Error Limits Goals for <u>Emergency Responses</u>		
True Concentration of Sample (% of Action Level)	Typical Decision Error Probability Goals (Based on Professional Judgment)	Type of Decision Error
0B75	Less than 5%	False negative
75B100	Gray area ¹	False negative
100B120	10%B50% ²	False positive
120-150	5%B10% ²	False positive
150B200	Less than 5%	False positive
>200	Very small	False positive
The goals in this table are based on professional judgment as relevant to a typical emergency response for soil contamination. Specific project goals may vary with the situation.		
¹ <i>Gray area</i> is where relatively large decision errors are acceptable.		
² Note that large decision errors are expected when the true contaminant concentrations are 100% to 150% of the action level.		

STEP 7. DESIGN FOR OBTAINING DATA

All sampling, analytical, and QA activities will proceed under the START QAPP and documents referenced therein. All site-specific planning and activities will be documented either in an emergency response sampling plan or within a bound field logbook. A record of sampling activities must also be documented in a bound field logbook.

START has developed an emergency response quality assurance sampling plan (ER-QASP) for soil and water sampling. This ER-QASP will be used for all emergency response situations that require soil sampling and analysis. When possible, this sampling plan will be completed before the sample collection. In all cases, it will be completed within 30 days of the emergency response sampling event. The ER-QASP comprises four sections: ABackground,@ AObjectives,@ ASampling and Analysis Methodology,@ and AProject Organization and Responsibilities.@ The ER-QASP, the START QAPP, and the DQOs are intended to meet the EPA, Region 9, planning requirements for emergency response situations.

Before sample collection, the emergency responders should review sampling procedures and relevant QA/quality control (QC) requirements for selected analytical methods.

General Design

The collection of background/reference samples, replicates, and field blanks is recommended but not required. All analytical QA/QC and documentation specified in the START QAPP is recommended; however, such QA/QC and documentation may be considered secondary to the expeditious generation of data.

Based on emergency response goals and objectives, statistical measurement and determination of sampling error for emergency soil sampling are not practical or necessary. However, where practicable, sampling and analytical measurement error will be estimated and reported with the data validation report.

Because of the emergency nature of the response, the specific sampling methodology and emergency response sampling design must be chosen in the field based on the experience, training, and professional judgment of the responders. Emergency response decisions will be made by the OSC based on professional judgment and training using analytical and non-analytical information. The analytical information initially generated by sampling will comprise discrete sample data and not statistical data. Concentrations of contaminants in unsampled areas will be estimated based on the professional judgment of the responders.

When possible, analytical measurement error will be minimized through the use of proper QA/QC practices and conformance to QA limits. Sampling error will be minimized when possible by increasing sampling points, reducing the AOC, and compositing.

The OSC will consider data uncertainty when making decisions based on discrete sampling data and estimated values. For most standardized soil methods, the greatest uncertainty is assumed to lie within reported ranges 60% to 100% of the action level. For unqualified and validated definitive data, the range will be 75% to 100% of action level. The uncertainty range for field-screening methods depends on the method and will be determined and considered before the data is used for decisions. The uncertainty for estimated data (i.e., data based on extrapolations and interpolations) is typically greater than that for discrete data. The use of standard methods and procedures could mitigate all other false positive and false negative decisions.

Data validation, independent of the laboratory, will be performed on all enforcement data and all definitive data that are used in decision making. Data review, independent of project management, will be performed on all non-definitive and screening data used in the decision-making process. Because of the nature of emergency response activities, the validation will be performed after the decision making but before final reporting.

Hot Spot and Grid Sampling

Because the primary objective of sample collection in an emergency response is to expeditiously identify the significant contaminant threats, the initial sampling approach will concentrate on the search for and identification of contamination hot spots that are significantly above the action level. Systematic grid and search sampling can provide a probabilistic approach to locating a contamination hot spot. When this approach is used, the responder must determine the search parameters before sampling. This information will be specified in the site's emergency response sampling plan.

The lateral extent and concentrations of contamination will be extrapolated and interpolated from sampling grid data.

Biased and Judgmental Sampling

Additional sampling approaches will generally include sample collection at locations expected to exhibit the worst-case contamination. This biased sampling may be based on direct visual observations or the results of field-screening instruments and techniques.

If physical information suggests that contamination may have migrated to other media (e.g., water and air), then limited judgmental sampling of those media, when practicable, should be included.

Enforcement Sampling

Biased samples may be collected from selected locations and analyzed in order to document the presence and magnitude of contamination at those locations for legal enforcement. This sampling would include complete documentation regarding the sampling and analysis performed. The samples would be analyzed in a non-time-critical manner to ensure maximum analytical quality and documentation.

Other Sampling Approaches

Random or transect sampling approaches are typically not used during an emergency response. The data that these approaches generate are not needed to meet the emergency response objective.

CHEMICAL HAZARD EVALUATION – LANDFILL FIRE									
Compound	Exposure Limits (TWA)			Dermal Hazard (Y/N)	Route(s) of Exposure	Acute Symptoms	Odor Threshold/ Description	FID/PID	
	PEL	REL	TLV					Relative Response	Ioniz. Poten. (eV)
*Benzene	1 ppm	0.1 ppm	0.5 ppm	Yes	Inh Abs Ing Con	Irrit skin eyes resp, vom dizz, conv	5 mg/m ³ / smoke or pyrolytic oil		9.8 eV
*Benzo (a) pyrene (coal tar pitch volatiles)	0.2 mg/m ³	0.1 mg/m ³	Carcin -ogen	Yes	Inh Abs Con	Irrit skin w/burning, color changes, warts	Aromatic odor / smoke or pyrolytic oil		NA
*1,3-Butadiene	1 ppm	Carcin -ogen	2 ppm	Yes	Inh Ing Con	Irrit eye nose throat; nausea dizz, unconc	Aromatic odor / smoke or pyrolytic oil		NA
Carbon Monoxide	50 ppm	35 ppm	25 ppm	No	Inh Con	Headache confusion dizz unconc	None / smoke		14.01 eV
Chromium	0.5 mg/m ³	0.5 mg/m ³	0.5 mg/m ³	No	Inh Ing Con	Irrit eye nose throat lungs skin	None / Ash		NA
Copper	1 mg/m ³	1 mg/m ³	1 mg/m ³	No	Inh Ing Con	Irrit eyes nose pharynx	None / Ash		NA
Hydrogen Sulfide	20 ppm	10 ppm	10 ppm	Yes	Inh Con	Headache dizziness cough sore throat nausea labored breathing delayed symptom	Rotten eggs / Ash		10.46 eV
*Lead	0.050 mg/m ³	0.050 mg/m ³	0.05 mg/m ³	No	Inh Ing Con	Irrit eyes, Weakness, Nausea, vom, headache	None / Smoke, Ash		7.41 eV
Nickel	1 mg/m ³	0.015 mg/m ³	0.015 mg/m ³	No	Inh Ing Con	Cough, shortness of breath, dermatitis, asthma, pneumonia	Low / Ash		7.63 eV
Sulfur Dioxide	5 ppm	2 ppm	2 ppm	Yes	Inh Con	Irrit eyes skin, throat & resp. cough, shortness of breath, sore throat	Rotten eggs / Smoke, Ash		12.3 eV
Zinc Oxide (fume)	5 mg/m ³	5 mg/m ³	10 mg/m ³	No	Inh Ing Con	Irrit throat, metallic taste, malaise, fever	None / Smoke, Ash		NA

Note: Use an asterisk (*) to indicate known or suspected carcinogens.



Title Here
U.S. Environmental Protection Agency, Region 9
Emergency Response Section
Consolidated Site-Specific Health & Safety Plan

This Consolidated Site-Specific Health and Safety Plan (HASP) is for use on U.S. Environmental Protection Agency (USEPA) emergency response actions to incorporate the individual site safety plans of the USEPA, other participating government agencies, the Superfund Technical Assessment and Response Team (START) contractor, the Emergency and Rapid Removal Service (ERRS) contractor, and other subcontractors into a unified site safety plan. This plan is designed to conform with the requirements pursuant to 29 Code of Federal Regulations (CFR) 1910.120(b)(4) by summarizing the hazards on-site, personal protective equipment issues and emergency procedures and incorporating all applicable corporate and government agency safety plans and SOPs by reference. This plan does not supersede any individual entity's safety program plans as mandated by 29 CFR 1910.120(b), site specific safety plans or other standard operating procedures (SOPs). Individual corporations or government agencies should refer to their internal site safety program plan and site specific safety plan for compliance with their safety requirements.

All entities that participate in this plan acknowledge that they comply with the relevant sections of 29 CFR 1910.120, 29 CFR 1910 Subpart I, 29 CFR 1910.146 and 29 CFR 1910 Subpart Z. This plan meets the requirements pursuant to 40 CFR 300.135(l) and 300. 150. Requirements pursuant to 29 CFR 1910.146: Permit Required Confined Space (PRCS) will be addressed in a separate document prepared by the contractor making the PRCS entry.

Plan Acceptance/Approval:

_____	_____
USEPA On-Scene Coordinator Date	_____ Date
_____	_____
START Project Manager Date	_____ Date
_____	_____
ERRS Project Manager Date	_____ Date
_____	_____
USEPA ERT Date	_____ Date

A. SITE INFORMATION, ROLES AND RESPONSIBILITIES

Site Name:
Site Address:
Date of Activities:
Participants: 9 USEPA 9 START 9 ERRS 9 PST 9 Other (Individual site safety plans in Appendix C)

Table A-1 Site Roles/Responsibilities			
SiteRole/Responsibility	Agency / Entity	Name	Title
USEPA-Lead	USEPA		
Site Safety Officer	USEPA		
START Project Manager	TEAM9		
START Safety Officer	TEAM9		
ERRS Response Manager	EQM, Inc.		
ERRS Safety Officer	EQM, Inc.		

B. SITE CHARACTERIZATION

Site Description:
map:
The area is: <input type="checkbox"/> predominately commercial <input type="checkbox"/> predominately residential <input type="checkbox"/> mixed commercial/residential <input checked="" type="checkbox"/> rural
Site History:
Scope of Work:

The individual activities that are required to complete the scope of work are divided into numbered tasks. Table B-1 provides a description of each numbered task.

Table B-1 Project Tasks and Task Descriptions	
Task Number	Task Description
1	
2	
3	
4	
5	

C. EVALUATION AND HAZARD CONTROL

This section identifies and describes safety and health hazards associated with site work. The hazards associated with each task, by site location are identified in the following table(s). Based on the best available knowledge of how that task will be performed, the likelihood of exposure to the hazards identified at that location specified and control measures implemented to protect employees from the hazard. Engineering controls, work practices, personal protective equipment, or a combination of these shall be implemented in accordance with 29 CFR 1910.120(g) to protect employees from exposure to health hazards.

Overall Hazard Summary		
Hazard (low, med, high)	Task (s)	Discussion

Overall Control Measures		
Hazard	PPE	Discussion

Job Hazard Analysis (JHA)			
JHA Number	Task	Location Where Task Performed	
1			
Date JHA conducted:		Date(s) JHA updated:	
Biological Hazards			
Name of Biological Hazard	Characteristics	Concentration	Exposure Potential during Task
	<input type="checkbox"/> Infectious/Pathogenic <input type="checkbox"/> Toxic	NA	<input type="checkbox"/> High <input type="checkbox"/> Low <input type="checkbox"/> Medium <input type="checkbox"/> Unknown
Chemical Hazards			
Chemical Name or Type	Characteristics	State/Concentration	Exposure Potential during Task
Fugitive/ nuisance dust, Arsenic, lead present	<input type="checkbox"/> Flammable / Ignitable <input type="checkbox"/> Corrosive <input type="checkbox"/> Poison / Acutely Toxic <input type="checkbox"/> Air/Water Reactive <input type="checkbox"/> Carcinogenic <input type="checkbox"/> Explosive/Shock Sensitive <input type="checkbox"/> Volatile	<input type="checkbox"/> Gas/ Vapor <input type="checkbox"/> Solid <input type="checkbox"/> Liquid	<input type="checkbox"/> High <input type="checkbox"/> Low <input type="checkbox"/> Medium <input type="checkbox"/> Unknown
See Table D-1 for a summary of Chemical information. Chemical Evaluation Sheet or Material Safety Data Sheets (MSDS) are located in Appendix A for known chemical hazards.			
Physical Hazards			
Type of Physical Hazard			Exposure Potential during Task
<input type="checkbox"/> Overhead <input type="checkbox"/> Below Grade <input type="checkbox"/> Trip/Fall <input type="checkbox"/> Burn <input type="checkbox"/> Puncture <input type="checkbox"/> Cut <input type="checkbox"/> Splash <input type="checkbox"/> Animal/Insect/Plant <input type="checkbox"/> Noise <input type="checkbox"/> Heat Stress <input type="checkbox"/> Cold Stress <input type="checkbox"/> Other - Electrocution, traffic			<input type="checkbox"/> High <input type="checkbox"/> Low <input type="checkbox"/> Medium <input type="checkbox"/> Unknown
<input type="checkbox"/> Ionizing Radiation <input type="checkbox"/> Alpha Particles <input type="checkbox"/> Beta Particles <input type="checkbox"/> Gamma Rays <input type="checkbox"/> Neutrons			<input type="checkbox"/> High <input type="checkbox"/> Low <input type="checkbox"/> Medium <input type="checkbox"/> Unknown
X Confined Space (Hazards associated with permit required confined space (PRCS) entries will be addressed in separate document prepared by the contractor making the PRCS entry. Mine shafts could be encountered.			<input type="checkbox"/> High <input type="checkbox"/> Low <input type="checkbox"/> Medium <input type="checkbox"/> Unknown
Control Measures			
Engineering Controls:			
Work Practices: (describe those work practices specific to this task or that differ from the general work practices described in Section G) Use qualified electrician during site set up. Limit set up operations to non-contaminated areas. Use proper lifting techniques when lifting heavy equipment and bending. Exercise caution around moving vehicles. Use traffic spotter when loading and unloading equipment.			
PPE D: work boots, hard hat			
Group	PPE Level	Modifications Allowed	

USEPA		
START		
ERRS		

Job Hazard Analysis (JHA)			
JHA Number	Task	Location Where Task Performed	
2			
Date JHA conducted:		Date(s) JHA updated:	
Biological Hazards			
Name of Biological Hazard	Characteristics	Concentration	Exposure Potential during Task
	<input type="checkbox"/> Infectious/Pathogenic <input type="checkbox"/> Toxic	NA	<input type="checkbox"/> High <input type="checkbox"/> Low <input type="checkbox"/> Medium <input type="checkbox"/> Unknown
Chemical Hazards			
Chemical Name or Type	Characteristics	State/Concentration	Exposure Potential during Task
	<input type="checkbox"/> Flammable / Ignitable <input type="checkbox"/> Corrosive <input type="checkbox"/> Poison / Acutely Toxic <input type="checkbox"/> Air/Water Reactive <input type="checkbox"/> Carcinogenic <input type="checkbox"/> Explosive/Shock Sensitive <input type="checkbox"/> Volatile	<input type="checkbox"/> Gas/ Vapor <input type="checkbox"/> Solid <input type="checkbox"/> Liquid	<input type="checkbox"/> High <input type="checkbox"/> Low <input type="checkbox"/> Medium <input type="checkbox"/> Unknown
	<input type="checkbox"/> Flammable / Ignitable <input type="checkbox"/> Corrosive <input type="checkbox"/> Poison / Acutely Toxic <input type="checkbox"/> Air/Water Reactive <input type="checkbox"/> Carcinogenic <input type="checkbox"/> Explosive/Shock Sensitive <input type="checkbox"/> Volatile	<input type="checkbox"/> Gas/ Vapor <input type="checkbox"/> Solid <input type="checkbox"/> Liquid	<input type="checkbox"/> High <input type="checkbox"/> Low <input type="checkbox"/> Medium <input type="checkbox"/> Unknown
See Table D-1 for a summary of Chemical information. Chemical Evaluation Sheet or Material Safety Data Sheets (MSDS) are located in Appendix A for known chemical hazards.			
Physical Hazards			
Type of Physical Hazard			Exposure Potential during Task
<input type="checkbox"/> Overhead <input type="checkbox"/> Below Grade <input type="checkbox"/> Trip/Fall <input type="checkbox"/> Burn <input type="checkbox"/> Puncture <input type="checkbox"/> Cut <input type="checkbox"/> Splash <input type="checkbox"/> Animal/Insect/Plant <input type="checkbox"/> Noise <input type="checkbox"/> Heat Stress <input type="checkbox"/> Cold Stress <input type="checkbox"/> Other			<input type="checkbox"/> High <input type="checkbox"/> Low <input type="checkbox"/> Medium <input type="checkbox"/> Unknown
<input type="checkbox"/> Ionizing Radiation <input type="checkbox"/> Alpha Particles <input type="checkbox"/> Beta Particles <input type="checkbox"/> Gamma Rays <input type="checkbox"/> Neutrons			<input type="checkbox"/> High <input type="checkbox"/> Low <input type="checkbox"/> Medium <input type="checkbox"/> Unknown
			<input type="checkbox"/> High <input type="checkbox"/> Low <input type="checkbox"/> Medium <input type="checkbox"/> Unknown

Control Measures		
Engineering Controls:		
Work Practices:		
PPE		
Group	PPE Level	Modifications Allowed
USEPA		
START		
ERRS		

Job Hazard Analysis (JHA)			
JHA Number	Task	Location Where Task Performed	
3			
Date JHA conducted:		Date(s) JHA updated:	
Biological Hazards			
Name of Biological Hazard	Characteristics	Concentration	Exposure Potential during Task
	<input type="checkbox"/> Infectious/Pathogenic <input type="checkbox"/> Toxic		<input type="checkbox"/> High <input type="checkbox"/> Low <input type="checkbox"/> Medium <input type="checkbox"/> Unknown
Chemical Hazards			
Chemical Name or Type	Characteristics	State/Concentration	Exposure Potential during Task
	<input type="checkbox"/> Flammable / Ignitable <input type="checkbox"/> Corrosive <input type="checkbox"/> Poison / Acutely Toxic <input type="checkbox"/> Air/Water Reactive <input type="checkbox"/> Carcinogenic <input type="checkbox"/> Explosive/Shock Sensitive <input type="checkbox"/> Volatile	<input type="checkbox"/> Gas/ Vapor <input type="checkbox"/> Solid <input type="checkbox"/> Liquid	<input type="checkbox"/> High <input type="checkbox"/> Low <input type="checkbox"/> Medium <input type="checkbox"/> Unknown
	<input type="checkbox"/> Flammable / Ignitable <input type="checkbox"/> Corrosive <input type="checkbox"/> Poison / Acutely Toxic <input type="checkbox"/> Air/Water Reactive <input type="checkbox"/> Carcinogenic <input type="checkbox"/> Explosive/Shock Sensitive <input type="checkbox"/> Volatile	<input type="checkbox"/> Gas/ Vapor <input type="checkbox"/> Solid <input type="checkbox"/> Liquid	<input type="checkbox"/> High <input type="checkbox"/> Low <input type="checkbox"/> Medium <input type="checkbox"/> Unknown
See Table D-1 for a summary of Chemical information. Chemical Evaluation Sheet or Material Safety Data Sheets (MSDS) are located in Appendix A for known chemical hazards.			
Physical Hazards			
Type of Physical Hazard			Exposure Potential during Task
<input type="checkbox"/> Overhead <input type="checkbox"/> Below Grade <input type="checkbox"/> Trip/Fall <input type="checkbox"/> Burn <input type="checkbox"/> Puncture <input type="checkbox"/> Cut <input type="checkbox"/> Splash <input type="checkbox"/> Animal/Insect/Plant <input type="checkbox"/> Noise <input type="checkbox"/> Heat Stress <input type="checkbox"/> Cold Stress <input type="checkbox"/> Other			<input type="checkbox"/> High <input type="checkbox"/> Low <input type="checkbox"/> Medium <input type="checkbox"/> Unknown
<input type="checkbox"/> Ionizing Radiation <input type="checkbox"/> Alpha Particles <input type="checkbox"/> Beta Particles <input type="checkbox"/> Gamma Rays <input type="checkbox"/> Neutrons			<input type="checkbox"/> High <input type="checkbox"/> Low <input type="checkbox"/> Medium <input type="checkbox"/> Unknown
X Mine Shaft, Confined Space (Hazards associated with permit required confined space (PRCS) entries will be addressed in separate document prepared by the contractor making the PRCS entry.			<input type="checkbox"/> High <input type="checkbox"/> Low <input type="checkbox"/> Medium <input type="checkbox"/> Unknown

Control Measures		
Engineering Controls: (if feasible, describe) Develop solid support for excavator.		
Work Practices: (describe those work practices specific to this task or that differ from the general work practices described in Section G) Buddy system and/or maintain radio communications.		
PPE		
Group	PPE Level	Modifications Allowed
USEPA		
START		
ERRS		

Job Hazard Analysis (JHA)			
JHA Number	Task	Location Where Task Performed	
4			
Date JHA conducted:		Date(s) JHA updated:	
Biological Hazards			
Name of Biological Hazard	Characteristics	Concentration	Exposure Potential during Task
	<input type="checkbox"/> Infectious/Pathogenic <input type="checkbox"/> Toxic	NA	<input type="checkbox"/> High <input type="checkbox"/> Low <input type="checkbox"/> Medium <input type="checkbox"/> Unknown
Chemical Hazards			
Chemical Name or Type	Characteristics	State/Concentration	Exposure Potential during Task
	<input type="checkbox"/> Flammable / Ignitable <input type="checkbox"/> Slightly Corrosive <input type="checkbox"/> Poison / Acutely Toxic <input type="checkbox"/> Air/Water Reactive <input type="checkbox"/> Carcinogenic <input type="checkbox"/> Explosive/Shock Sensitive <input type="checkbox"/> Volatile	<input type="checkbox"/> Gas/ Vapor <input type="checkbox"/> Solid <input type="checkbox"/> Liquid	<input type="checkbox"/> High <input type="checkbox"/> Low <input type="checkbox"/> Medium <input type="checkbox"/> Unknown
See Table D-1 for a summary of Chemical information. Chemical Evaluation Sheet or Material Safety Data Sheets (MSDS) are located in Appendix A for known chemical hazards.			
Physical Hazards			
Type of Physical Hazard			Exposure Potential during Task
<input type="checkbox"/> Overhead <input type="checkbox"/> Below Grade <input type="checkbox"/> Trip/Fall <input type="checkbox"/> Burn <input type="checkbox"/> Puncture <input type="checkbox"/> Cut <input type="checkbox"/> Splash <input type="checkbox"/> Animal/Insect/Plant <input type="checkbox"/> Noise <input type="checkbox"/> Heat Stress <input type="checkbox"/> Cold Stress <input type="checkbox"/> Other			<input type="checkbox"/> High <input type="checkbox"/> Low <input type="checkbox"/> Medium <input type="checkbox"/> Unknown
<input type="checkbox"/> Ionizing Radiation <input type="checkbox"/> Alpha Particles <input type="checkbox"/> Beta Particles <input type="checkbox"/> Gamma Rays <input type="checkbox"/> Neutrons			<input type="checkbox"/> High <input type="checkbox"/> Low <input type="checkbox"/> Medium <input type="checkbox"/> Unknown
X Mine Shaft, Confined Space (Hazards associated with permit required confined space (PRCS) entries will be addressed in separate document prepared by the contractor making the PRCS entry.			<input type="checkbox"/> High <input type="checkbox"/> Low <input type="checkbox"/> Medium <input type="checkbox"/> Unknown
Control Measures			
Engineering Controls: (if feasible, describe)			
Work Practices: (describe those work practices specific to this task or that differ from the general work practices described in Section G)			

PPE		
Group	PPE Level	Modifications Allowed
USEPA		
START		
ERRS		

Job Hazard Analysis (JHA)			
JHA Number	Task	Location Where Task Performed	
5			
Date JHA conducted:		Date(s) JHA updated:	
Biological Hazards			
Name of Biological Hazard	Characteristics	Concentration	Exposure Potential during Task
	<input type="checkbox"/> Infectious/Pathogenic <input type="checkbox"/> Toxic	NA	<input type="checkbox"/> High <input type="checkbox"/> Low <input type="checkbox"/> Medium <input type="checkbox"/> Unknown
Chemical Hazards			
Chemical Name or Type	Characteristics	State/Concentration	Exposure Potential during Task
	<input type="checkbox"/> Flammable / Ignitable <input type="checkbox"/> Corrosive <input type="checkbox"/> Poison / Acutely Toxic <input type="checkbox"/> Air/Water Reactive <input type="checkbox"/> Carcinogenic <input type="checkbox"/> Explosive/Shock Sensitive <input type="checkbox"/> Volatile	<input type="checkbox"/> Gas/ Vapor <input type="checkbox"/> Solid <input type="checkbox"/> Liquid	<input type="checkbox"/> High <input type="checkbox"/> Low <input type="checkbox"/> Medium <input type="checkbox"/> Unknown
See Table D-1 for a summary of Chemical information. Chemical Evaluation Sheet or Material Safety Data Sheets (MSDS) are located in Appendix A for known chemical hazards.			
Physical Hazards			
Type of Physical Hazard			Exposure Potential during Task
<input type="checkbox"/> Overhead <input type="checkbox"/> Below Grade <input type="checkbox"/> Trip/Fall <input type="checkbox"/> Burn <input type="checkbox"/> Puncture <input type="checkbox"/> Cut <input type="checkbox"/> Splash <input type="checkbox"/> Animal/Insect/Plant <input type="checkbox"/> Noise <input type="checkbox"/> Heat Stress <input type="checkbox"/> Cold Stress <input type="checkbox"/> Other			<input type="checkbox"/> High <input type="checkbox"/> Low <input type="checkbox"/> Medium <input type="checkbox"/> Unknown
<input type="checkbox"/> Ionizing Radiation <input type="checkbox"/> Alpha Particles <input type="checkbox"/> Beta Particles <input type="checkbox"/> Gamma Rays <input type="checkbox"/> Neutrons			<input type="checkbox"/> High <input type="checkbox"/> Low <input type="checkbox"/> Medium <input type="checkbox"/> Unknown
<input type="checkbox"/> Confined Space (Hazards associated with permit required confined space (PRCS) entries will be addressed in separate document prepared by the contractor making the PRCS entry.			<input type="checkbox"/> High <input type="checkbox"/> Low <input type="checkbox"/> Medium <input type="checkbox"/> Unknown
Control Measures			
Engineering Controls:			
Work Practices:			
PPE			
Group	PPE Level	Modifications Allowed	

USEPA		
START		
ERS		

D. CHEMICAL HAZARDS

Table D-1 Chemical Compound Information Summary							
Compound	Exposure Limits			IDLH Level	Route(s) of Exposure	Acute Symptoms	Odor Threshold/ Description
	PEL	REL	TLV				

Note: Use and asterisk (*) to indicate known or suspected carcinogens.
NA = Not available.

E. ACTION LEVELS AND HEALTH AND SAFETY MONITORING

Delete information for biological agents not of concern at the site.

Table E-1 Site-Specific Action Levels				
Contaminant	Level	Action	Level	Action

Table E-2 General Action Levels				
Contaminant	Level	Action	Level	Action
Oxygen	19.5% - 22%	Continue work in Level D or C	< 19.5% or > 22%	Upgrade to Level B or A
Lower Explosive Limit (LEL)	10 to 25% of LEL	Continuous monitoring	> 25% of LEL	Evacuate immediately
Particulates	≥ 5 mg/m ³ (assume all dust is respirable dust)	Upgrade to Level C		
Radiation	Above background but <1 mR/hr	Continue monitoring	≥ 1 mR/hr	Withdraw, contact Health Physicist and reassess work plan
Unknown Organic Vapors/Gases	Background to 1 part per million (ppm)	Level D with continuous monitoring	> 5 ppm to ≤ 500 ppm	Level B
	1 ppm to ≤ 5 ppm	Level C with continuous monitoring	>500 ppm	Level A
Other:				

F. DECONTAMINATION PROCEDURES

All equipment, materials, and personnel will be evaluated for contamination upon leaving the exclusion area. Equipment and materials will be decontaminated and/or disposed and personnel will be decontaminated, as necessary. Decontamination will be performed in the contamination reduction area or any designated area such that the exposure of uncontaminated employees, equipment, and materials will be minimized. Specific procedures are described below.

Table F-1 Decontamination Procedures:	
Type	Responsible Entity
<p>Personnel: PPE will be removed in the order and manner described in the <i>Guidelines for Removal of Protective Clothing</i> RAG.</p> <p>Disposable PPE will be directed to the proper waste stream. Contaminated spots identified on nondisposable PPE, including respirators and hard hats, will be decontaminated using controlled dry or damp methods (e.g. towelettes) Respirators may also be directed to the respirator washing station for full decontamination.</p> <p>Contaminated areas on the skin or body will be decontaminated using controlled dry or damp methods (e.g. towelettes). All contamination incidents on the skin or body will be documented in the Personnel Decontamination Form (Appendix C).</p>	
Equipment/Instruments:	
Emergency Decon: Non Life Threatening:	
Life Threatening:	
Waste Management:	

G. SITE CONTROL

Draw site map indicating work zones.

Buddy System: All on-site personnel shall comply with the buddy system. The buddy system will be maintained on a line-of-sight basis.

Work Practices and Site Control Measures Common to All Site Tasks:

The exclusion zone and contamination reduction zone (CRZ) will be clearly marked and access to it restricted to those personnel directly involved with the response operations.

Entry and exit corridors leading to the CRZ will be clearly marked.

Exclusion and CRZ zone entry and egress protocols will be established prior to any entry to these zones.

Prior to entering the exclusion zone and CRZ, personnel will know their specific tasks for the entry.

Personnel will enter and exit the exclusion zone only through designated corridors, which are located in and traverse the CRZ, unless emergency exiting of the facility is required.

Communications:

On-Site Radio Frequencies: Determined during on site safety meeting

Cell Phone #: Cell phones do not work at this site

Hand Signals: Use appropriately

Illumination: All work will be conducted during daytime operational period unless sufficient artificial lighting in compliance with 29 CFR 1910.120(m) has been provided.

Sanitation: All work sites will be in compliance with the requirements pursuant to 29 CFR 1910.120(n).

H. TRAINING/MEDICAL SURVEILLANCE

Check all that apply:

Table H-1 Personnel Training and Surveillance Requirements				
Regulation	USEPA	START	ERRS	Other
29 CFR 1910.120(e)(3)(i): General Site Worker - 40 hr				
29 CFR 1910.120(e)(3)(ii): Occasional Worker - 24 hr				
29 CFR 1910.120(e)(3)(iii): Workers in Area <PEL - 24 hr				
29 CFR 1910.120(e)(4): Management & Supervisors - 40/8 hr				
29 CFR 1910.120(e)(7): Emergency Response				
29 CFR 1910.120(e)(8): Refresher - 8 hr				
First Responder Awareness				
First Responder Operational - 8 hr				
Hazmat Technician - 24 hr				
Hazmat Specialist- 24 hr				
On-Scene Commander - 24 hr				
29 CFR 1910.134: Resp. Std.				
29 CFR 1910.146: PRCs				
29 CFR 1910.120(f): Medical Surveillance Participation				
8-Hour General Radiation Training				
Radiation Exposure Surveillance - External Dosimetry (TLD Badge and/or electronic dosimeters)				

I. EMERGENCY RESPONSE PLAN

This section contains additional information pertaining to on-site emergency response and does not duplicate pertinent emergency response information contained in earlier sections of this plan (e.g., site layout, monitoring equipment, etc.). Emergency response procedures will be rehearsed regularly, as applicable, during project activities.

Section I.1 Emergency Responsibilities

Section I.1.1 All Personnel: All personnel shall be alert to the possibility of an on-site emergency; report potential or actual emergency situations directly to supervision or to the FOSC, SSO and RSO; When practicable, the lead Federal official on-site will make the decision to declare a site emergency and notify appropriate emergency resources, as necessary.

Section I.1.2 Entry Team Leader: The team leader will determine the emergency actions to be performed by site personnel and will direct these actions. The team leader also will ensure that applicable incidents are reported to appropriate project personnel and the FOSC. The FOSC will determine what other government agency notifications are required.

Section I.1.3 SSO: The SSO will recommend health/safety and protective measures appropriate to the emergency. The SSO is authorized to terminate all activities deemed to be unsafe. In the case of an emergency, the SSO shall call 911 or designate someone to call 911.

Section I.1.4 RSO: The RSO is responsible for all radiation safety issues. If emergency decontamination is required, the RSO shall supervise.

Section I.1.5 FOSC: The FOSC has overall responsibility for all emergency operations. The FOSC shall interface with all rescue personnel.

On-Site Emergency Signal: Three long horn blasts

On-Site Meeting Location: EPA/START/ERRS Trailer

Emergency Egress Route Off-Site: See Map to Hospital

Off-Site Meeting Location: TBD

Emergency Decontamination Procedures: None

Company/Resource	Name Contact	Telephone Numbers
USEPA	Region Response Center Harry Allen	(415) 947-4400 (415) 972-3063 (Office) (415) 218-7406 (Cell)
START	Cindy McLeod Robin Clemens	(415) 238-3379 (Cell) (510) 893-6700 (Office) (415) 238-3383 (Cell) (510) 893-6700 (Office)
ERRS	RM: Peter Lawrence	(916) 739-1366 (Office) (415) 793-5942 (Cell)
Hospital (Route Map Appendix B)		
Poison Control Center		
Police		911
Fire		911
Site	USEPA: START: ERRS	

Participant Acknowledgment Sheet

<u>Name</u>	<u>Organization</u>	<u>Date</u>

Appendix A: Chemical Hazard Sheets

Appendix B: Hospital Map

Directions:

Appendix C: Participants Site Safety Plans

1,3-Butadiene	Formula: CH ₂ =CHCH=CH ₂	CAS#: 106-99-0	RTECS#: EI9275000	IDLH: Ca [2000 ppm] [10%LEL]	B
Conversion: 1 ppm = 2.21 mg/m ³		DOT: 1010 116P (inhibited)			
Synonyms/Trade Names: Biethylene, Bivinyll, Butadiene, Divinyll, Erythrene, Vinylethylene					
Exposure Limits: NIOSH REL: Ca See Appendix A OSHA PEL: [1910.1051] TWA 1 ppm ST 5 ppm			Measurement Methods (see Table 1): NIOSH 1024 OSHA 56		
Physical Description: Colorless gas with a mild aromatic or gasoline-like odor. [Note: A liquid below 24°F. Shipped as a liquefied compressed gas.]					
Chemical & Physical Properties: MW: 54.1 BP: 24°F Sol: Insoluble FLP: NA (Gas) -105°F (Liquid) IP: 9.07 eV RGasD: 1.88 Sp.Gr: 0.65 (Liquid at 24°F) VP: 2.4 atm FRZ: -164°F UEL: 12.0% LEL: 2.0% Flammable Gas		Personal Protection/Sanitation (see Table 2): Skin: Frostbite Eyes: Frostbite Wash skin: N.R. Remove: When wet (flamm) Change: N.R. Provide: Frostbite wash		Respirator Recommendations (see Tables 3 and 4): NIOSH ⚠: ScbaF: Pd, Pp/ SaF: Pd, Pp: AScba Escape: GmFS/ScbaE See Appendix E (page 351)	
Incompatibilities and Reactivities: Phenol, chlorine dioxide, copper, crotonaldehyde [Note: May contain inhibitors (e.g., tributylcatechol) to prevent self-polymerization. May form explosive peroxides upon exposure to air.]					
Exposure Routes, Symptoms, Target Organs (see Table 5): ER: Inh, Con (liquid) SY: Irrit eyes, nose, throat; drow, dizz; liquid: frostbite; terato, repro effects; [carc] TO: Eyes, resp sys, CNS, repro sys [hemato cancer]			First Aid (see Table 6): Eye: Frostbite Skin: Frostbite Breath: Resp support		

n-Butane	Formula: CH ₃ CH ₂ CH ₂ CH ₃	CAS#: 106-97-8	RTECS#: EJ4200000	IDLH: N.D.
Conversion: 1 ppm = 2.38 mg/m ³		DOT: 1011 115; 1075 115		
Synonyms/Trade Names: normal-Butane, Butyl hydride, Diethyl, Methylenehydramethane [Note: Also see specific listing for Isobutane.]				
Exposure Limits: NIOSH REL: TWA 800 ppm (1900 mg/m ³) OSHA PEL †: none			Measurement Methods (see Table 1): OSHA 56	
Physical Description: Colorless gas with a gasoline-like or natural gas odor. [Note: Shipped as a liquefied compressed gas. A liquid below 31°F.]				
Chemical & Physical Properties: MW: 58.1 BP: 31°F Sol: Slight F.I.P: NA (Gas) IP: 10.63 eV RGasD: 2.11 Sp.Gr: 0.6 (Liquid at 31°F) VP: 2.05 atm FRZ: -217°F UEL: 8.4% LEL: 1.6% Flammable Gas		Personal Protection/Sanitation (see Table 2): Skin: Frostbite Eyes: Frostbite Wash skin: N.R. Remove: When wet (flamm) Change: N.R. Provide: Frostbite wash	Respirator Recommendations (see Tables 3 and 4): Not available.	
		Incompatibilities and Reactivities: Strong oxidizers (e.g., nitrates and perchlorates), chlorine, fluorine, (nickel carbonyl + oxygen)		
Exposure Routes, Symptoms, Target Organs (see Table 5): ER: Inh, Con (liquid) SY: Drow, narco, asphy; liquid: frostbite TO: CNS		First Aid (see Table 6): Eye: Frostbite Skin: Frostbite Breath: Resp support		

B	Benzene	Formula: C ₆ H ₆	CAS#: 71-43-2	RTECS#: CY1400000	IDLH: Ca [500 ppm]
	Conversion: 1 ppm = 3.19 mg/m ³		DOT: 1114 130		
	Synonyms/Trade Names: Benzol, Phenyl hydride				
	Exposure Limits: NIOSH REL: Ca TWA 0.1 ppm ST 1 ppm See Appendix A			Measurement Methods (see Table 1): NIOSH 1500, 1501, 3700, 3800 OSHA 12, 1005	
	OSHA PEL: [1910.1028] TWA 1 ppm ST 5 ppm See Appendix F				
Physical Description: Colorless to light-yellow liquid with an aromatic odor. [Note: A solid below 42°F.]					
Chemical & Physical Properties: MW: 78.1 BP: 176°F Sol: 0.07% Fl.P: 12°F IP: 9.24 eV Sp.Gr: 0.88 VP: 75 mmHg FRZ: 42°F UEL: 7.8% LEL: 1.2% Class IB Flammable Liquid		Personal Protection/Sanitation (see Table 2): Skin: Prevent skin contact Eyes: Prevent eye contact Wash skin: When contam Remove: When wet (flamm) Change: N.R. Provide: Eyewash Quick drench		Respirator Recommendations (see Tables 3 and 4): NIOSH ¥: ScbaF: Pd, Pp/ SaF: Pd, Pp: AScba Escape: GmFOv/ScbaE See Appendix E (page 351)	
Incompatibilities and Reactivities: Strong oxidizers, many fluorides & perchlorates, nitric acid					
Exposure Routes, Symptoms, Target Organs (see Table 5): ER: Inh, Abs, Ing, Con SY: Irrit eyes, skin, nose, resp sys; dizz; head, nau, staggered gait; anor, lass; derm; bone marrow depres; [carc] TO: Eyes, skin, resp svs, blood, CNS, bone marrow [leukemia]			First Aid (see Table 6): Eye: Irr immed Skin: Soap wash immed Breath: Resp support Swallow: Medical attention immed		

Benzenethiol	Formula: C ₆ H ₅ SH	CAS#: 108-98-5	RTECS#: DC0525000	IDLH: N.D.
Conversion: 1 ppm = 4.51 mg/m ³		DOT: 2337 131		
Synonyms/Trade Names: Mercaptobenzene, Phenyl mercaptan, Thiophenol				
Exposure Limits: NIOSH REL: C 0.1 ppm (0.5 mg/m ³) [15-minute] OSHA PEL†: none			Measurement Methods (see Table 1): OSHA PV2075	
Physical Description: Water-white liquid with an offensive, garlic-like odor. [Note: A solid below 5°F.]				
Chemical & Physical Properties: MW: 110.2 BP: 336°F Sol(77°F): 0.08% Fl.P: 132°F IP: 8.33 eV Sp.Gr: 1.08 VP(65°F): 1 mmHg FRZ: 5°F UEL: ? LEL: ? Class II Combustible Liquid		Personal Protection/Sanitation (see Table 2): Skin: Prevent skin contact Eyes: Prevent eye contact Wash skin: When contam Remove: When wet or contam Change: N.R. Provide: Eyewash Quick drench		Respirator Recommendations (see Tables 3 and 4): NIOSH 1 ppm: CcrOv/Sa 2.5 ppm: Sa:Cf/PaprvOv 5 ppm: CcrFOv/GmFOv/PaprvTOv/ ScbaF/SaF §: ScbaF: Pd,Pp/SaF: Pd,Pp:AScba Escape: GmFOv/ScbaE
Incompatibilities and Reactivities: Strong acids & bases, calcium hypochlorite, alkali metals [Note: Oxidizes on exposure to air.]				
Exposure Routes, Symptoms, Target Organs (see Table 5): ER: Inh, Abs, Ing, Con SY: Irrit eyes, skin, resp sys; derm; cyan; cough, wheez, dysp, pulm edema, pneu; head, dizz, CNS depres; nau, vomit; kidney, liver, spleen damage TO: Eyes, skin, resp sys, CNS, kidneys, liver, spleen			First Aid (see Table 6): Eye: Irr immed Skin: Soap wash immed Breath: Resp support Swallow: Medical attention immed	

C	Carbon monoxide	Formula: CO	CAS#: 630-08-0	RTECS#: FG3500000	IDLH: 1200 ppm
	Conversion: 1 ppm = 1.15 mg/m ³		DOT: 1016 119; 9202 168 (cryogenic liquid)		
	Synonyms/Trade Names: Carbon oxide, Flue gas, Monoxide				
	Exposure Limits: NIOSH REL: TWA 35 ppm (40 mg/m ³) C 200 ppm (229 mg/m ³) OSHA PEL†: TWA 50 ppm (55 mg/m ³)			Measurement Methods (see Table 1): NIOSH 6604 OSHA ID209, ID210	
	Physical Description: Colorless, odorless gas. [Note: Shipped as a nonliquefied or liquefied compressed gas.]				
Chemical & Physical Properties: MW: 28.0 BP: -313°F Sol: 2% Fl.P: NA (Gas) IP: 14.01 eV RGasD: 0.97 VP: >35 atm MLT: -337°F UEL: 74% LEL: 12.5% Flammable Gas		Personal Protection/Sanitation (see Table 2): Skin: Frostbite Eyes: Frostbite Wash skin: N.R. Remove: When wet (flamm) Change: N.R. Provide: Frostbite wash		Respirator Recommendations (see Tables 3 and 4): NIOSH 350 ppm: Sa 875 ppm: Sa:Cf 1200 ppm: GmFS†/ScbaF/SaF §: ScbaF;Pd,Pp/SaF;Pd,Pp:AScba Escape: GmFS†/ScbaE	
Incompatibilities and Reactivities: Strong oxidizers, bromine trifluoride, chlorine trifluoride, lithium					
Exposure Routes, Symptoms, Target Organs (see Table 5): ER: Inh, Con (liquid) SY: Head, tachypnea, nau, lass, dizz, conf, halu; cyan; depres S-T segment of electrocardiogram, angina, syncope TO: CVS, lungs, blood, CNS				First Aid (see Table 6): Eye: Frostbite Skin: Frostbite Breath: Resp support	

Carbon tetrabromide		Formula: CBr ₄	CAS#: 558-13-4	RTECS#: FG4725000	IDLH: N.D.
Conversion: 1 ppm = 13.57 mg/m ³		DOT: 2516 151			
Synonyms/Trade Names: Carbon bromide, Methane tetrabromide, Tetrabromomethane					
Exposure Limits: NIOSH REL: TWA 0.1 ppm (1.4 mg/m ³) ST 0.3 ppm (4 mg/m ³) OSHA PEL†: none				Measurement Methods (see Table 1): None available	
Physical Description: Colorless to yellow-brown crystals with a slight odor.					
Chemical & Physical Properties: MW: 331.7 BP: 374°F Sol: 0.02% FLP: NA IP: 10.31 eV Sp.Gr: 3.42 VP(205°F): 40 mmHg MLT: 194°F UEL: NA LEL: NA Noncombustible Solid		Personal Protection/Sanitation (see Table 2): Skin: N.R. Eyes: Prevent eye contact Wash skin: Daily Remove: N.R. Change: Daily Provide: Eyewash		Respirator Recommendations (see Tables 3 and 4): Not available.	
Incompatibilities and Reactivities: Strong oxidizers, hexacyclohexyldilead, lithium					
Exposure Routes, Symptoms, Target Organs (see Table 5): ER: Inh, Ing, Con SY: Irrit eyes, skin, resp sys; lac; lung, liver, kidney inj; in animals: corn damage TO: Eyes, skin, resp sys, liver, kidneys			First Aid (see Table 6): Eye: Irr immed Skin: Soap wash prompt Breath: Resp support Swallow: Medical attention immed		

C	Coal tar pitch volatiles	Formula:	CAS#: 65996-93-2	RTECS#: GF8655000	IDLH: Ca [80 mg/m³]
	Conversion:	DOT: 2713 153 (acridine)			
	Synonyms/Trade Names: Synonyms vary depending upon the specific compound (e.g., pyrene, phenanthrene, acridine, chrysene, anthracene & benzo(a)pyrene). [Note: NIOSH considers coal tar, coal tar pitch, and creosote to be coal tar products.]				
	Exposure Limits: NIOSH REL: Ca TWA 0.1 mg/m³ (cyclohexane-extractable fraction) See Appendix A See Appendix C OSHA PEL: TWA 0.2 mg/m³ (benzene-soluble fraction) [1910.1002] See Appendix C			Measurement Methods (see Table 1): OSHA 58	
	Physical Description: Black or dark-brown amorphous residue.				
Chemical & Physical Properties: Properties vary depending upon the specific compound. Combustible Solids		Personal Protection/Sanitation (see Table 2): Skin: Prevent skin contact Eyes: Prevent eye contact Wash skin: Daily Remove: N.R. Change: Daily		Respirator Recommendations (see Tables 3 and 4): NIOSH ☒: ScbaF: Pd, Pp/SaF: Pd, Pp: AScba Escape: GmFOv100/ScbaE	
Incompatibilities and Reactivities: Strong oxidizers					
Exposure Routes, Symptoms, Target Organs (see Table 5): ER: Inh, Con SY: Derm, bron, [carc] TO: Resp sys, skin, bladder, kidneys [lung, kidney & skin cancer]				First Aid (see Table 6): Eye: Irr immed Skin: Soap wash immed Breath: Resp support Swallow: Medical attention immed	

Cobalt carbonyl (as Co)	Formula: C ₅ Co ₂ O ₈	CAS#: 10210-68-1	RTECS#: GG0300000	IDLH: N.D.
Conversion:		DOT:		
Synonyms/Trade Names: di-mu-Carbonylhexacarbonyldicobalt, Cobalt octacarbonyl, Cobalt tetracarbonyl dimer, Dicobalt carbonyl, Dicobalt Octacarbonyl, Octacarbonyldicobalt				
Exposure Limits: NIOSH REL: TWA 0.1 mg/m ³ OSHA PEL†: none			Measurement Methods (see Table 1): None available	
Physical Description: Orange to dark-brown, crystalline solid. [Note: The pure substance is white.]				
Chemical & Physical Properties: MW: 341.9 BP: 126°F (Decomposes) Sol: Insoluble F.P: NA IP: ? Sp.Gr: 1.87 VP: 0.7 mmHg MLT: 124°F UEL: NA LEL: NA Noncombustible Solid, but flammable carbon monoxide is emitted during decomposition.		Personal Protection/Sanitation (see Table 2): Skin: Prevent skin contact Eyes: Prevent eye contact Wash skin: When contam Remove: When wet or contam Change: Daily		Respirator Recommendations (see Tables 3 and 4): Not available.
Incompatibilities and Reactivities: Air [Note: Decomposes on exposure to air or heat; stable in atmosphere of hydrogen & carbon monoxide.]				
Exposure Routes, Symptoms, Target Organs (see Table 5): ER: Inh, Abs, Ing, Con SY: Irrit eyes, skin, muc memb; cough, decr pulm func, wheez, dysp; in animals: liver, kidney inj, pulm edema TO: Eyes, skin, resp sys, blood, CNS			First Aid (see Table 6): Eye: Irr immed Skin: Soap wash Breath: Resp support Swallow: Medical attention immed	


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Hydrogen chloride			CAS 7647-01-0
HCl			RTECS MW4025000
Synonyms & Trade Names Anhydrous hydrogen chloride; Aqueous hydrogen chloride (i.e., Hydrochloric acid, Muriatic acid) [Note: Often used in an aqueous solution.]			DOT ID & Guide 1050 125 (anhydrous) 1789 157 (solution)
Exposure Limits	NIOSH REL: C 5 ppm (7 mg/m ³) OSHA PEL: C 5 ppm (7 mg/m ³)		
IDLH 50 ppm See: 7647010		Conversion 1 ppm = 1.49 mg/m ³	
Physical Description Colorless to slightly yellow gas with a pungent, irritating odor. [Note: Shipped as a liquefied compressed gas.]			
MW: 36.5	BP: -121°F	FRZ: -174°F	Sol(86°F): 67%
VP: 40.5 atm	IP: 12.74 eV	RGasD: 1.27	
Fl.P: NA	UEL: NA	LEL: NA	
Nonflammable Gas			
Incompatibilities & Reactivities Hydroxides, amines, alkalis, copper, brass, zinc [Note: Hydrochloric acid is highly corrosive to most metals.]			
Measurement Methods NIOSH 7903 ; OSHA ID174SG See: NMAM or OSHA Methods			
Personal Protection & Sanitation (See protection codes) Skin: Prevent skin contact (solution)/Frostbite Eyes: Prevent eye contact/Frostbite Wash skin: When contaminated (solution) Remove: When wet or contaminated (solution) Change: No recommendation Provide: Eyewash (solution), Quick drench (solution), Frostbite wash		First Aid (See procedures) Eye: Irrigate immediately (solution)/Frostbite Skin: Water flush immediately (solution)/Frostbite Breathing: Respiratory support Swallow: Medical attention immediately (solution)	
Respirator Recommendations NIOSH/OSHA Up to 50 ppm: (APF = 10) Any chemical cartridge respirator with cartridge(s) providing protection against the compound of concern* (APF = 50) Any air-purifying, full-facepiece respirator (gas mask) with a chin-style, front- or back-mounted canister providing protection against the compound of concern (APF = 25) Any powered, air-purifying respirator with cartridge(s) providing protection against the compound of concern* (APF = 10) Any supplied-air respirator* (APF = 50) Any self-contained breathing apparatus with a full facepiece Emergency or planned entry into unknown concentrations or IDLH conditions: (APF = 10,000) Any self-contained breathing apparatus that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode (APF = 10,000) Any supplied-air respirator that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode in combination with an auxiliary self-contained positive-pressure breathing apparatus Escape: (APF = 50) Any air-purifying, full-facepiece respirator (gas mask) with a chin-style, front- or back-mounted acid gas canister/Any appropriate escape-type, self-contained breathing apparatus Important additional information about respirator selection			
Exposure Routes inhalation, ingestion (solution), skin and/or eye contact			
Symptoms Irritation nose, throat, larynx; cough, choking; dermatitis; solution: eye, skin burns; liquid: frostbite; in animals: laryngeal spasm; pulmonary edema			

Target Organs Eyes, skin, respiratory system

See also: [INTRODUCTION](#) See ICSC CARD: [0163](#) See MEDICAL TESTS: [0116](#)

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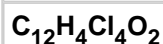
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2,3,7,8-Tetrachloro-dibenzo-p-dioxin

CAS 1746-01-6

RTECS [HP3500000](#)

Synonyms & Trade Names

Dioxin; Dioxine; TCDBD; TCDD; 2,3,7,8-TCDD [Note: Formed during past production of 2,4,5-trichlorophenol, 2,4,5-T & 2(2,4,5-trichlorophenoxy)propionic acid.]

DOT ID & Guide

Exposure Limits

NIOSH REL: Ca [See Appendix A](#)

OSHA PEL: none

IDLH Ca [N.D.] See: [IDLH INDEX](#)

Conversion

Physical Description

Colorless to white, crystalline solid. [Note: Exposure may occur through contact at previously contaminated worksites.]

MW: 322.0

BP: Decomposes

MLT: 581°F

Sol: 0.00000002%

VP(77°F): 0.000002 mmHg

IP: ?

Sp.Gr: ?

Fl.P: ?

UEL: ?

LEL: ?

Incompatibilities & Reactivities

UV light (decomposes)

Measurement Methods

None available

See: [NMAM](#) or [OSHA Methods](#)

Personal Protection & Sanitation [\(See protection codes\)](#)

Skin: Prevent skin contact

Eyes: Prevent eye contact

Wash skin: When contaminated/Daily

Remove: When wet or contaminated

Change: Daily

Provide: Eyewash, Quick drench

First Aid [\(See procedures\)](#)

Eye: Irrigate immediately

Skin: Soap flush immediately

Breathing: Respiratory support

Swallow: Medical attention immediately

Respirator Recommendations NIOSH

At concentrations above the NIOSH REL, or where there is no REL, at any detectable concentration:

(APF = 10,000) Any self-contained breathing apparatus that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode

(APF = 10,000) Any supplied-air respirator that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode in combination with an auxiliary self-contained positive-pressure breathing apparatus

Escape:

(APF = 50) Any air-purifying, full-facepiece respirator (gas mask) with a chin-style, front- or back-mounted organic vapor canister having an N100, R100, or P100 filter. [Click here](#) for information on selection of N, R, or P filters./Any appropriate escape-type, self-contained breathing apparatus

[Important additional information about respirator selection](#)

Exposure Routes inhalation, skin absorption, ingestion, skin and/or eye contact

Symptoms Irritation eyes; allergic dermatitis, chloracne; porphyria; gastrointestinal disturbance; possible reproductive, teratogenic effects; in animals: liver, kidney damage; hemorrhage; [potential occupational carcinogen]

Target Organs Eyes, skin, liver, kidneys, reproductive system

Cancer Site [in animals: tumors at many sites]

See also: [INTRODUCTION](#) See ICSC CARD: [1467](#)

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Furfural			CAS 98-01-1
C ₅ H ₄ O ₂			RTECS LT7000000
Synonyms & Trade Names Fural, 2-Furancarboxaldehyde, Furfuraldehyde, 2-Furfuraldehyde			DOT ID & Guide 1199 132P
Exposure Limits	NIOSH REL: See Appendix D		
	OSHA PEL†: TWA 5 ppm (20 mg/m ³) [skin]		
IDLH 100 ppm See: 98011		Conversion 1 ppm = 3.93 mg/m ³	
Physical Description Colorless to amber liquid with an almond-like odor. [Note: Darkens in light and air.]			
MW: 96.1	BP: 323°F	FRZ: -34°F	Sol: 8%
VP: 2 mmHg	IP: 9.21 eV		Sp.Gr: 1.16
Fl.P: 140°F	UEL: 19.3%	LEL: 2.1%	
Class IIIA Combustible Liquid: Fl.P. at or above 140°F and below 200°F.			
Incompatibilities & Reactivities Strong acids, oxidizers, strong alkalis [Note: May polymerize on contact with strong acids or strong alkalis.]			
Measurement Methods NIOSH 2529 ; OSHA 72 See: NMAM or OSHA Methods			
Personal Protection & Sanitation (See protection codes) Skin: Prevent skin contact Eyes: Prevent eye contact Wash skin: When contaminated Remove: When wet or contaminated Change: No recommendation		First Aid (See procedures) Eye: Irrigate immediately Skin: Water flush promptly Breathing: Respiratory support Swallow: Medical attention immediately	
Respirator Recommendations OSHA Up to 50 ppm: (APF = 10) Any chemical cartridge respirator with organic vapor cartridge(s)* (APF = 10) Any supplied-air respirator* Up to 100 ppm: (APF = 25) Any supplied-air respirator operated in a continuous-flow mode* (APF = 50) Any chemical cartridge respirator with a full facepiece and organic vapor cartridge(s) (APF = 25) Any powered, air-purifying respirator with organic vapor cartridge(s)* (APF = 50) Any air-purifying, full-facepiece respirator (gas mask) with a chin-style, front- or back-mounted organic vapor canister (APF = 50) Any self-contained breathing apparatus with a full facepiece (APF = 50) Any supplied-air respirator with a full facepiece Emergency or planned entry into unknown concentrations or IDLH conditions: (APF = 10,000) Any self-contained breathing apparatus that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode (APF = 10,000) Any supplied-air respirator that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode in combination with an auxiliary self-contained positive-pressure breathing apparatus Escape: (APF = 50) Any air-purifying, full-facepiece respirator (gas mask) with a chin-style, front- or back-mounted organic vapor canister/Any appropriate escape-type, self-contained breathing apparatus Important additional information about respirator selection			
Exposure Routes inhalation, skin absorption, ingestion, skin and/or eye contact			
Symptoms Irritation eyes, skin, upper respiratory system; headache; dermatitis			

Target Organs Eyes, skin, respiratory system

See also: [INTRODUCTION](#) See ICSC CARD: [0276](#) See MEDICAL TESTS: [0252](#)

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Hydrogen fluoride				CAS 7664-39-3	
HF				RTECS MW7875000	
Synonyms & Trade Names				DOT ID & Guide	
Anhydrous hydrogen fluoride; Aqueous hydrogen fluoride (i.e., Hydrofluoric acid); HF-A				1052 125 (anhydrous) 1790 157 (solution)	
Exposure Limits		NIOSH REL: TWA 3 ppm (2.5 mg/m ³) C 6 ppm (5 mg/m ³) [15-minute]			
		OSHA PEL†: TWA 3 ppm			
IDLH 30 ppm See: 7664393		Conversion 1 ppm = 0.82 mg/m ³			
Physical Description					
Colorless gas or fuming liquid (below 67°F) with a strong, irritating odor. [Note: Shipped in cylinders.]					
MW: 20.0	BP: 67°F	FRZ: -118°F	Sol: Miscible		
VP: 783 mmHg	IP: 15.98 eV	RGasD: 0.69	Sp.Gr: 1.00 (Liquid at 67°F)		
Fl.P: NA	UEL: NA	LEL: NA			
Nonflammable Gas					
Incompatibilities & Reactivities					
Metals, water or steam [Note: Corrosive to metals. Will attack glass and concrete.]					
Measurement Methods					
NIOSH 3800 , 7902 , 7903 , 7906 ; OSHA ID110					
See: NMAM or OSHA Methods					
Personal Protection & Sanitation (See protection codes)			First Aid (See procedures)		
Skin: Prevent skin contact (liquid)			Eye: Irrigate immediately (solution/liquid)		
Eyes: Prevent eye contact (liquid)			Skin: Water flush immediately (solution/liquid)		
Wash skin: When contaminated (liquid)			Breathing: Respiratory support		
Remove: When wet or contaminated (liquid)			Swallow: Medical attention immediately (solution)		
Change: No recommendation					
Provide: Eyewash (liquid), Quick drench (liquid)					
Respirator Recommendations NIOSH/OSHA					
Up to 30 ppm:					
(APF = 10) Any chemical cartridge respirator with cartridge(s) providing protection against the compound of concern*					
(APF = 25) Any powered, air-purifying respirator with cartridge(s) providing protection against the compound of concern*					
(APF = 50) Any air-purifying, full-facepiece respirator (gas mask) with a chin-style, front- or back-mounted canister providing protection against the compound of concern					
(APF = 10) Any supplied-air respirator*					
(APF = 50) Any self-contained breathing apparatus with a full facepiece					
Emergency or planned entry into unknown concentrations or IDLH conditions:					
(APF = 10,000) Any self-contained breathing apparatus that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode					
(APF = 10,000) Any supplied-air respirator that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode in combination with an auxiliary self-contained positive-pressure breathing apparatus					
Escape:					
(APF = 50) Any air-purifying, full-facepiece respirator (gas mask) with a chin-style, front- or back-mounted canister providing protection against the compound of concern/Any appropriate escape-type, self-contained breathing apparatus					
Important additional information about respirator selection					
Exposure Routes inhalation, skin absorption (liquid), ingestion (solution), skin and/or eye contact					
Symptoms Irritation eyes, skin, nose, throat; pulmonary edema; eye, skin burns; rhinitis; bronchitis; bone changes					
Target Organs Eyes, skin, respiratory system, bones					
See also: INTRODUCTION See ICSC CARD: 0283 See MEDICAL TESTS: 0118					

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Hydrogen sulfide		Formula: H ₂ S	CAS#: 7783-06-4	RTECS#: MX1225000	IDLH: 100 ppm
Conversion: 1 ppm = 1.40 mg/m ³		DOT: 1053 117			
Synonyms/Trade Names: Hydrosulfuric acid, Sewer gas, Sulfuretted hydrogen					
Exposure Limits: NIOSH REL: C 10 ppm (15 mg/m ³) [10-minute] OSHA PEL†: C 20 ppm 50 ppm [10-minute maximum peak]				Measurement Methods (see Table 1): NIOSH 6013 OSHA ID141	
Physical Description: Colorless gas with a strong odor of rotten eggs. [Note: Sense of smell becomes rapidly fatigued & can NOT be relied upon to warn of the continuous presence of H ₂ S. Shipped as a liquefied compressed gas.]					
Chemical & Physical Properties: MW: 34.1 BP: -77°F Sol: 0.4% Fl.P: NA (Gas) IP: 10.46 eV RGasD: 1.19 VP: 17.6 atm FRZ: -122°F UEL: 44.0% LEL: 4.0% Flammable Gas		Personal Protection/Sanitation (see Table 2): Skin: Frostbite Eyes: Frostbite Wash skin: N.R. Remove: When wet (flamm) Change: N.R. Provide: Frostbite wash		Respirator Recommendations (see Tables 3 and 4): NIOSH 100 ppm: PaprS/GmFS/Sa*/ScbaF §: ScbaF: Pd, Pp/SaF: Pd, Pp: AScba Escape: GmFS/ScbaE	
Incompatibilities and Reactivities: Strong oxidizers, strong nitric acid, metals					
Exposure Routes, Symptoms, Target Organs (see Table 5): ER: Inh, Con SY: Irrit eyes, resp sys; apnea, coma, convuls; conj, eye pain, lac, photo, corn vesic; dizz, head, lass, irrity, insom; GI dist; liquid: frostbite TO: Eyes, resp sys, CNS				First Aid (see Table 6): Eye: Frostbite Skin: Frostbite Breath: Resp support	

Hydroquinone		Formula: C ₆ H ₄ (OH) ₂	CAS#: 123-31-9	RTECS#: MX3500000	IDLH: 50 mg/m ³
Conversion:		DOT: 2662 153			
Synonyms/Trade Names: p-Benzenediol; 1,4-Benzenediol; Dihydroxybenzene; 1,4-Dihydroxybenzene; Quinol					
Exposure Limits: NIOSH REL: C 2 mg/m ³ [15-minute] OSHA PEL: TWA 2 mg/m ³				Measurement Methods (see Table 1): NIOSH 5004 OSHA PV2094	
Physical Description: Light-tan, light-gray, or colorless crystals.					
Chemical & Physical Properties: MW: 110.1 BP: 545°F Sol: 7% Fl.P: 329°F (Molten) IP: 7.95 eV Sp.Gr: 1.33 VP: 0.00001 mmHg MLT: 338°F UEL: ? LEL: ? Combustible Solid; dust cloud may explode if ignited in an enclosed area.		Personal Protection/Sanitation (see Table 2): Skin: Prevent skin contact Eyes: Prevent eye contact Wash skin: When contam Remove: When wet or contam Change: Daily Provide: Eyewash (>7%)		Respirator Recommendations (see Tables 3 and 4): NIOSH/OSHA 50 mg/m³: PaprHie£/100F/SaT:Cf£/ ScbaF/SaF §: ScbaF: Pd,Pp/SaF: Pd,Pp: AScba Escape: 100F/ScbaE	
Incompatibilities and Reactivities: Strong oxidizers, alkalis					
Exposure Routes, Symptoms, Target Organs (see Table 5): ER: Inh, Ing, Con SY: Irrit eyes; conj; kera; CNS excitement; colored urine, nau, dizz, suffocation, rapid breath; musc twitch, delirium; collapse; skin irrit, sens, derm TO: Eyes, skin, resp sys, CNS				First Aid (see Table 6): Eye: Irr immed Skin: Water flush Breath: Resp support Swallow: Medical attention immed	

Ketene	Formula: CH ₂ =CO	CAS#: 463-51-4	RTECS#: OA7700000	IDLH: 5 ppm
Conversion: 1 ppm = 1.72 mg/m ³	DOT:			
Synonyms/Trade Names: Carbomethene, Ethenone, Keto-ethylene				
Exposure Limits: NIOSH REL: TWA 0.5 ppm (0.9 mg/m ³) ST 1.5 ppm (3 mg/m ³) OSHA PEL†: TWA 0.5 ppm (0.9 mg/m ³)			Measurement Methods (see Table 1): NIOSH S92 (II-2)	
Physical Description: Colorless gas with a penetrating odor.				
Chemical & Physical Properties: MW: 42.0 BP: -69°F Sol: Reacts F.L.P: NA (Gas) IP: 9.61 eV RGasD: 1.45 VP: >1 atm FRZ: -238°F UEL: ? LEL: ? Flammable Gas	Personal Protection/Sanitation (see Table 2): Skin: N.R. Eyes: N.R. Wash skin: N.R. Remove: N.R. Change: N.R.	Respirator Recommendations (see Tables 3 and 4): NIOSH/OSHA 5 ppm: Sa*/ScbaF §: ScbaF: Pd, Pp/SaF: Pd, Pp: AScba Escape: GmFOv/ScbaE		
	Incompatibilities and Reactivities: Water, alcohols, ammonia [Note: Readily polymerizes. Reacts with water to form acetic acid.]			
	Exposure Routes, Symptoms, Target Organs (see Table 5): ER: Inh, Con SY: Irrit eyes, skin, nose, throat, resp sys; pulm edema TO: Eyes, skin, resp sys		First Aid (see Table 6): Breath: Resp support	

L

Lead	Formula: Pb	CAS#: 7439-92-1	RTECS#: OF7525000	IDLH: 100 mg/m ³ (as Pb)
Conversion:	DOT:			
Synonyms/Trade Names: Lead metal, Plumbum				
Exposure Limits: NIOSH REL*: TWA 0.050 mg/m ³ See Appendix C OSHA PEL*: [1910.1025] TWA 0.050 mg/m ³ See Appendix C [*Note: The REL and PEL also apply to other lead compounds (as Pb) -- see Appendix C.]			Measurement Methods (see Table 1): NIOSH 7082, 7105, 7300, 7301, 7303, 7700, 7701, 7702, 9102, 9105 OSHA ID121, ID125G, ID206	
Physical Description: A heavy, ductile, soft, gray solid.				
Chemical & Physical Properties: MW: 207.2 BP: 3164°F Sol: Insoluble FLP: NA IP: NA Sp.Gr: 11.34 VP: 0 mmHg (approx) MLT: 621°F UEL: NA LEL: NA Noncombustible Solid in bulk form.	Personal Protection/Sanitation (see Table 2): Skin: Prevent skin contact Eyes: Prevent eye contact Wash skin: Daily Remove: When wet or contam Change: Daily		Respirator Recommendations (see Tables 3 and 4): NIOSH/OSHA 0.5 mg/m³: 100XQ/Sa 1.25 mg/m³: Sa:Cf/Paprhie 2.5 mg/m³: 100F/SaT:Cf/Paprhie/ ScbaF/SaF 50 mg/m³: Sa:Pd,Pp 100 mg/m³: SaF:Pd,Pp §: ScbaF:Pd,Pp/SaF:Pd,Pp:AScba Escape: 100F/ScbaE	
See Appendix E (page 351)				
Incompatibilities and Reactivities: Strong oxidizers, hydrogen peroxide, acids				
Exposure Routes, Symptoms, Target Organs (see Table 5): ER: Inh, Ing, Con SY: Lass, insom; facial pallor; anor, low-wgt, malnut; constip, abdom pain, colic; anemia; gingival lead line; tremor; para wrist, ankles; encephalopathy; kidney disease; irrit eyes; hypotension TO: Eyes, GI tract, CNS, kidneys, blood, gingival tissue			First Aid (see Table 6): Eye: Irr immed Skin: Soap flush prompt Breath: Resp support Swallow: Medical attention immed	


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NIOSH Publication 2005-149

September 2005

NIOSH Pocket Guide to Chemical Hazards

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Nitric acid		CAS 7697-37-2
HNO₃		RTECS QU5775000
Synonyms & Trade Names Aqua fortis, Engravers acid, Hydrogen nitrate, Red fuming nitric acid (RFNA), White fuming nitric acid (WFNA)		DOT ID & Guide 2031 157 (other than red fuming) 2032 157 (fuming)
Exposure Limits	NIOSH REL: TWA 2 ppm (5 mg/m ³) ST 4 ppm (10 mg/m ³)	
	OSHA PEL†: TWA 2 ppm (5 mg/m ³)	
IDLH 25 ppm See: 7697372		Conversion 1 ppm = 2.58 mg/m ³
Physical Description Colorless, yellow, or red, fuming liquid with an acrid, suffocating odor. [Note: Often used in an aqueous solution. Fuming nitric acid is concentrated nitric acid that contains dissolved nitrogen dioxide.]		
MW: 63.0	BP: 181°F	FRZ: -44°F
VP: 48 mmHg	IP: 11.95 eV	Sol: Miscible
Fl.P: NA	UEL: NA	LEL: NA
Noncombustible Liquid, but increases the flammability of combustible materials.		
Incompatibilities & Reactivities Combustible materials, metallic powders, hydrogen sulfide, carbides, alcohols [Note: Reacts with water to produce heat. Corrosive to metals.]		
Measurement Methods NIOSH 7903 ; OSHA ID165SG See: NMAM or OSHA Methods		
Personal Protection & Sanitation (See protection codes) Skin: Prevent skin contact Eyes: Prevent eye contact Wash skin: When contaminated Remove: When wet or contaminated Change: No recommendation Provide: Eyewash (pH<2.5), Quick drench (pH<2.5)		First Aid (See procedures) Eye: Irrigate immediately Skin: Water flush immediately Breathing: Respiratory support Swallow: Medical attention immediately
Respirator Recommendations NIOSH/OSHA Up to 25 ppm: (APF = 25) Any supplied-air respirator operated in a continuous-flow mode* (APF = 50) Any chemical cartridge respirator with a full facepiece and cartridge(s) providing protection against the compound of concern ^c (APF = 50) Any air-purifying, full-facepiece respirator (gas mask) with a chin-style, front- or back-mounted canister providing protection against the compound of concern ^c (APF = 50) Any self-contained breathing apparatus with a full facepiece (APF = 50) Any supplied-air respirator with a full facepiece Emergency or planned entry into unknown concentrations or IDLH conditions: (APF = 10,000) Any self-contained breathing apparatus that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode (APF = 10,000) Any supplied-air respirator that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode in combination with an auxiliary self-contained positive-pressure breathing apparatus Escape: (APF = 50) Any air-purifying, full-facepiece respirator (gas mask) with a chin-style, front- or back-mounted canister providing protection against the compound of concern ^c /Any appropriate escape-type, self-contained breathing apparatus Important additional information about respirator selection		
Exposure Routes inhalation, ingestion, skin and/or eye contact		

Symptoms Irritation eyes, skin, mucous membrane; delayed pulmonary edema, pneumonitis, bronchitis; dental erosion
Target Organs Eyes, skin, respiratory system, teeth
See also: INTRODUCTION See ICSC CARD: 0183 See MEDICAL TESTS: 0158

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Sulfuric acid		Formula: H ₂ SO ₄	CAS#: 7664-93-9	RTECS#: WS5600000	IDLH: 15 mg/m ³
Conversion:		DOT: 1830 137; 1831 137 (fuming); 1832 137 (spent)			
Synonyms/Trade Names: Battery acid, Hydrogen sulfate, Oil of vitriol, Sulfuric acid (aqueous)					
Exposure Limits: NIOSH REL: TWA 1 mg/m ³ OSHA PEL: TWA 1 mg/m ³				Measurement Methods (see Table 1): NIOSH 7903 OSHA ID113, ID165SG	
Physical Description: Colorless to dark-brown, oily, odorless liquid. [Note: Pure compound is a solid below 51°F. Often used in an aqueous solution.]					
Chemical & Physical Properties: MW: 98.1 BP: 554°F Sol: Miscible F.I.P: NA IP: ? Sp.Gr: 1.84 (96-98% acid) VP: 0.001 mmHg FRZ: 51°F UEL: NA LEL: NA Noncombustible Liquid, but capable of igniting finely divided combustible materials.		Personal Protection/Sanitation (see Table 2): Skin: Prevent skin contact Eyes: Prevent eye contact Wash skin: When contam Remove: When wet or contam Change: N.R. Provide: Eyewash (>1%) Quick drench (>1%)		Respirator Recommendations (see Tables 3 and 4): NIOSH/OSHA 15 mg/m³: Sa:Cff/PapraAgHief/ CcrFAg100/GmFAg100/ ScbaF/SaF \$: ScbaF: Pd,Pp/SaF: Pd,Pp:AScba Escape: GmFAg100/ScbaE	
Incompatibilities and Reactivities: Organic materials, chlorates, carbides, fulminates, water, powdered metals [Note: Reacts violently with water with evolution of heat. Corrosive to metals.]					
Exposure Routes, Symptoms, Target Organs (see Table 5): ER: Inh, Ing, Con SY: Irrit eyes, skin, nose, throat; pulm edema, bron; emphy; conj; stomatitis; dental erosion; eye, skin burns; derm TO: Eyes, skin, resp sys, teeth			First Aid (see Table 6): Eye: Irr immed Skin: Water flush immed Breath: Resp support Swallow: Medical attention immed		

Sulfur monochloride		Formula: S ₂ Cl ₂	CAS#: 10025-67-9	RTECS#: WS4300000	IDLH: 5 ppm
Conversion: 1 ppm = 5.52 mg/m ³		DOT: 1828 137			
Synonyms/Trade Names: Sulfur chloride, Sulfur subchloride, Thiosulfurous dichloride					
Exposure Limits: NIOSH REL: C 1 ppm (6 mg/m ³) OSHA PEL†: TWA 1 ppm (6 mg/m ³)				Measurement Methods (see Table 1): None available	
Physical Description: Light-amber to yellow-red, oily liquid with a pungent, nauseating, irritating odor.					
Chemical & Physical Properties: MW: 135.0 BP: 280°F Sol: Decomposes F.I.P: 245°F IP: 9.40 eV Sp.Gr: 1.68 VP: 7 mmHg FRZ: -107°F UEL: ? LEL: ? Class IIIB Combustible Liquid		Personal Protection/Sanitation (see Table 2): Skin: Prevent skin contact Eyes: Prevent eye contact Wash skin: When contam Remove: When wet or contam Change: N.R. Provide: Eyewash Quick drench		Respirator Recommendations (see Tables 3 and 4): NIOSH/OSHA 5 ppm: CcrFS/GmFS/PapRSE/ ScbaF/SaF \$: ScbaF: Pd, Pp/PaF: Pd, Pp: AScba Escape: GmFS/ScbaE	
Incompatibilities and Reactivities: Peroxides, oxides of phosphorous, organics, water [Note: Decomposes violently in water to form hydrochloric acid, sulfur dioxide, sulfur, sulfite, thiosulfate, and hydrogen sulfide. Corrosive to metals.]					
Exposure Routes, Symptoms, Target Organs (see Table 5): ER: Inh, Ing, Con SY: Irrit eyes, skin, muc memb; lac; cough; eye, skin burns; pulm edema TO: Eyes, skin, resp sys				First Aid (see Table 6): Eye: Irr immed Skin: Water flush immed Breath: Resp support Swallow: Medical attention immed	

p-Terphenyl	Formula: C ₆ H ₅ C ₆ H ₄ C ₆ H ₅	CAS#: 92-94-4	RTECS#: WZ6475000	IDLH: 500 mg/m ³
Conversion: 1 ppm = 9.57 mg/m ³	DOT:			
Synonyms/Trade Names: p-Diphenylbenzene; 1,4-Diphenylbenzene; 4-Phenylbiphenyl; 1,4-Terphenyl; para-Terphenyl; p-Triphenyl				
Exposure Limits: NIOSH REL: C 5 mg/m ³ (0.5 ppm) OSHA PEL†: C 9 mg/m ³ (1 ppm)			Measurement Methods (see Table 1): NIOSH 5021	
Physical Description: White or light-yellow solid.				
Chemical & Physical Properties: MW: 230.3 BP: 761°F Sol: Insoluble FLP: 405°F IP: 7.78 Sp.Gr: 1.23 VP: Very low MLT: 415°F UEL: ? LEL: ? Combustible Solid	Personal Protection/Sanitation (see Table 2): Skin: Prevent skin contact Eyes: Prevent eye contact Wash skin: When contam Remove: When wet or contam Change: Daily Provide: Eyewash Quick drench	Respirator Recommendations (see Tables 3 and 4): NIOSH 25 mg/m³: Qm£ 50 mg/m³: 95XQ£/Sa£ 125 mg/m³: Sa:C££/Paprhie£ 250 mg/m³: 100F/ScbaF/SaF 500 mg/m³: SaF:Pd,Pp §: ScbaF:Pd,Pp/SaF:Pd,Pp:AScba Escape: 100F/ScbaE		
Incompatibilities and Reactivities: None reported				
Exposure Routes, Symptoms, Target Organs (see Table 5): ER: Inh, Ing, Con SY: Irrit eyes, skin, muc memb; thermal skin burns; head; sore throat; in animals: liver, kidney damage TO: Eyes, skin, resp sys, liver, kidneys		First Aid (see Table 6): Eye: Irr immed Skin: Water flush immed Breath: Resp support Swallow: Medical attention immed		

2,3,7,8-Tetrachloro-dibenzo-p-dioxin		Formula: C ₁₂ H ₄ Cl ₄ O ₂	CAS#: 1746-01-6	RTECS#: HP3500000	IDLH: Ca [N.D.]
Conversion:		DOT:			
Synonyms/Trade Names: Dioxin; Dioxine; TCDBD; TCDD; 2,3,7,8-TCDD [Note: Formed during past production of 2,4,5-trichlorophenol, 2,4,5-T & 2(2,4,5-trichlorophenoxy)propionic acid.]					
Exposure Limits: NIOSH REL: Ca See Appendix A OSHA PEL: none				Measurement Methods (see Table 1): None available	
Physical Description: Colorless to white, crystalline solid. [Note: Exposure may occur through contact at previously contaminated worksites.]					
Chemical & Physical Properties: MW: 322.0 BP: Decomposes Sol: 0.00000002% FLP: ? IP: ? Sp.Gr: ? VP(77°F): 0.000002 mmHg MLT: 581°F UEL: ? LEL: ?		Personal Protection/Sanitation (see Table 2): Skin: Prevent skin contact Eyes: Prevent eye contact Wash skin: When contam/Daily Remove: When wet or contam Change: Daily Provide: Eyewash Quick drench		Respirator Recommendations (see Tables 3 and 4): NIOSH ¥: ScbaF:Pd,Pp/SaF:Pd,Pp:AScba Escape: GmFov100/ScbaE	
Incompatibilities and Reactivities: UV light (decomposes)					
Exposure Routes, Symptoms, Target Organs (see Table 5): ER: Inh, Abs, Ing, Con SY: Irrit eyes; allergic derm, chloracne; porphyria; GI dist; possible repro, terato effects; in animals: liver, kidney damage; hemorr; [carc] TO: Eyes, skin, liver, kidneys, repro sys [in animals: tumors at many sites]				First Aid (see Table 6): Eye: Irr immed Skin: Soap flush immed Breath: Resp support Swallow: Medical attention immed	



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Landfill Fires Guidance Document

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Landfill fires, both surface and subsurface, are more common than one might expect. Although no one agency in the United States tracks the number of landfill fires a local search of web engines will indicate landfill fires have occurred from California to Minnesota and throughout the northern hemisphere. In California alone more than 25 subsurface landfill fires have been reported during the past 15 years. Most of the incidents are small fires or rapid oxidation events and are usually handled by the operating facility and the local or state regulatory agency. Seldom do the subsurface events become large-scale environmental responses.

Types of Landfill Fires

The most common types of fires occur at the surface, where fuel and oxygen are abundant. These fires can burn between the surface and one foot below ground. The other type smolders below ground and can extend down to 40 feet.

Surface Landfill Fires

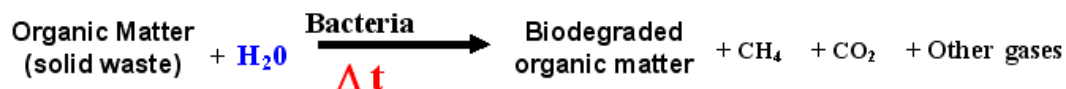
A surface fire can start if the facility accepts hot objects (for example, barbeque coals or other ashes) or overdraws the landfill gas collection system. Also arson, spontaneous combustion, or a discarded cigarette can start fires. To keep fires small and manageable, immediate action is necessary. Actions may include using heavy equipment to remove the burning material to a safe area, the application of soil to suffocate the fire, or the use of suppression agent and firefighting activities. If no action is taken, significant amounts of rancid and toxic smoke will be generated from burning surface trash. Toxicity of this smoke depends on the composition of the waste stream.

Subsurface Landfill Fires

A subsurface fire typically starts from overdrawing a gas collection system or spontaneous combustion. These fires are more likely to burn slowly without visible flame or large quantities of smoke and are characterized by rapid oxidation of an organic waste. The waste mass tends to oxidize around the extraction well, in the influence zone of the extraction well, or near a surface feature that allows oxygen to enter the waste mass. Subsurface fires in gas collection systems are detected by elevated temperature at the well head or by the detection of soot in the gas collection system. At times, underground combustion/oxidation will go undetected until a sinkhole or smoke appears. Normally you will never see an actual flame during this type of fire unless the subsurface fire is excavated and exposed to the atmosphere.

How Spontaneous Combustion Occurs

In spontaneous combustion, waste material is heated by chemical oxidation and biological decomposition. The resulting heat causes the material to reach the point of ignition. This type of rapid oxidation in a municipal or construction/wood waste facility is directly related to the amount of moisture present in the fill. The bacteria--both aerobic and anaerobic--present in organic matter require water to biologically breakdown organic matter. As shown in the equation below, as organic material is biodegraded, heat is produced along with other constituents.



Equation Text Description: In the presence of bacteria, organic matter (solid waste) and water react to produce increased heat (delta t), methane (CH₄) gas and carbon dioxide (CO₂) gas as well as other gases and degraded organic material.

With the correct conditions present, spontaneous combustion can occur in household trash or at construction debris facilities. This type of combustion will produce excessive amounts of carbon monoxide (CO) and other trace toxic gases due to incomplete oxidation.

Detecting Subsurface Fires

To determine if a subsurface fire exists, one must have visual confirmation or other conditions present. Generally a subsurface fire can be confirmed by:

Substantial settlement over a short period of time
Smoke or smoldering odor emanating from the gas extraction system or landfill
Levels of CO in excess of 1000 parts per million (ppm)
Combustion residue in extraction wells and/or headers
Increase in gas temperature in the extraction system (above 140° Fahrenheit) or
Temperatures in excess of 170° Fahrenheit.

To confirm a subsurface fire by using CO, the results must be acquired through quantitative laboratory analysis. Most field portable equipment only have qualitative abilities and are susceptible to cross-sensitivity with high temperatures, humidity, and other constituents of landfill gas (for example, volatile organic compounds, hydrogen sulfide, etc.). As a result, landfill gas containing these conditions and constituents may produce artificially high carbon monoxide readings when using portable monitors.

The CIWMB staff considers levels of CO in excess of 1,000 ppm to be a positive indication of an active underground landfill fire. Levels of CO between 100 and 1,000 ppm are viewed as suspicious and require further air and temperature monitoring. Levels between 10 and 100 ppm may be an indication of a fire but active combustion is not present.

Employee Health and Safety Risks

Subsurface landfill fire can create many types of life threatening conditions. These conditions must be communicated to all site personnel and anyone who is involved in the project. Site hazards may include slips, trips, and falls; confined space issues; carbon monoxide and toxic gas exposures; possible cave-ins due to the void spaces; and burn issues from the elevated temperatures. Safety protocols and considerations related to subsurface landfill fires should be implemented for site workers.

For example, CIWMB air monitoring data from subsurface landfill fires detected CO levels in the range of 2,500 to 28,000 parts per million (ppm) at ground surface. Given that the immediate danger to life and health (IDLH) level is 1,200 ppm, personnel and site air quality monitoring for CO and other chemical exposures may be necessary. CIWMB staff has also recorded temperatures in excess of 300 degrees Fahrenheit within 1 to 3 feet below ground surface. Although not typical, sinkholes in excess of 8 feet in diameter and 5 feet in depth have occurred during underground fires. For additional information on employee protection, contact Cal/OSHA at 1-800-963-9424 or via e-mail at: InfoCons@dir.ca.gov.

Suppression Methods

As with any fire, once one side of the fire tetrahedron collapses the chemical reaction will stop. Landfill fires can be extinguished by smothering with soil, using heavy equipment and a suppressant agent, or simply temporarily shutting down the gas extraction system. No one method will work for all conditions. Each suppression plan will be unique due to site-specific conditions. At times, only an interim cap will prevent the extension of the fire, while other times the use of heavy equipment and foam is preferable.

Interim Cap Recommendations

Based on past experiences with other landfill fires and the thermal properties of plastics (e.g. geomembrane, geotextile, or geosynthetic anything), it is not recommended that a geomembrane or geosynthetic clay liner (GCL) be used to cover the landfill unit until the subsurface fire is extinguished. Although some GCLs do have a large clay component, the potential for rapid settlement from subsurface fires can make the repair and maintenance very difficult. It is recommended that the cap be constructed of a soil with the following properties:

1. A clean, low permeability soil capable of obtaining a permeability of 1×10^{-5} cm/sec with a maximum particle size of three inches or less
2. The soil should be classified as SC, ML, CL, or CH according to the unified soil classification system
3. The soil should be compacted to a minimum of 89 percent of the maximum dry density as determined by ASTM D-1557
4. The cover should extend a minimum of 10 feet beyond the landfill area if feasible
5. The clay cover should be a minimum of 18 inches, but recommended the clay cover be 24 inches and placed over a graded foundation layer
6. Each lift of clay should not exceed 9 inches before compaction.

Once the fire is confirmed extinguished, other layers including geotextile, geomembrane, GCL, and/or vegetative could be installed.

Suppression Agents

Although there are many types of foam and wetting agents, it is best to use a class A foam or wetting agent. These chemicals include a surfactant that reduces surface tension and improves penetration depth. Class B foams are ineffective because it is impossible to separate the oxygen from the fuel as it is done with

flammable liquids. Class B foams are a two dimensional product, while class A and wetting agents work on three dimensional fires such as landfill and tire fires.

Water

The application of large amounts of water without a suppression agent is not recommend. Large amounts of water may actually acerbate the fire potential by increasing the amount of biodegraded matter and heat. The excess water will also increase contaminated runoff and leachate.

Who Needs to Be Notified?

Typically, if the landfill fire is localized and contained in a small area, the LEA, appropriate CIWMB staff, and the local fire department should be notified. Site specific factors, permit conditions, or other mandates may require that the landfill operator or site owner notify other entities including the local air quality management district, the United States Environmental Protection Agency, the California Office of Emergency Services, local hazardous materials program, and neighbors.

Conclusion

The recommendations presented in this document are based on practical working knowledge of past surface and subsurface fires at waste facilities. Each debris or landfill fire will have site-specific issues that must be addressed. For more information on monitoring requirements or other protocols, please contact [Todd Thalhamer](#), P.E., at the CIWMB.

Todd Thalhamer has worked at CIWMB as a waste management engineer since 1992. He has worked on several major waste fires, including the Tracy tire fire and the Fresno debris fire. He is a registered civil engineer and also a Lieutenant with the El Dorado Hills Fire Department.

Last updated: April 18, 2008

LEA Support Services <http://www.ciwmb.ca.gov/LEACentral/>

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LANDFILL FIRES

THEIR MAGNITUDE, CHARACTERISTICS, AND MITIGATION

MAY 2002/FA-225

Federal Emergency Management Agency
United States Fire Administration
National Fire Data Center



FA-225

LANDFILL FIRES
THEIR MAGNITUDE, CHARACTERISTICS,
AND MITIGATION

MAY 2002

Prepared by

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for

Federal Emergency Management Agency
United States Fire Administration
National Fire Data Center

U.S. FIRE ADMINISTRATION MISSION STATEMENT

As an entity of the Federal Emergency Management Agency, the mission of the U.S. Fire Administration is to reduce life and economic losses due to fire and related emergencies through leadership, advocacy, coordination, and support. We serve the Nation independently, in coordination with other Federal agencies and in partnership with fire protection and emergency service communities. With a commitment to excellence, we provide public education, training, technology, and data initiatives.

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The United States Fire Administration greatly appreciates the help of the following persons who provided information or reviewed this report:

Rodney Slaughter	Rodney Slaughter is the President of Dragonfly Communications Network, a fire service training and consulting firm.
Todd Thalhamer	Todd Thalhamer, P.E., is a waste management engineer with the California Integrated Waste Management Board. Mr. Thalhamer specializes in investigating and mitigating landfill and tire fires for the State of California.
Dr. Tony Sperling	Dr. Sperling is the President of Sperling Hansen Associates and the founding partner of Landfillfire.com (http://www.Landfill-fire.com). Since 1997, he has specialized in landfill fire risk reduction training and landfill fire extinguishment on more than 30 landfill fire projects.

EXECUTIVE SUMMARY

Landfills can be controversial in and of themselves. Homeowners and business owners tend not to support the siting and development of landfills in their neighborhoods due to perceived notions about noxious fumes, health and environmental effects, and adverse influences on property values. Fires occurring in landfill sites are an ongoing, complex problem that has existed for decades.

Although relatively uncommon, fires in landfills generally receive substantial media attention and have the potential to become politically damaging events. Landfill fires threaten the environment through toxic pollutants emitted into the air, water, and soil.

Landfill fires are particularly challenging to the fire service. A large landfill fire normally requires numerous personnel and a significant period of time before it is contained. Both of these circumstances can strain a jurisdiction, particularly one dependent on volunteer staffing.

Landfill operators, members of the fire service, and community residents need to learn as much as possible from past experience to prevent and mitigate future landfill fires.

REGULATION. In 1976, Congress passed the Resource Conservation and Recovery Act (RCRA), which gave the Environmental Protection Agency (EPA) the authority to control hazardous waste from “cradle-to-grave.” RCRA covers the generation, transportation, treatment, storage, and disposal of hazardous waste and provides a framework for the management of non-hazardous wastes. A turning point in landfill regulation and remediation occurred in 1980, first with the “Superfund” legislation, followed by the Hazardous and Solid Waste Amendments (HSWA) in 1984, which finally gave the EPA regulatory authority over landfills. The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), known as Superfund, governs closed and abandoned hazardous material waste sites, provides for the liability of persons responsible for the release of hazardous materials at these sites, and established a trust fund to provide for cleanup where no responsible party could be identified.

CHARACTERISTICS. The most common type of landfill is one that is designed to accept municipal solid waste (MSW). Other types of landfills include hazardous materials landfills, construction and demolition landfills, and industrial landfills. Each type of landfill has specific characteristics based on the type of waste it is designed to accept.

The passage of liquid through solid waste in a landfill creates leachate, which contains potentially dangerous pollutants. As such, landfills must operate in a manner that protects the environment, particularly surface and ground waters, from leachate contamination. To do this, landfill designs generally incorporate a composite liner and a leachate collection system, and landfill procedures require that the waste collected each day be completely covered.

Because of the methods normally adopted to deposit, compact, and cover waste in landfills, the decomposition of waste is largely anaerobic, which results in the production of large quantities of methane and carbon dioxide. Landfills are the largest source of methane emissions in the United States; in 1999, 35 percent of methane emissions were from landfills. Methane is highly flammable and plays a large role in the ignition of landfill fires.

EXTINGUISHING LANDFILL FIRES. The different dynamics, characteristics, and regulations of landfills and the fires that occur in them suggest that firefighting tactics need to be determined on a case-by-case basis depending on the materials buried in the landfill, which materials have ignited, depth of the fire, and the fire's ignition source. Challenges explored in this report include wind/weather; water supply; multi-agency response; personnel safety; access to, access by and maneuverability of heavy equipment; logistics; environmental impact; and landfill contents (potentially hazardous or illegal).

PREVENTION. Fire prevention actions can reduce property damage and the risk of injury and death, as well as decrease health and environmental hazards associated with landfill fires. As a rule, the cost of prevention is less expensive than the cost of fighting and cleaning up a fire. In many cases, particularly at larger landfills, fire prevention activities are mandated by law. The principal methods for landfill fire prevention include effective landfill management and appropriate methane gas detection and collection.

STATISTICAL ANALYSIS. Data from the National Fire Incident Reporting System (NFIRS) does not include MSW landfills as a fixed property use category. Rather, the NFIRS data set includes a category for "dump or sanitary landfill" under NFIRS Fixed Property Use code 932. Although this definition is broader than the definition of a landfill, it is the closest match available in NFIRS. Based on extrapolation of the NFIRS data, each year in the United States an average of 8,400 dump and landfill fires are reported to the fire service. This represents less than a half percent of all reported fires. Undoubtedly, some landfill fires go unreported because they burned undetected or were on private property and extinguished by the landfill operator. Reported fires are responsible for less than 10 civilian injuries, 30 firefighter injuries, and between \$3 and \$8 million in property loss each year.¹ Deaths (civilian or fire service) are rare in these fires. Since NFIRS represents a sample of data, it may be that fatalities occurred during the study period and were not reported or captured in the data.

CASE STUDIES. A sample of landfill fires throughout the world sheds light on the landfill fire problem. Waste disposal practices and the regulation of landfill sites are similar in the comparison countries. Landfill fires have been investigated and studied in more detail in these jurisdictions than in the United States. In addition to presenting U.S. case studies, this report includes brief synopses of interviews and media reports detailing landfill fires in the United States and the lessons that were learned from them.

¹ National estimates are based on NFIRS data (1996–1998) and the National Fire Protection Association's (NFPA) annual survey, *Fire Loss in the United States*.

LANDFILL FIRES

THEIR MAGNITUDE, CHARACTERISTICS, AND MITIGATION

Fires occurring at landfill sites across the United States are an ongoing, complex problem that has existed for decades. Landfill fires threaten the environment through toxic pollutants emitted into the air, water, and soil. These fires also pose a risk to firefighters and civilians who are exposed to the hazardous chemical compounds they emit. The degree of risk depends in part on the contents buried in the landfill, the geography of the landfill, and the nature of the fire. There can be great difficulty in the detection and extinguishment of landfill fires, which is compounded because these fires often smolder for weeks under the surface of the landfill before being discovered.

This report was prepared by TriData Corporation, Arlington, Virginia, under contract to the Federal Emergency Management Agency, U.S. Fire Administration (USFA), National Fire Data Center. It presents an overview of the landfill fire problem. Issues examined include the landfill components that create fire hazards; the effect of Environmental Protection Agency (EPA) regulations and landfill cleanup efforts; a profile of landfill fires including their characteristics, methods of extinguishing, and safety issues for firefighters; prevention efforts to reduce landfill fires; and past examples of significant landfill fires and lessons learned.

SOURCES OF DATA

Data on the number of municipal solid waste (MSW) landfill sites in the United States and their current regulations regarding disposal, including those open for disposal and those retired from service, were obtained from the EPA. Data and regulation information pertaining to the Superfund project, including current maps outlining ongoing landfill cleanup efforts, were also obtained from the EPA.

The EPA derives their landfill statistics from *BioCycle* magazine, which conducts an annual survey called "The State of Garbage in America." *BioCycle* magazine sends the survey to state officials and follows up the collected data with phone calls, e-mails, and letters to obtain as complete and accurate information on each participating state as possible. The survey collects data on MSW disposal practices in the United States, including information on national recycling rates, number of municipal solid waste landfills, and disposal rates.

Other information on landfill definitions, landfill dynamics, landfill regulations, and chemical compounds contained in emissions were derived from several sources within the EPA.

Landfill fire statistics presented here are based on data from the National Fire Incident Reporting System (NFIRS). NFIRS, established in 1975, is a data system maintained by USFA and today is the largest fire data set in the world. Not all fire departments participate in NFIRS, but the distribution of participants in NFIRS is reasonably representative of the entire nation, even though the sample is not random. Since the data set is incomplete and represents only a sample of American fire departments (<40 percent), many of the numbers in this analysis are national estimates or percentages rather than raw totals or absolute numbers.

Technical information on the characteristics of landfill fires was gathered from sources ranging from the textbook *The Essentials of Firefighting*² to various international studies on landfill fires.

Interviews were conducted with fire department representatives who have dealt with landfill fires. Examples of these fires are included in the report, along with lessons learned by the departments in suppressing the fires. Media reports (newspapers, magazines) provided further information about those fires discussed during the interviews.

WHY STUDY LANDFILL FIRES?

Landfills tend to be controversial in and of themselves. Homeowners and business owners may not be inclined to support new siting or development in their areas due to perceived notions about noxious fumes, health effects, and adverse influences on property values. As such, landfill fires can raise political issues and have implications for elected officials on election day. Further, the costs associated with fire suppression and environmental monitoring during a landfill fire can be enormous. This raises questions as to who is responsible for those costs—the municipal jurisdiction, a private company that operates the landfill, a combination of both, or some other entity.

Although relatively uncommon, fires in landfills generally receive substantial media attention. In some cases, landfill fires can smolder for weeks, producing odorous and noxious smoke that can be a community annoyance and that pose a health risk to civilians, firefighters, and others who are exposed.

Depending on the type of landfill and its contents, the smoke from a landfill fire may contain dangerous chemical compounds, which can cause respiratory disorders and other medical conditions. Even if the smoke is benign, it can still aggravate existing respiratory conditions and reduce visibility around the landfill. In addition, contrary to conventional thinking, the use of large amounts of water to suppress a landfill fire can actually make the fire worse by increasing the rate of aerobic decomposition, which increases the heat available inside the landfill. Further, runoff from suppression efforts can overwhelm a landfill's leachate collection system and contaminate ground or surface water sources.

² *Essentials of Firefighting 4th Edition*, International Fire Service Training Association, 2001.

Landfill fires are particularly challenging to the fire service. A large landfill fire will generally require numerous personnel and significant amounts of time to contain. Both of these circumstances can strain a jurisdiction, particularly one dependent on volunteer staffing. Depending on the type and location of the fire, extinguishing it may require specialized personnel and equipment that may not be immediately available. For example, fires involving hazardous materials require specially trained personnel who are equipped with specialized protective gear. Underground fires generally necessitate the use of heavy equipment (bulldozers, excavators, etc.) to dig out burning waste to be extinguished. Fire may also compromise the structural integrity of a landfill, posing a collapse hazard for personnel operating on the fireground.

Because these fires are relatively uncommon, it is important for communities and the fire service to learn as much as possible from past experience to prevent and mitigate future landfill fires and, if one occurs, to understand the best methods for extinguishing it.

CHARACTERISTICS OF LANDFILLS

Landfills have a variety of unique characteristics, which are primarily determined by the type of waste they are designed to accept. Landfills are regulated by different agencies at the federal, state, and local levels. (Regulatory mechanisms are discussed in detail later in this report.)

The characteristics of landfills constructed before 1984, however, may not conform to those discussed in this section. Prior to 1984, no federal agency had the jurisdiction to regulate landfills. Although some state-based agencies may have had regulatory authority before then, older landfill sites may have accepted both hazardous and nonhazardous waste if they were in operation prior to federal or state regulation. Further, older facilities may not have been constructed with leachate collection systems, gas-monitoring systems, or composite liners that meet the specifications required today.

MUNICIPAL SOLID WASTE LANDFILL. The most common type of landfill is designed for the disposal of municipal solid waste. MSW includes household waste such as product packaging, food scraps, furniture, clothing, and grass clippings. In 1999 alone, Americans generated nearly 230 million tons of MSW.³ Table 1 illustrates the components of the MSW produced in 1999 by material category. Only 57 percent of this waste, however, went to a landfill for disposal; the remainder was either recovered through recycling (28 percent) or incinerated (15 percent).⁴

The Code of Federal Regulations (CFR) defines an MSW landfill (MSWLF) as “a discrete area of land or an excavation site that receives household waste, and that is not a land application unit, surface impoundment, injection well, or waste pile...MSWLF unit may also receive other types of RCRA [Resource Conservation and Recovery Act] Subtitle D wastes, such

³ U.S. Code of Federal Regulations, 40 CFR 258.2 (Title 40—Protection of Environment Chapter I—Environmental Protection Agency. Part 258 – Criteria For Municipal Solid Waste Landfills).

⁴ *Municipal Solid Waste Basic Facts*, Environmental Protection Agency, Office of Solid Waste, January 4, 2002. <http://www.epa.gov/epaoswer/non-hw/muncpl/facts.htm>.

**Table 1. Components of MSW Produced in 1999
(prior to recycling)⁵**

Component	Percent of Waste
Paper	38.1
Yard Waste	12.1
Food Waste	10.9
Plastics	10.5
Metals	7.8
Rubber, Leather and Textiles	6.6
Glass	5.5
Wood	5.3
Other	3.2

as commercial solid waste, nonhazardous sludge, conditionally exempt small quantity of generator waste and industrial solid waste. Such a landfill may be publicly or privately owned.”⁶

The passage of liquid through the solid waste in a landfill creates leachate. Leachate is defined as “a liquid that has passed through or emerged from solid waste and contains soluble, suspended, or miscible materials removed from such waste.”⁷ As such, MSW landfills must operate in a manner that protects the environment, particularly surface and ground waters, from leachate contamination. To do this, MSW landfills generally use a combination of a composite liner and a leachate collection system. A composite liner “combines an upper liner of a synthetic flexible membrane and a lower layer of soil at least 2 feet thick with a hydraulic conductivity of no greater than 1×10^{-7} cm/sec”⁸ (Figure 1). A leachate collection system consists of a network of pipes that collect the leachate. The collected leachate is typically pumped to the surface of the landfill so that it can be treated and decontaminated. “The leachate collection system must be designed to keep the depth of the leachate over the liner to no greater than 30 centimeters.”⁹

While an MSW landfill is in operation, waste is disposed of in layers. These layers are compacted to the smallest practical volume and covered with earthen material at the end of each operating day, except at facilities exempt from cover placement or that use an alternate daily cover such as a tarp.

When a landfill reaches its capacity for waste disposal, a final cover is constructed. The final cover must be designed and constructed to minimize the flow of water into the closed landfill. It must also contain an erosion layer to prevent the disintegration of the cover. This layer must be composed of a minimum of 6 inches of earthen material capable of sustaining plant

⁵ *Municipal Solid Waste in the United States: 1999 Facts and Figures*, Environmental Protection Agency.

⁶ U.S. Code of Federal Regulations, 40 CFR 258.2, op. cit.

⁷ Ibid.

⁸ *Criteria for Solid Waste Disposal Facilities: A Guide for Owners/Operators*, Environmental Protection Agency, EPA/530-SW-91-089, March 1993.

⁹ Ibid.

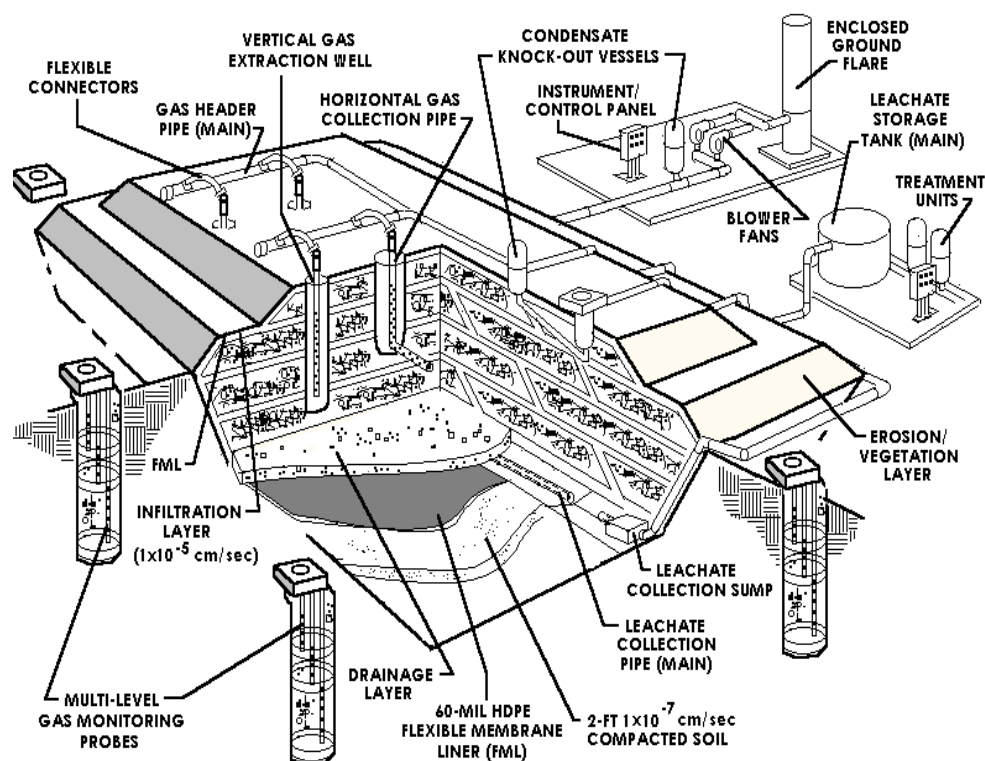


Figure 1. Landfill Components¹⁰

growth. An independent engineer must certify that the landfill was closed in accordance with federal regulations. For the next 30 years, landfill owners or operators are required to maintain the integrity of the final cover, monitor groundwater and methane gas, and continue leachate management. Finally, the property deed must reflect the property's prior use as a landfill, which restricts the future development of the site.¹¹

OTHER TYPES OF LANDFILLS. Some types of waste (e.g., industrial waste and hazardous waste) cannot necessarily be disposed of in an MSW landfill. Instead, these materials must be disposed of in specially designed landfills or in MSW landfills in limited quantities.

Construction and Demolition. Waste from construction and demolition (C&D) projects, including untreated lumber, drywall, plaster, plumbing materials, etc., is not considered MSW. These wastes can be deposited either in MSW landfills or in specially constructed C&D landfills that are required to meet less stringent regulations than MSW landfills. Based on anecdotal remarks by landfill fire suppression professionals, C&D landfills are at a much higher risk for a significant fire than other types of landfills.¹²

¹⁰ Courtesy of the California Integrated Waste Management Board.

¹¹ *Criteria for Solid Waste Disposal Facilities*, op. cit.

¹² From information received in e-mail correspondence with Dr. Tony Sperling, P.Eng.

Industrial. Each year, about 7.6 billion tons of industrial waste are generated and managed by manufacturing facilities. The majority of this waste is wastewater or non-wastewater sludges and solids. Nearly 97 percent is wastewater managed in surface impoundments; the remainder is managed in landfills, waste piles, and land application units.¹³ Industrial waste is classified as neither MSW nor hazardous waste under RCRA Subtitle C, which places industrial landfills under the regulatory authority of states and local government, not the federal authorities.

Hazardous Materials. In 1999, 1.4 million tons of hazardous waste were disposed of in landfills.¹⁴ Hazardous waste landfills are similar in character and design to MSW landfills, but they are required to meet more stringent regulations for leachate collection and decontamination.

LANDFILL EMISSIONS. Landfill emissions are the result of the decomposition of organic materials in the landfill (including yard waste, household waste, food waste, and paper). Because of the nature of the construction of landfills, this decomposition is anaerobic¹⁵ and results in the production of large quantities of methane (which is highly flammable) and carbon dioxide. In fact, landfills are the largest source of methane emissions in the United States, accounting for 35 percent of methane emissions in 1999.¹⁶ MSW landfills generate about 93 percent of U.S. landfill emissions; industrial landfills account for the remaining emissions.¹⁷ Methane emissions from landfills are affected by site-specific factors such as waste composition, available moisture, and landfill size.¹⁸ Approximately 28 percent of the methane generated in landfills in 1999 was recovered.¹⁹ The remainder of landfill-generated methane was dispersed in the air.

Approximately 50 percent of gas emitted from landfills is methane; carbon dioxide accounts for about 45 percent, and the remainder is composed of nitrogen, oxygen, hydrogen, and other gases.²⁰ Both methane and carbon dioxide are greenhouse gases that pose environmental problems. Of the two gases, methane is far more potent than carbon dioxide. Methane has a global warming potential (GWP)²¹ of 21 over a 100-year period. This means that on a kilogram-for-kilogram basis, over a 100-year period, methane is 21 times more potent than carbon dioxide in causing climate change.²²

¹³ *Guide for Industrial Waste Management*, Environmental Protection Agency, EPA530-R-99-001, June 1999.

¹⁴ *National Biennial RCRA Hazardous Waste Report*, Environmental Protection Agency, EPA530-S-01-001, June 2001, p. ES-8.

¹⁵ An *anaerobe* is an organism, such as a bacterium, that can live in the absence of atmospheric oxygen. Conversely, an *aerobe* is an organism that requires oxygen to live.

¹⁶ *Inventory of U.S. Greenhouse Gas Emissions and Sinks*, Environmental Protection Agency, EPA 236-R-01-001, April 2001, p. ES-19.

¹⁷ U.S. Methane Emissions 1990-2000: Inventories, Projections, and Opportunities for Reductions, Environmental Protection Agency, EPA 430-R-99-013, September 1999, p. 2-1.

¹⁸ *Inventory of U.S. Greenhouse Gas Emissions and Sinks*, op. cit.

¹⁹ *Ibid.*

²⁰ *Landfill Methane Outreach Program*, Environmental Protection Agency, FAQ Sheet, June 2001.

²¹ The term *global warming potential* has been developed by the EPA to compare the ability of each greenhouse gas to trap heat in the atmosphere relative to another gas. This measurement of GWP relies on carbon dioxide as the reference gas. The GWP of a greenhouse gas is the ratio of global warming (both direct and indirect) from one unit mass of a greenhouse gas to one unit mass of carbon dioxide over a set period of time.

²² *Climate Change, Methane and Other Greenhouse Gases*, Environmental Protection Agency, July 2001.

Current EPA regulations under the Clean Air Act and the New Source Performance Standards and Emissions Guidelines specify that many landfills must collect and combust landfill gas (regulated by size of the landfill). To comply with these regulations, landfill owners can either burn the gas off by flaring²³ it or capture the gas by installing a “landfill gas-to-energy” system. (This is discussed in detail later in this report.)

In addition to regulations governing the emission of landfill gases, federal law also regulates the incineration or open burning of waste. Federal law specifically prohibited open burning of MSW at municipal landfills in 1979 (40 CFR 257).²⁴ The incineration of MSW is strictly regulated by a variety of federal, state, and local policies.

NUMBER OF LANDFILLS. The amount of MSW produced in the United States has risen substantially over the past 50 years, from 88.1 million tons in 1960 to 230 million tons in 1999.²⁵ On the other hand, the number of landfills has significantly decreased over the last 10 years, from about 8,000 in 1988 to about 2,200 in 1999.²⁶ Figure 2 shows the decline over the past 14 years; Figure 3 and Table 2 show the number of landfills per state. This decrease in the number of landfills is generally due to stricter regulations imposed by the EPA regarding landfill gas emissions, safety regulations, and content regulations of a landfill. Over the same period, the size of the remaining landfills has grown steadily to accommodate the increased production of MSW.

The number of landfills recorded by the EPA, however, does not take into account all of the individual, and in many cases illegal, dumping sites that were common in the early 1980s. Many businesses, factories, and enterprises had their own dumping sites where they disposed of various types of unregulated wastes. This was a widespread practice before environmental groups began lobbying against such sites and publicizing links between diseases such as cancer and the dumping of hazardous chemicals and toxic wastes that were contaminating water, soil, and air.

THE DEVELOPMENT OF LANDFILL REGULATION.²⁷ The EPA was established in 1970 after scientists, elected officials, and citizens recognized the need to protect the environment. The new agency was pieced together from programs elsewhere in the federal government, including from the Department of Health, Department of the Interior, and Food and Drug Administration. It was not until 1984 that the EPA gained regulatory authority over landfills. Over the intervening years, various legislative acts have strengthened the EPA's regulatory authority over these sites.

In 1976, Congress passed the Resource Conservation and Recovery Act (RCRA), which gave the EPA the authority to control hazardous waste from the “cradle-to-grave.” RCRA covers the generation, transportation, treatment, storage, and disposal of hazardous waste and provides a

²³ In this context, *flaring* is the controlled burning of methane collected from a landfill.

²⁴ “Volume III—Area Sources, Chapter 16, Open Burning,” *Revised Final: Emission Inventory Improvement Program Document Series*, Environmental Protection Agency, Section 2.1, January 2001.

²⁵ *Municipal Solid Waste in 1999: Facts and Figures*, Environmental Protection Agency. Some EPA sources quote this numbers as being closer to 2,300.

²⁶ *Environmental Fact Sheet, Municipal Solid Waste Generation*, Environmental Protection Agency, 1998.

²⁷ Information on federal regulations was taken from the EPA website, Major Environmental Laws. <http://www.epa.gov/epahome/laws.htm>.

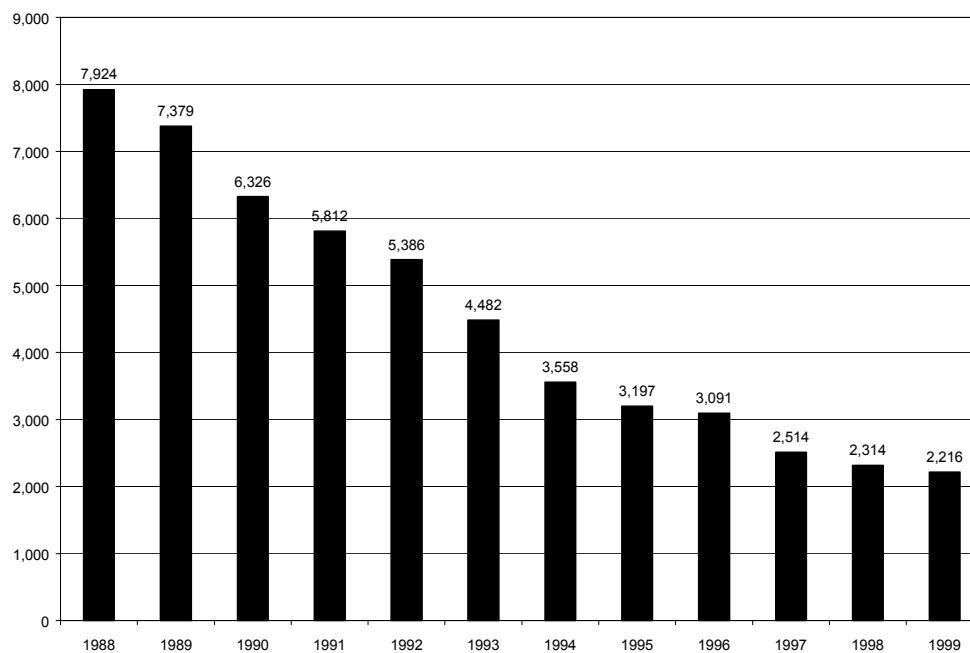


Figure 2. MSW Landfills in the United States, by Year²⁸

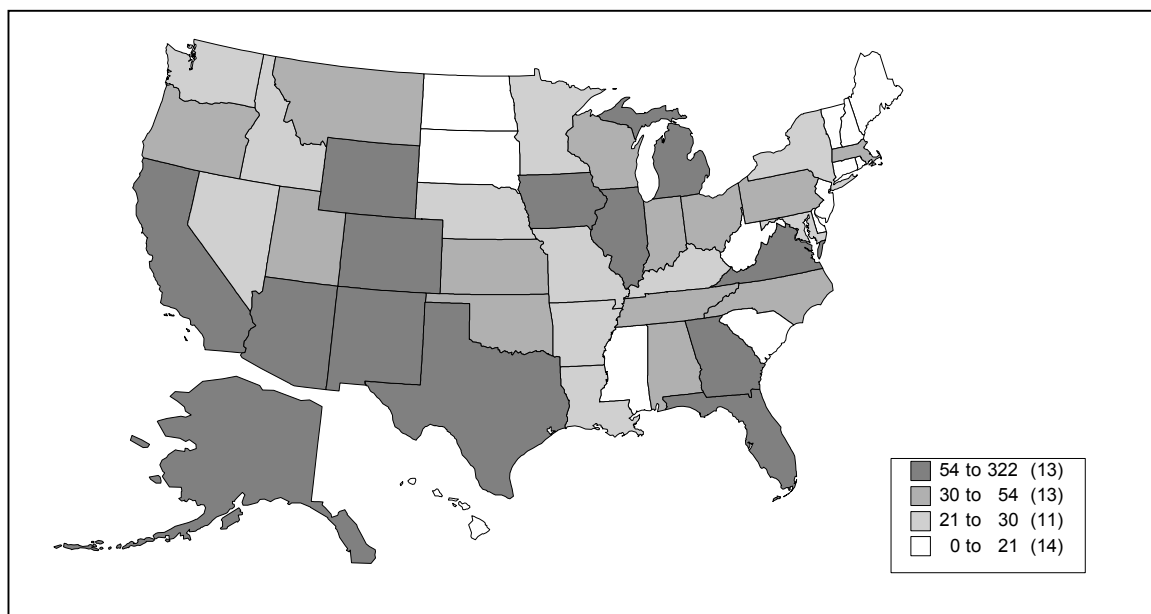


Figure 3. Distribution of Landfills²⁹

²⁸ *Municipal Solid Waste in 1999*, op. cit., p. 15.

²⁹ *BioCycle*, June 1999.

Table 2. Landfills by State³⁰

State	Landfills	State	Landfills	State	Landfills
Alabama	30	Kentucky	26	New York	28
Alaska	322	Louisiana	25	Ohio	52
Arizona	54	Maine	8	Oklahoma	41
Arkansas	23	Maryland	22	Oregon	33
California	188	Massachusetts	47	Pennsylvania	51
Colorado	68	Michigan	58	Rhode Island	4
Connecticut	3	Minnesota	26	South Carolina	19
Delaware	3	Mississippi	19	South Dakota	15
District of Columbia	0	Missouri	26	Tennessee	34
Florida	95	Montana	33	Texas	181
Georgia	76	North Carolina	35	Utah	45
Hawaii	8	North Dakota	15	Vermont	5
Idaho	27	Nebraska	23	Virginia	70
Illinois	56	Nevada	25	Washington	21
Indiana	45	New Hampshire	19	West Virginia	19
Iowa	60	New Jersey	11	Wisconsin	46
Kansas	53	New Mexico	55	Wyoming	66

framework for the management of nonhazardous wastes. RCRA focuses only on active and future facilities.

The turning point in landfill regulation and remediation occurred in 1980, first with the Superfund legislation, then by the Hazardous and Solid Waste Amendments (HSWA) in 1984, which finally gave the EPA regulatory authority over landfills.

Technically known as the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), the Superfund legislation governs closed and abandoned hazardous material waste sites, provides for the liability of persons responsible for the release of hazardous materials at these sites, and establishes a trust fund to provide for cleanup where no responsible party could be identified.

In 1984, the HSWA amended RCRA. HSWA required the phasing out of land-based disposal of hazardous waste and gave the EPA regulatory authority over landfills. The final major piece of legislation, the Superfund Amendments and Reauthorization Act (SARA), was passed in 1986 as an amendment to CERCLA. SARA increased the participation of states in the Superfund program and expanded the size of the cleanup trust fund.

In recent years, federal, state, local, and private programs have increased the emphasis placed on reducing the production of municipal waste to conserve resources and reduce pollution while delaying the entry of waste into the waste collection and disposal system. “Source

³⁰ Ibid.

reduction” focuses on designing, manufacturing, purchasing, or using materials in ways that reduce the amount or toxicity of trash created.

Some such programs include “pay-as-you-throw,” where residents pay for each can or bag of trash they have collected for disposal rather than funding this collection by a flat rate or through the tax base. This provides tangible financial benefits for households that reduce the amount of waste they produce. Other programs target businesses and corporations in an effort to promote waste-reducing manufacturing processes and business practices.³¹ The benefits of these practices include a reduction of the combustible material that enters the waste stream. Although MSW facilities will still contain large amounts of combustible materials, this reduction in waste can be a factor in the reduction of landfill fires.

CHARACTERISTICS OF LANDFILL FIRES³²

Landfill fires fall into one of two categories, surface and underground fires. Depending on the type of landfill and type of fire, landfill fires can pose unique challenges to the landfill/waste management industry and the fire service. This section addresses the particular challenges and the specific types of fires found in landfill sites and describes their characteristics and causes.

SURFACE FIRES. Surface fires involve recently buried or uncompacted refuse, situated on or close to the landfill surface in the aerobic decomposition layer, generally 1 to 4 feet in depth.³³ These fires can be intensified by landfill gas (methane), which may cause the fire to spread throughout the landfill.

Surface fires generally burn at relatively low temperatures and are characterized by the emission of dense white smoke and the products of incomplete combustion. The smoke includes irritating agents, such as organic acids and other compounds. When surface fires burn materials such as tires or plastics, the temperature in the burning zone can be quite high. Higher temperature fires can cause the breakdown of volatile compounds, which emit dense black smoke. Surface fires are classified as either accidental or deliberate.

Surface fires include the following:

- *Dumping of undetected smoldering materials into the landfill.* Hot load fires are caused by the disposal of refuse that is still burning on arrival to the landfill (e.g., cleared brush).
- *Fires associated with landfill gas control or venting systems.* Landfill gas control systems can themselves pose a fire hazard. Landfill gas (predominantly methane) can be

³¹ “Source Reduction and Reuse,” Environmental Protection Agency, April 23, 2002.
<http://www.epa.gov/epaoswer/non-hw/muncpl/sourcred.htm>.

³² Much of this section represents a synopsis of a report prepared for the New Zealand Ministry of the Environment. The report, *Landfill Guidelines: Hazards of Burning at Landfills*, was published in December 1997.

³³ E-mail correspondence with Todd Thalhamer, California Integrated Waste Management Board.

ignited as it escapes from the vents or from leaks in the collection pipe network. Excessive gas extraction can also be a fire cause. The vacuum created by excessive extraction can increase the airflow and thereby increase the oxygen level in the landfill, which can cause underground fires (as discussed further in the following section).

- *Fires caused by human error on the part of the landfill operators or users.* Landfill operators and users can cause fires through careless smoking on the landfill, which can ignite waste or landfill gas. Also, as some hazardous substances can ignite when mixed, operators must take care to prevent the dumping of reactive materials into the landfill.
- *Fires caused by construction or maintenance work.* Fires can occur while construction and maintenance takes place, including fires caused by sparks from vehicles used in the landfill (dump trucks, bulldozers, backhoes, etc.). A surface fire could also be ignited when drilling or while driving metal pipes through layers of buried waste if a hard object buried in the landfill is struck. Usage of welding or electrical equipment on site poses a fire hazard, due especially to the increased presence of methane gas.
- *Spontaneous combustion of materials in the landfill.* The mixing of certain materials in a landfill can result in spontaneous combustion. Even in small quantities, some chemicals can ignite if exposed to one another. Also, some materials, such as oily rags, can spontaneously combust under certain conditions. Spontaneous combustion can also result from bacterial decomposition, which is discussed in more detail later in this section.
- *Deliberate fires, which are used by the landfill operator to reduce the volume of waste.* Landfills contain refuse such as dry garden waste, grass, leaves, and branches. Sometimes these materials are deliberately set on fire to reduce refuse volumes, reduce operating costs, and increase a landfill's operating life. This is an accepted practice under strictly controlled conditions.³⁴ Uncontrolled, these deliberate fires could escalate into larger fires, cause explosions, or create hazardous products from the ash and residue burned.
- *Deliberate arson fires, which are set with malicious intent.* Arson is a serious problem in the United States; therefore, it is not surprising that landfills are targets for malicious fires.

UNDERGROUND FIRES. Underground fires in landfills occur deep below the landfill surface and involve materials that are months or years old.³⁵ These fires are generally more difficult to extinguish than surface fires. Underground fires also have the potential to create large

³⁴ This controlled combustion at landfills is regulated by U.S. Code of Federal Regulations, 40 CFR 60 (Title 40 – Protection of Environment Chapter I – Environmental Protection Agency. Part 60 – Standards Of Performance For New Stationary Sources).

³⁵ This report addresses operating landfills. Closed landfills are subject to a variety of restrictions on future development, maintenance, etc. It would be difficult to determine the frequency of fires in closed landfills because such sites are likely to be coded in NFIRS according to their property use at the time of the fire (e.g., open land, park, golf course).

voids in the landfill, which can cause cave-ins of the landfill surface. Further, they produce flammable and toxic gases (such as carbon monoxide) and can damage leachate containment liners and landfill gas collection systems.

The most common cause of underground landfill fires is an increase in the oxygen content of the landfill, which increases bacterial activity and raises temperatures (aerobic decomposition). These so-called “hot spots” can come into contact with pockets of methane gas and result in a fire. Of particular concern with these long-smoldering, underground fires is the fact they tend to smolder for weeks to months at a time. This can cause a build up of the byproducts of combustion in confined areas such as landfill site buildings or surrounding homes, which adds an additional health hazard.

Underground fires are often only detected by smoke emanating from some part of the landfill site or by the presence of carbon monoxide (CO) in landfill gas. In the event of an underground fire, CO may be present at toxic levels near the landfill’s surface. Generally an underground fire can be confirmed by:³⁶

- Substantial settlement over a short period of time.
- Smoke or smoldering odor emanating from the gas extraction system or landfill.
- Elevated levels of CO in excess of 1,000 parts per million (ppm).
- Combustion residue in extraction wells or headers.
- Increase in gas temperature in the extraction system (above 140°F).
- Temperatures in excess of 170°F.

To confirm a subsurface fire using CO, the results must be acquired through quantitative laboratory analysis (using portable monitors may result in artificially high concentrations). In California, levels of CO in excess of 1,000 ppm are considered a positive indication of an active underground landfill fire. Levels of CO between 100 and 1,000 ppm are viewed as suspicious and require further air and temperature monitoring. Levels between 10 and 100 ppm may be an indication of a fire but active combustion is not present.³⁷

HEALTH EFFECTS OF LANDFILL FIRES. In addition to the burn and explosion hazards posed by landfill fires, smoke and other byproducts of landfill fires also present a health risk to firefighters and others exposed to them. Smoke from landfill fires generally contains particulate matter (the products of incomplete combustion of the fuel source), which can aggravate pre-existing pulmonary conditions or cause respiratory distress. As with all fires, those in landfills produce toxic smoke and gases. The danger and level of toxicity of these gases depend on the length of exposure one has to them and on the type of material that is burning.

³⁶ *Response to Landfill Fires Guidance Document*, California Integrated Waste Management Board, Internal Bulletin 2001.

³⁷ Ibid.

Underground fires can result in CO levels in excess of 50,000 ppm—the Occupational Safety and Health Administration (OSHA) permissible exposure limit for CO is 50 ppm. OSHA standards prohibit worker exposure to more than 50 parts of the gas per million parts of air averaged during an 8-hour time period. Carbon monoxide is harmful when breathed because it displaces oxygen in the blood and deprives the heart, brain, and other vital organs of oxygen, which can cause permanent damage or death.³⁸

Another serious concern in landfill fires is the emission of dioxins. Accidental fires at landfills and the uncontrolled burning of residential waste are considered the largest sources of dioxin emissions in the United States.³⁹ The term *dioxins* refers to a group of chemical compounds with similar chemical and biological characteristics that are released into the air during the combustion process. Dioxins are also naturally occurring and are present throughout the environment. However, exposure to high levels of dioxins has been linked to cancer, liver damage, skin rashes, and reproductive and developmental disorders.⁴⁰

EXTINGUISHING LANDFILL FIRES

This section is not intended to address or recommend specific tactical approaches for landfill firefighting. It is important to note that the different dynamics, characteristics, and regulations of landfills and the fires that occur in them suggest that tactics need to be determined on a case-by-case basis depending on the materials buried, which materials have ignited, depth of the fire, and the fire's ignition source. This section explores some of the challenges posed in the suppression of landfill fires.

WIND/WEATHER. Wind and inclement weather can increase the health hazards for firefighters operating on the fireground (e.g., in extremely hot or cold weather) and can directly affect fire spread.

WATER SUPPLY. The use of water to suppress landfill fires is controversial. The application of large volumes of water may actually exacerbate a fire by contributing to the process of aerobic decomposition. Further, adding water to the landfill creates additional leachate, which may overwhelm the leachate collection system in the landfill (if one exists). If the collection system is overwhelmed, the additional leachate could contaminate ground and surface waters surrounding the landfill. Depending on the landfill's location, there might not be an adequate supply of water available for fire suppression. Firefighters may have to establish a water supply using tankers and nearby static water sources (e.g., lakes, reservoirs).

³⁸ OSHA Fact Sheet, *Carbon Monoxide Poisoning*, U.S. Department of Labor, Occupational Safety and Health Administration, 2002. http://www.osha.gov/OshDoc/data_General_Facts/carbonmonoxide-factsheet.pdf

³⁹ *Questions and Answers About Dioxins*, Environmental Protection Agency, July 2000, p. 6. <http://www.epa.gov/ncea/pdfs/dioxin/dioxin%20questions%20and%20answers.pdf>.

⁴⁰ Idem, p. 4.

Foam is an important consideration in landfill fire suppression. There are two primary types of firefighting foam. Class A foam is a special formulation of hydrocarbon surfactants. These surfactants reduce the surface tension of water, which provides for better water penetration and increased effectiveness. When aerated, Class A foam coats and insulates fuels, protecting them from ignition. Class B foam is used to extinguish fires involving flammable and combustible liquids. It is also used to suppress vapors from unignited spills of these liquids.⁴¹ As with all fires, there are advantages and disadvantages to using foam during fire suppression operations on landfills. The on-scene incident commander makes the decision to use foam based on the specific tactical situation at hand.

MULTI-AGENCY RESPONSE. A major landfill fire will likely require the expertise of personnel from multiple agencies (e.g., the EPA, Department of Natural Resources). Some fire departments have Standard Operating Procedures in place that define all landfill fires as hazardous materials incidents, which require a specialized response. To ensure that all personnel (regardless of their agency affiliation) are operating according to the same plan, landfill fires require a strong Incident Command System.

PERSONNEL SAFETY. Fires, particularly those underground, can undermine the integrity of the landfill, which could cause a collapse under the weight of landfill employees, firefighters, or equipment. Such a collapse could necessitate a confined space, trench, or other type of technical rescue operation in addition to fire suppression.

Given the potential adverse effects of exposure to burning landfill contents or the smoke produced by a landfill fire, personnel may have to use specialized personal protective equipment, which may be difficult to obtain.

ACCESS TO AND MANEUVERABILITY OF HEAVY EQUIPMENT. To access waste below the landfill surface or move burning waste away from the landfill, it may be necessary to use heavy equipment such as bulldozers. Landfill operators may already own this equipment and have staff trained in its use. If not, this equipment will need to be located and brought to the fire-ground. If a fire affects the structural stability of a landfill, operating heavy equipment on the landfill surface would be dangerous. Finally, depending on the landfill's location and design, operating heavy equipment on the site could be quite difficult.

LOGISTICS. As with any protracted fire suppression operation, Incident Commanders at landfill fires must address a variety of logistical concerns to facilitate operations. These include rotating personnel on a regular basis, compensating personnel for overtime spent operating at the landfill or filling in at fire stations in the jurisdiction, keeping firefighters on the landfill hydrated and fed, and, keeping records for future reimbursement. (Depending on the nature and location of the incident, local fire departments can seek reimbursement from the federal government or the landfill operator for costs associated with fire suppression.)

ENVIRONMENTAL IMPACT. The smoke and runoff from landfill fires can be dangerous to those living in the area and to the environment. It is important that air and water quality issues

⁴¹ *Essentials of Firefighting 4th Edition*, International Fire Service Training Association, 2001, p. 500.

be addressed early in a fire suppression operation to prevent contamination as much as possible. As mentioned earlier, water used to suppress a landfill fire can overwhelm a facility's leachate collection system, if one exists (older facilities may have been constructed prior to regulations requiring leachate collection systems).

LANDFILL CONTENTS. Fires occurring in landfills where hazardous wastes are buried can be particularly difficult. In past years, illegal dumping of hazardous and toxic materials in landfills and other dumping sites was relatively common. When a fire occurs and rescue workers have wrong or misleading information about the buried contents (e.g., illegal or unknown toxic or radioactive wastes), the fire suppression operation can be extremely dangerous.

Although not a landfill fire, the Wade Dump fire in February 1978 clearly illustrates the dangers posed by fires involving unknown hazardous materials. Firefighters responded to a suspected tire fire at an abandoned rubber shredding plant on the Delaware River outside of Philadelphia. They were unaware that the property's owner and namesake, Melvin Wade, had transformed the plant into one of the most toxic hazardous waste dumpsites in U.S. history. By the night of the fire, more than 3 million gallons of cyanide, benzene, toluene, and other chemicals were stored on the site—plus thousands of junk tires. The burning chemicals produced multi-colored smoke and noxious fumes, which alerted firefighters to the unusual nature of the fire they were fighting. Intensified by chemicals and other fuels, the fire raged for hours. Drums of chemicals exploded, injuring firefighters and even damaging fire trucks. As the night progressed, firefighters and other emergency workers noticed that the chemicals were dissolving their protective gear and making it difficult for them to breathe; more than 40 firefighters were sent to a nearby hospital for treatment. Over the past 20 or more years, dozens of those who were present at the Wade Dump fire have become ill, and many have died from cancers and other diseases. Melvin Wade and others responsible for creating the toxic site were found criminally responsible for their actions.⁴²

LANDFILL FIRES: STATISTICAL ANALYSIS

Data from the National Fire Incident Reporting System (NFIRS) does not include MSW landfills as a fixed property use category. Rather, the NFIRS data set includes a category for “dump or sanitary landfill: included are refuse disposal areas, trash receptacles, and dumps in open ground” (NFIRS Fixed Property Use code 932). Although this definition is broader than the definition of a landfill, it is the closest match available in NFIRS. As such, despite the broader definition, this section refers to these fires as *landfill fires* for the sake of clarity.

Based on extrapolation of the NFIRS data, each year in the United States an average of 8,400 landfill fires are reported to the fire service. This represents less than a half percent of all reported fires. Undoubtedly, some landfill fires go unreported because they burned undetected or they were on private property and extinguished by the landfill operator. Reported fires are responsible for less than 10 civilian injuries, 30 firefighter injuries, and between \$3 and

⁴² This paragraph is a synopsis of an investigative report published by the *Philadelphia Inquirer* in April 2000.

\$8 million in property loss each year.⁴³ Deaths (civilian or fire service) are rare in these fires; since NFIRS represents a sample of data, it may be that fatalities occurred during the study period and were not reported or captured in the data.

TYPE OF LANDFILL FIRES. Table 3 shows the five types of fires that occur on landfills. The prevalence of refuse fires is not surprising, but it is interesting that other types of fires occur on landfill properties. Vehicle fires involve dump trucks, compactors, and other vehicles commonly found in landfills. Brush fires may occur when landfill fires spread to the surrounding lands. Structure fires at landfill sites probably involve small offices or other facilities constructed for the landfill staff.

Table 3. Types of Fires Occurring on Landfills⁴⁴

Type of Fire	Percent of Fires
Refuse	77
Trees, brush, grass	12
Outside structure, where material burning has value	6
Vehicle	4
Structure	1

CAUSES OF LANDFILL FIRES. Over half of the landfill fires reported to NFIRS have no information available as to the primary ignition factor. This makes it particularly difficult to accurately pinpoint the cause of landfill fires. Of those fires with reported ignition factors, nearly 40 percent are of an incendiary or suspicious nature. Another 20 percent are attributed to lit or smoldering materials that have been abandoned or discarded, which include cigarettes, matches, or ashes that were discarded without being properly extinguished. Spontaneous heating accounts for about 5 percent of landfill fires. Other leading factors influencing fire ignition include rekindling from a previous fire and inadequate control of open fires.

WHEN LANDFILL FIRES OCCUR. Landfill fires occur most often between March and August. This half-year period accounts for nearly 60 percent of landfill fires, with the peak (11 percent) occurring in July (Figure 4). This monthly incidence of fires generally applies to the major causes of landfill fires (incendiary/suspicious and smoldering materials). Rekindled fires and spontaneous ignition fires, however, are exceptions. Rekindled fires have a peak period in April and May that accounts for one-third of these fires with an additional peak in July (15 percent). Landfill fires that result from spontaneous combustion gradually increase as the weather warms, dropping in September. The peak period, however, occurs in October and November, when 22 percent of the spontaneous combustion fires occur. Figure 5 illustrates the incidence of spontaneous combustion fires by month.

⁴³ National estimates are based on NFIRS data (1996–1998) and the National Fire Protection Association's (NFPA) annual survey, *Fire Loss in the United States*.

⁴⁴ U.S. Fire Administration NFIRS data (1996–1998).

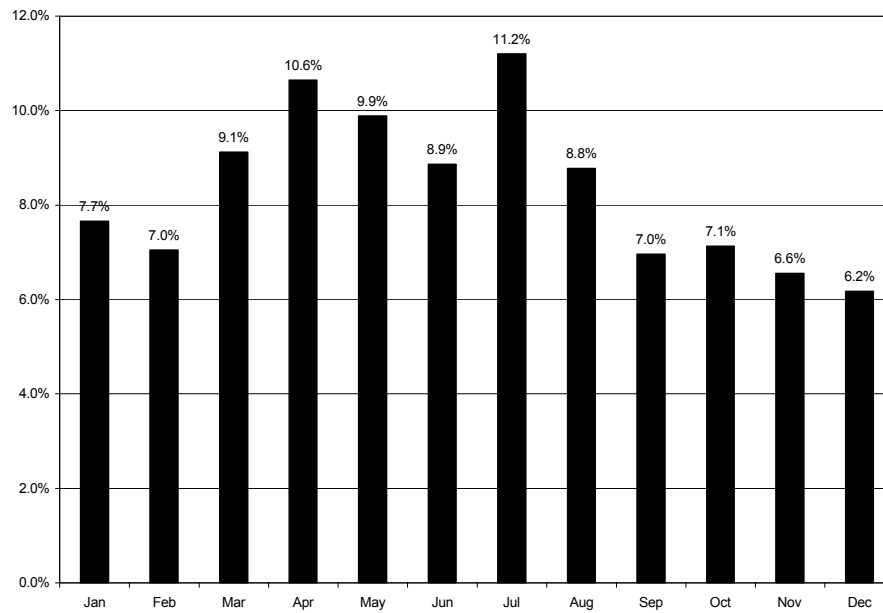


Figure 4. Incidence of Landfill Fires by Month⁴⁵

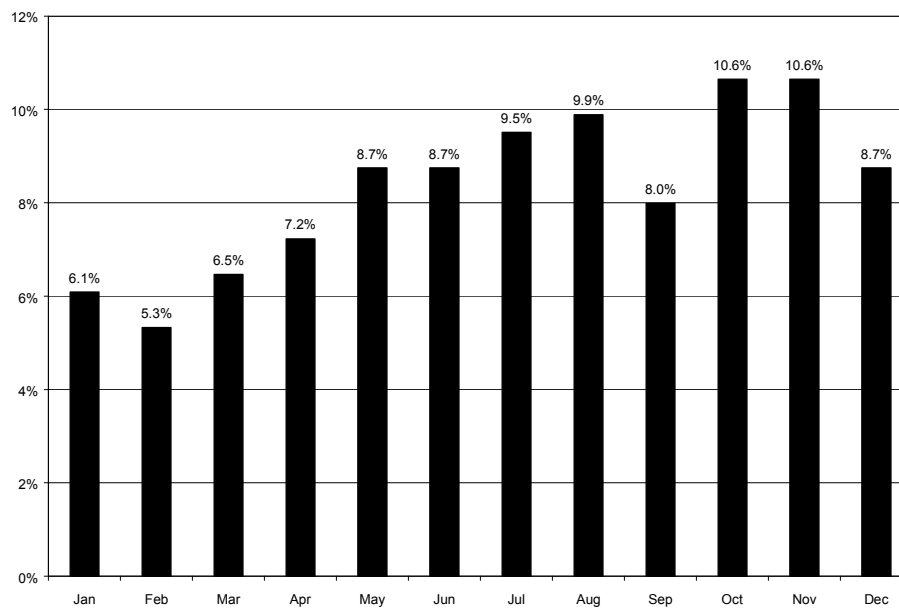


Figure 5. Incidence of Spontaneous Combustion Landfill Fires by Month⁴⁶

⁴⁵ Ibid.

⁴⁶ Ibid.

The spring peaks in rekindled fires and the fall peaks in spontaneous combustion fires may result from increased winds during these months as many landfills may have inadequate caps (particularly if they use alternate daily covers) to prevent air infiltration. Inadequate caps can allow large volumes of air to enter the landfill, accelerating the oxidation reaction. The air intrusion is due, in part, to the differential in barometric pressure between the landfill and the atmosphere. This condition occurs most frequently in the late fall and spring with the large, naturally occurring atmospheric changes in conjunction with land surface heating and cooling. The increased oxidation raises the temperature in the landfill and can increase spontaneous combustion events. Some of the rekindled fires may be the result of earlier smoldering underground fires that, with the increase in airflow brought by winds, are oxygenated enough to break through to the surface.⁴⁷

LANDFILL FIRE PREVENTION

Fire prevention can reduce property damage, injury, health, and environmental hazards of landfill fires. The cost of prevention is usually much less expensive than the cost of fighting and cleaning up a fire. In many cases, particularly for larger landfills, fire prevention activities are required by law. This section outlines some of the principal methods in landfill fire prevention.

LANDFILL MANAGEMENT. Effective landfill management is a vital key to efficient landfill fire prevention tactics. Management measures include prohibiting all forms of deliberate burning, thoroughly inspecting and controlling incoming refuse, compacting refuse buried to prevent hot spots from forming, prohibiting smoking onsite, and maintaining good site security.

METHANE GAS DETECTION AND COLLECTION. Landfill gas emissions can be a hazard to the environment and to the health of residents surrounding landfill sites. Methane gas, a flammable gas, can present a fire hazard. Federal regulations require all MSW landfill operators to monitor the emission of methane on a quarterly basis. If methane levels in or around the landfill become explosive, the landfill operator must take immediate steps to mitigate the danger. The operator must also implement a remediation program to prevent future explosive buildups.⁴⁸

Federal regulations currently require MSW landfills that opened after November 8, 1987, and have a capacity of over 2.5 million cubic meters to install a gas collection and control system.⁴⁹ These regulations, however, affect only about 4 percent of operating landfills in the United States as the vast majority of landfills do not have such a large capacity.⁵⁰ Some states, however, (e.g., California) have stricter regulations for gas collection systems, which affect a higher percentage of facilities; these jurisdictions may include closed facilities as well.

⁴⁷ E-mail correspondence with Dr. Tony Sperling and Todd Thalhamer.

⁴⁸ U.S. Code of Federal Regulations, 40 CFR 258.23 (Title 40—Protection of Environment Chapter I—Environmental Protection Agency. Part 258—Criteria for Municipal Solid Waste Landfills).

⁴⁹ U.S. Code of Federal Regulations, 40 CFR 60.33c (Title 40—Protection of Environment Chapter I—Environmental Protection Agency. Part 60—Standards of Performance for New Stationary Sources).

⁵⁰ *Air Rule for Municipal Solid Waste Landfills*, Environmental Protection Agency, January 10, 2002. <http://www.epa.gov/reg3artd/airregulations/ap22/landfil2.htm>.

Methane gas collection systems actively remove landfill gas using gas recovery wells and vacuum pumps with an interconnected pipe network. Operators must take care to ensure the system is not overdrawn, which can lead to fire ignition. Once the gas is collected, landfill owners/operators have two choices: (1) burn off the gas (flaring); or (2) convert the gas to an energy commodity.

Flaring. Burning landfill gas is the method most large landfills use (as opposed to the more costly waste-to-energy projects). Burning the landfill gas converts methane to carbon dioxide, which not only is less harmful to the environment, but also destroys the components of landfill gas that cause odor, stress vegetation, create smog, and increase the risk for fire or explosion.

Shallow gas venting trenches or gas venting pipes can also be installed in the landfill's surface. These vents allow gas from interior regions of the landfill to escape naturally to the surface where flares can burn off the gas.

Converting Landfill Gas to Energy. The conversion of landfill gas to energy turns this landfill byproduct into a marketable resource. The converted gas can be used to generate electricity, heat, or steam. According to the EPA, landfill gas is the only renewable energy source that, when used, removes pollution from the atmosphere.⁵¹ By converting the landfill gas to energy, the harmful emissions causing global warming are removed from the air and converted to a useful form such as electricity to power a home. Reducing landfill gas emissions is imperative as it reduces local ozone levels and smog formation while simultaneously decreasing explosion and fire risks and unpleasant odors produced by the landfill.⁵²

As of September 2001, the EPA estimates that there were more than 335 landfill gas recovery and utilization projects operating in the United States; another 500 landfills are considered good candidates for future program development.⁵³

CASE STUDIES

A sample of landfill fires throughout the world sheds light on the landfill fire problem. Waste disposal practices and the regulation of landfill sites are similar in the comparison countries. Landfill fires have been investigated and studied in more detail in several countries outside the continental United States. The concluding portion of this section contains brief synopses of interviews and media reports detailing landfill fires in the United States and the lessons that were learned from them.

⁵¹ Landfill Methane Outreach Program, *Frequently Asked Questions*, Environmental Protection Agency, updated June 5, 2001. <http://www.epa.gov/lmop/faq.htm>.

⁵² Ibid.

⁵³ Landfill Methane Outreach Program, *Current Projects and Candidate Landfills*, Environmental Protection Agency, January 10, 2002. <http://www.epa.gov/lmop/projects.htm>.

FINLAND.⁵⁴ An experimental study that sheds significant light on methods of extinguishing landfill fires was conducted in Finland in 1993. The study was conducted in two parts: a questionnaire was distributed to landfill operators throughout Finland, and an experimental landfill was constructed with similar characteristics to an MSW landfill. To determine the most effective methods for extinguishing landfill fires, an underground fire was ignited and allowed to burn in the experimental landfill. The fire was extinguished by smothering it with soil and dousing it with water.

From the questionnaires, the study determined that most landfill fires are small and tend to be of short duration. It concluded that using soil and water to extinguish the fires was insufficient and that a potentially significant factor in landfill fires is the improper compaction of waste in the landfill. The study suggested that one way to prevent landfill fires is to sufficiently compact all waste buried in the landfill site. Only one-quarter of the fires reported to the study team were underground; those fires were particularly difficult to extinguish and tended to last over 2 months. In fact, for underground fires, it was found that covering the smoldering refuse with layers of soil actually prolonged some fires. Another serious concern raised in the study was that by using water to extinguish landfill fires, the runoff could contaminate the surrounding soil and ground water.

Ultimately, based on both the questionnaire and the experimental landfill, the study concluded that the most effective way to suppress landfill fires is by digging out the burning material and cooling it with water, soil, or snow.⁵⁵

CANADA.⁵⁶ In November 1999, a fire ignited at the Delta Shake and Shingle Landfill, a C&D landfill outside Vancouver, British Columbia. Although smoke and steam had been emanating from the landfill for weeks, the fire was finally discovered when flames broke through the landfill surface. The landfill operator originally attempted to extinguish the fire without fire department assistance; his efforts only served to exacerbate the fire. After several weeks, residents began to complain about the smoky haze hovering over Vancouver, and officials were concerned about air and water contamination from the suppression efforts. Ultimately, local officials declared a state of emergency and requested assistance from both the private sector and the provincial government.

To contain the fire and starve it of oxygen, officials covered the burning materials with a thick layer of refuse. Next, they determined that although using high-pressure water worked to extinguish the surface fire, it did not extinguish the burning refuse underground. To increase the water's effectiveness, firefighters misted the water and added Class A foam. Once the fire was contained, the firefighters used heavy machinery to excavate burning materials and move them to

⁵⁴ Ettala et al., "Landfill Fires in Finland," *Waste Management & Research* (1996) 14, pp. 377-384.

⁵⁵ Other landfill fire suppression professionals, however, have found that landfill fires can be extinguished by excavating and extinguishing the burning debris layer-by-layer using soil and a suppressant agent, or simply by temporarily shutting down the gas extraction system.

⁵⁶ Sources for this section: "Landfill Fire in Delta Gets Provincial Emergency Funding," British Columbia Ministry of Environment, Lands, and Parks. Press Release 330-30:ELP99/00-340, November 30, 1999. Sperling, Tony. *Extinguishing the Delta Shake and Shingle Landfill Fire: Case Study*, Sperling Hansen Associates, January 18, 2002. <http://www.landfillfire.com/delta1.html>.

areas offsite where they could be fully extinguished. Firefighters used infrared technology to determine which loads were “hot” and required extinguishment and which ones were cool enough to be left alone. After the materials were fully extinguished using foam and water, they were returned to the reconstructed landfill.

A private contractor involved in the suppression effort summarized the following as lessons learned from this fire:

- Soil berms are effective at containing fire spread.
- Trenches that do not fully penetrate the refuse pile are ineffective; trenches should only be excavated if they penetrate the full thickness of the refuse to inert material.

HAWAII. In the late 1990s, fires in legal and illegal landfills were a serious concern for officials on all of the Hawaiian Islands. In July 1996, a fire at an illegal dumpsite in Lualualei, Oahu, attracted government and media attention. The site contained municipal waste, C&D debris, and hazardous materials. After explosions involving gas cylinders or drums, the State Department of Health hired a hazardous waste contractor to remove drums containing chemicals and some hazardous waste. Despite the attention, government officials had difficulty shutting down the dumpsite, as the property changed hands over the years and the cost of cleaning up the site exceeded the land’s value.⁵⁷

In January 1998, an odd odor at a C&D landfill in Ma’alaea led to the discovery of an underground fire.⁵⁸ Efforts to extinguish the fire with carbon dioxide were unsuccessful and, while the fire was contained, it smoldered for months.

Hawaii has less rigorous air quality standards than other areas of the United States because of its tradewinds, low population density, and isolation. Contractors are allowed to burn brush before depositing it in landfills. This practice decreases the waste volume and amount they are charged for using the landfills. Burned material goes through two inspection sites to check for “hot loads.” In the Ma’alaea fire, it appears the ignition source was a smoldering palm tree. Palm trees are spongy inside and, though the outside may have appeared cool, the inside was still simmering. Once inside the landfill, the tree continued to smolder until it ignited surrounding waste.

Although relatively small, the fire sparked a debate involving the landfill operator, EPA, and different divisions of the Department of Health. The debate revealed that there were no regulations on methods to control landfill fires. This motivated government officials to develop guidelines that address underground fires and study the health effects of landfill fires. Also, the fire emphasized the need to thoroughly inspect suspected hot loads to ensure that smoldering materials do not accidentally enter the landfill.

⁵⁷ “State Health Department To Close Illegal Dump in Lualualei,” *Environment Hawaii*, Volume 11, Number 3, September 2000.

⁵⁸ “Ma’alaea Landfill Sparks State Effort To Develop Guidelines,” *Environment Hawaii*, Volume 9, Number 4, October 1998.

OTHER EXAMPLES. The following examples were taken from media reports and interviews with fire officials in the affected jurisdictions. These examples shed light on firefighting tactics and local concerns associated with landfill fires.

Fairfax County, Virginia.⁵⁹ Fairfax County Fire Station 19 (Lorton) has two landfills within its call range. In November 2000, a fire broke out at the I-95 Landfill, near Lorton, VA. A 250-foot by 50-foot pile of debris, consisting of trees, stumps, and mulch, was ignited. Firefighters used water and foam to control and extinguish the fire. A fire technician who participated in the suppression effort stated that the most important tactic used in the fire was having firefighters and machinery overhaul the burning or smoldering areas to ensure that the fire did not rekindle.

Cumberland County, North Carolina.⁶⁰ In July 1998, flames at a landfill sent plumes of smoke over a large area. Firefighters were forced to contain the fire and let it burn since it was too hot for water to extinguish it effectively. An estimated 26 trailer loads of mulch were in the landfill. The mulch was very finely packed, the heat remained at the core, and water would not have cooled or extinguished the fire. Firefighters assured the fire did not spread to nearby tire piles by digging a ditch all around the fire, containing it. The fire burned itself out after several weeks.

Montezuma County Landfill, Colorado.⁶¹ In June 2001, smoke from this 6-acre fire spread high over the Montezuma Valley. The 320-acre landfill was filled with compressed, baled trash and municipal and industrial waste.⁶² Attempts were made to douse the fire with water, but they were ineffective. State landfill officials and other experts decided the best way to attack the blaze was to remove the smoldering bales of refuse, break them apart, and extinguish them individually. The cause of the fire was not determined. Landfill officials reported that confining the fire and smothering it proved to be the most effective method of extinguishing it.

Danbury, Connecticut⁶³ In 1996 and 1997, numerous underground landfill fires occurred at the Danbury city landfill. These fires were caused by spontaneous combustion of decomposing waste and were rekindled and continued smoldering underground over 18 months. Different underground “hotspots” increased the intensity of landfill odors. These fires in the 47-acre landfill were the subject of extensive media coverage and residential complaints. As elsewhere, water was ineffective in extinguishing these fires, and its use added to the stench, causing additional citizen complaints. Residents filed lawsuits for damages caused by exposure to hydrogen sulfide gas from the smoke. As a result of the lawsuits, the landfill was forced to close. A 40-foot high permanent flare had to be installed to burn off landfill gas and reduce the odors.

Bend, Oregon.⁶⁴ A youth fell into a burning sinkhole on the site of an old landfill and suffered third-degree burns across 30 percent of his body. The youth and his friend had noticed a thin trail of smoke coming from the ground while walking home and went to investigate. There

⁵⁹ Telephone interview with David Sweedland, Technician, Fairfax County Station 19, and *I-95 Landfill Debris Fire*, Fairfax County Fire and Rescue Department News Release, November 7, 2000.

⁶⁰ *Landfill Fire Continues To Burn*, WRAL 5 Cumberland County News, July 30, 1998.

⁶¹ “Landfill Fire Fills Valley With Smoke,” *Cortez Journal*, June 19, 2001.

⁶² Telephone interview with Montezuma County Landfill official.

⁶³ *The News-Times*, Danbury, CT, December 1996–October 1997.

⁶⁴ “Youth Slips Into Burning Bend Sinkhole,” *The Oregonian*, December 28, 1991.

was a small hole at the surface. While investigating the hole, the ground collapsed around the youth. The sinkhole was on a parcel of park district land on the outskirts of Bend, Oregon. The former landfill was owned by the county, and the land was later given to the park district. The original dump was used for wood waste. The decomposing waste smoldered and ignited through spontaneous combustion. Burned out pockets caused the landfill's earthen cover to weaken and collapse. Most of the problem areas were along the edges of the landfill where the earthen cap was the thinnest. The park district originally planned to put children's baseball fields on an unused portion of the old landfill, but reconsidered after conferring with the local Department of Environmental Quality.

Colerain Township, Ohio.⁶⁵ In 1996, the Colerain Township landfill experienced a major landslide that filled a nearby limestone quarry with acres of landfilled waste. The quarry was being excavated to hold additional waste in the landfill site when the landslide occurred. The area that had collapsed was dangerous; garbage was exposed and equipment was buried underneath, which made removal of the waste dangerous. The landfill officials could not move equipment to the site due to enormous voids in the exposed area; they feared bulldozers would be swallowed into the pile.

A series of four fires subsequently ignited, covering a 35-acre area. The first was a small 100-square-yard fire ignited by lightning. The second fire was as a result of combustion of decomposing waste and lasted 7 days covering a 20-acre area. Firefighters used pumped water and heavy equipment to tear down the fire area and then smothered it with dirt. Fifteen to 20 million gallons of water were used in the 7-day period. The last two fires were also a result of spontaneous combustion, but they were smaller in size. Water and heavy equipment were used to extinguish these two fires as well. Ultimately, restoring the landfill took approximately 2 years to complete.

San Bernardino County, California⁶⁶ In 1999, funding was approved for the cleanup of a smoldering fire at an illegal dumpsite in Cajon Pass. The illegal dumpsite had been in operation for about 3 years. At the time of the fire, the dumpsite contained 200,000 cubic yards of waste, which filled an area about 60 feet high and 450 feet long. Most of the waste consisted of rubble, telephone poles, railroad ties, whole trees, shrubs, and large stumps. About 80,000 cubic yards (60,000 tons) were organic wastes, which spontaneously ignited, causing the fire. The smoldering fire posed a significant risk to nearby residences, wildlands, power lines, and railroad tracks, and it threatened serious water contamination. Agencies from the state and local level were involved in the funding effort.

⁶⁵ Telephone interview with Ohio Colerain Township Dept. of Fire and EMS Fire Chief Bruce Smith.

⁶⁶ *State Waste Board Approves Funding for Cajon Pass Dump Cleanup*, California Integrated Waste Management Board, May 27, 1999, 99-053. <http://www.ciwmb.ca.gov/pressroom/1999/may/nr053.htm>.

CONCLUSION

Landfill fires are not common occurrences. When they do occur, however, they tend to attract a great deal of public attention and challenge the fire service. Illegal dumping continues to be a problem for regulatory agencies and the fire service. Illegal sites are particularly hazardous to firefighters, because the firefighters may be unaware of the presence or nature of chemicals or other toxic substances involved in the fire. Landfill fires in regulated facilities also challenge Incident Commanders, who must make a series of tactical decisions in a situation far different from that found at a “normal” structure fire.

Closed landfills are another area of concern, from both a regulatory and a fire service perspective. By federal law, landfill operators must commit to maintaining a landfill for at least 30 years after it has closed. Landfills continue to emit methane and other dangerous gases even after they are closed. As a result, buildings constructed on former landfills are often required to have automatic methane detectors, which sound an audible alarm in the event that methane levels become unsafe. Construction on closed landfills must not damage the final cover or the existing liners and leachate collection system. The true implications of closed landfills are not clear, largely because, for data collection purposes, these sites are likely coded not as landfills but as the property use at the time of an incident (fire, explosion, etc.).

Through EPA regulation and cleanup efforts of landfills, landfill fires are less likely to contain toxic chemicals than they were decades ago. Also, fire departments are gaining the experience to more efficiently and safely extinguish the fires that occur. Working in conjunction with the public and landfill operators, the fire service can reduce the occurrence of landfill fires, thereby better protecting the public, the environment, and emergency responders.

Response Strategies for Tire Fires

(to reduce production of pyrolytic oil residue)

Description

- An estimated 270 million vehicle tires are disposed of each year in the United States. The management of scrap tires has become a major economic and environmental issue. Although responsible means for disposal, such as recycling, reuse and energy recovery have become more common, the tire dumps of the last forty to fifty years continue to present environmental and safety hazards that will last into the foreseeable future.
- Waste tires are made using approximately 2.5 to 7 gallons of crude oil, mixed with vulcanized or cross-lined polymers, carbon black, dispersing oils, sulfur, synthetic fibers, pigments, processing chemicals, and steel or fiberglass. These components make tires readily combustible, and a potential hazard that must be addressed and planned for.

Table 11. Typical Tire Composition: Passenger Tire Recipe. (Taken from CA IWMB's LEA Advisory # 46, 1997).

Materials	Percentage
Styrene butadiene	46.78%
Carbon black	45.49%
Aromatic oil	1.74%
Zinc oxide	1.40%
Antioxidant 6C	1.40%
Sulfur	1.17%
Stearic acid	0.94%
Accelerator CZ	0.75%
Wax	0.23%

Understanding the Problem

- There are many tire dumps, legal and illegal, that exist throughout the United States. There are decreasing landfill options for used tires and the risk of fire is great.
- Most tire fires are started by arson and generate large amounts of heat, and smoke which makes them extremely difficult to extinguish. Some tire fires burn for months (e.g., the Rhinehart tire fire in Winchester VA burned for nearly 9 months).
- The intense heat also leads to the generation of pyrolytic oil (and other incomplete combustion by-product); a standard passenger car tire can generate about two gallons of pyrolytic oil as it burns and liquefies. The oil mixes with the extinguishing material, and can lead to contaminated soils, surface and ground waters in the surrounding area.



- Traditional fire department tactics have included smothering or cooling the fire with water or foam to extinguish it. The resulting efforts often generate incomplete combustion products, pyrolytic oils, smoke, and other toxic waste products.
- The environmental consequences of major tire fires are significant. A tire fire in Rhinehart, Virginia issued a plume of smoke 3,000 feet high and 50 miles long with fallout reported in three states. This fire also threatened the drinking water in the District of Columbia with lead and arsenic contamination.
- During periods of inverse atmospheric conditions, the contaminants will be kept close to the earth and will cause further problems to the community of population. This could result in Shelter in Place or other public protective actions for citizens with respiratory problems.

What to Do

- In recent times, there have been several fire incidents where the decision was made to allow the tire piles to burn to reduce the amount of polluted water runoff and hazardous smoke generation.
 - the Sinclairville Fire Department in New York (in charge of the Chautauqua County Tire fire in April 1995),
 - the Manitoba Conservation along with local fire departments (in charge of the April 2001 tire fire west of Winnipeg, Manitoba, Canada), and
 - the Roanoke County Fire and Rescue Department (in charge of the March, 2002 Roanoke, VA Buck Mountain tire fire),
- These agencies had pre-determined that their response efforts would be best served by only addressing any resultant brush fires, rather than trying to douse the tire fires. Roanoke County Fire and Rescue Chief Richard Burch was quoted stating that “The hotter [the pile] burns, the faster it consumes the tires, and the less smoke and runoff we will have” (Roanoke Times, March 25, 2002).

Authority Required

- **RRT approval is not required** for the use of conventional response techniques, but operations personnel should coordinate with appropriate state and local authorities with respect to the use of fire fighting foams.
- **Incident-specific RRT approval is required** to use an applied technology in the open environment **unless used to prevent**
- Examples of agencies with trustee and functional responsibilities during a tire fire would be:
 - (a) State and local Police
 - (b) Public Works agencies
 - (c) State Department of Emergency Management



- (d) Regional offices of the Federal Emergency Management Agency (FEMA)
- (e) Regional, State or Federal Environmental Protection Agency (EPA)
- (f) State Division/Department of Natural Resources or State Forestry Agency
- (g) State Fire Marshal's office
- (h) Finance, Purchasing and Budget agencies

Availability

- Response strategies for fighting tire fires and dealing with incomplete combustion products (smoke and pyrolytic oils) must be:
 - Well thought out;
 - Practiced by well-trained, properly equipped, and experienced crews under controlled conditions; and
 - Refined prior to implementation during an actual spill response.
- Each product or technology is evaluated for potential functionality for dealing with tire fires, both in assisting with fire suppression and runoff recovery. See Table 14 for a review of each product/technology, its applicability for addressing suppression of the tire fire, and addressing the need to collect/contain any pyrolytic oil produced as a result of incomplete combustion from the use of these products and technologies for the long-term cleanup needs.

NOTE:

Many of these suggestions found in Table 14 are untried, and are only considered potential response options. Small-scale field-testing of these products and technologies is highly recommended to ensure effectiveness and efficacy.

Health and Safety Issues

- Human health and safety are of primary concern, particularly for response operations in general and specifically threats from air contaminants.
- Tire fires can pose a significant health problem for humans, animals, and the environment. Smoke and a wide variety of incomplete combustion products are generated during scrap tire fires, including:
 - ash (carbon, zinc oxide, titanium dioxide, silicon dioxides, etc.),
 - sulfur compounds (carbon disulfide, sulfur dioxide, hydrogen sulfide),
 - polynuclear aromatic hydrocarbons, which are usually detected in oil runoff (such as benzo(a)pyrene, chrysene, benzo(a)anthracene, etc),
 - aromatic, naphthenic, and paraffinic oils,
 - oxides of carbon and nitrogen,



- particulates,
- pyrolytic oils, and
- various aromatic hydrocarbons including toluene, xylene, benzene, etc.
- These incomplete combustion products are extensive and vary depending on factors such as tire type, burn rate, pile size, ambient temperature and humidity, among others.
- A safety officer should be established immediately to address the need for exclusion zones, personal protection equipment (PPE) for all response personnel, and to ensure that these requirements are being followed.
- All personnel should be equipped with appropriate personal protective gear and be fully instructed in its use. Personal protective clothing (turn-out gear) and self-contained breathing apparatus (SCBA) meeting NFPA standards should also be worn by all personnel working in, or exposed to, the products of combustion.
- The ash produced in tire fires has been shown to contain high concentrations of heavy metals, including lead, cadmium, and zinc. The CA IWMB reports that the Total Threshold Limit Concentration (TTLC) for zinc should not exceed 5,000 mg/kg.
- Dermal or skin contact with contaminated materials should be avoided at all times. The metals act as primary irritants by removing the surface film, disturbing the water-holding quality of cells, and injuring the membrane structure of the epidermal cells (CA IWMB LEA Advisory 46).
- The smoke plume may contain hazardous substances that should not be inhaled or allowed to contact the skin. The two substances that are of greatest concern relative to excessive exposure are PAHs and carbon monoxide.
- Increased incidence of respiratory problems, especially in high risk or sensitive populations that include people with chronic lung or heart disease, such as asthma, emphysema, chronic bronchitis, angina, or congestive heart failure.

Pre-incident Planning Needs:

To address tire fires, the following should be considered (much of this list was taken from the IAFC and Scrap Tire Management Council, 2000, publication):

- Pre-incident plans should be developed to identify the special considerations and hazards of a particular site or property so that responding units will know what to expect and how to proceed during initial operations. Pre-incident plans must accommodate the agency's standard operating procedures and specify exactly how those procedures are to be applied should a fire break out at a given location.
- There will be great public concern over the polluting of the air primarily due to the highly visible, thick, black smoke plume from the fire. This is a short-term problem. Air Quality monitoring should be addressed immediately. The incident commander may require the evacuation of population facilities that are directly affected by the smoke plumes.



- A safety officer should be established immediately to address the need for exclusion zones, personal protection equipment (PPE) for all response personnel, and to ensure that these requirements are being followed.
 - A detailed health and safety plan must be developed. Exclusion zones, contamination reduction zones, and decontamination zones are all recommended as part of the response to a tire fire.
 - The potentially hazardous effects of rubber fire emissions, the physical exertion required to fight such fires, the intense heat, and the often unsanitary conditions of dumps all present unique dangers to fire fighters that need to be recognized as priority health and safety concerns.
 - The potential for run-off into, and pollution of, natural resources is a significant concern and should be addressed during size-up. If necessary, immediate efforts should be made to contain pollution from the fire and master-stream runoff.

Limiting Factors/Environmental Constraints

- Scrap tire piles are breeding grounds for millions of mosquitoes, rodents, and snakes. Personnel may need special protection from fleeing rodents, reptiles, and from insects. All food preparation facilities should be enclosed.
- Contaminated run-off water due to the fire fighting and rain needs to be contained and treated. Water sampling of surface waters and ground waters near the tire fire site should be conducted throughout the incident to determine if they are being contaminated by the pyrolytic oil and other compounds resulting from the tire fire.
- Because burning tires can yield oil, officials might require responders to assess the feasibility of taking action to deal with these oils. General response options include:
 - Restrict access to the site
 - Construct dams, ditches, ponds for the collection of drainage waters; -
 Extensive excavation may be required
 - Institute soil erosion controls
 - Collect and treat surface water runoff with gravity settling
 - Collect shallow ground water oily seeps
 - Conduct oil-water separation and transportation to waste water treatment facilities.
 - Skim off hydrocarbons (oil) from runoff and the residual water can be recycled for use on the incident.

Monitoring Requirements/Suggestions

Monitoring is very important during the actual burn. Air sampling and analysis to determine the particulate loads in the plume should be monitored throughout the incident to ensure worker and public safety.



- The plume should be monitored in terms of the particulate matter (PM) that is smaller than 10 microns in diameter. These small particles are easily respired and drawn deeply into the lungs where they can lodge in the lungs and cause damage. Table 12 provides a summary of the USEPA National Ambient Air Quality Standards for particulate matter.
- Table 13 provides a summary of the Air Quality Standards that were specified for response workers during the Filbin Tire Fire in Stanislaus County, California.
- The migrating oil and fire fighting residue needs to be collected/recovered and the site should be evaluated for soil, surface and groundwater contamination. This waste must be considered hazardous material and treated accordingly.
- Monitoring of surface and ground waters should be conducted as soon as possible.

Table 12. National Ambient Air Quality Standards for criteria pollutants of concern during tire fires. Based on the 1997 EPA Revised Particulate Matter Standards.

Criteria Pollutant	Primary Standard	Secondary Standard
Carbon Monoxide		
<i>8 hour average</i>	9 ppm or (10 mg/m ³)	9 ppm or (10 mg/m ³)
<i>1 hour average</i>	35 ppm or (40 mg/m ³)	35 ppm or (40 mg/m ³)
Sulfur Dioxide		
<i>Annual Average</i>	0.03 ppm or (80 .tg/m ³)	—
<i>24 hour average</i>	0.14 ppm or (365 .tg/m ³)	—
<i>3 hour average</i>	—	0.50 ppm or (1,300 .tg/m ³)
Inhalable Particulates (PM 10)		
<i>Annual Average</i>	'--0.02 ppm or (50 .tg/m ³)	'--0.02 ppm or (50 .tg/m ³)
<i>24 hour Average</i>	'--0.07 ppm or (150 .tg/m ³)	'--0.07 ppm or (150 .tg/m ³)



Table 13. Example of Air Quality Categories for the Filbin Tire Fire. (Taken from the California Office of Environmental Health Hazard Assessment, Integrated Waste Management Board for the Filbin Tire Fire in Stanislaus County, California (1999)).

Air Quality Index Category	PM 10 Reading	Potential Health Effects	Health Protective Action
Good	0-49	None	None
Moderate	50-149	Beginning of respiratory symptoms in very sensitive people	Very Sensitive* persons should begin to limit outdoor exertion
Unhealthy for Sensitive* Groups	150-249	Increased respiratory symptoms and aggravation in sensitive people; possible respiratory effects in general populations	Sensitive* persons should limit outdoor exertion
Unhealthy	250-349	Significant increased respiratory symptoms and aggravation in sensitive people; increased likelihood of respiratory effects in general population	Sensitive* persons, the elderly, and children should avoid outdoor exertion; everyone else should limit prolonged outdoor exertion
Very Unhealthy	350-424	Serious risk of respiratory symptoms and aggravation in sensitive people; respiratory effects likely in general population.	Sensitive* persons, the elderly, and children should avoid any outdoor activity; everyone else should limit prolonged outdoor exertion
Hazardous	425+	Serious risk of respiratory symptoms and aggravation in sensitive people; respiratory effects likely in the general population	Everyone should avoid outdoor exertion; sensitive* persons should remain indoors or evacuate

*Sensitive Groups: people with chronic lung or heart disease, such as asthma, emphysema, chronic bronchitis, angina, or congestive heart failure.

Waste Generation and Disposal Issues

- Many states have regulations regarding the disposal of tire fire debris. In some states, the solid tire fire debris is classified as solid waste and must be disposed of in approved landfill facilities.
- The debris remaining following the cessation of the tire fire burn includes large quantities of pyrolytic oils and oily waters (containing polyaromatic hydrocarbons (PAH) and other metals such as cadmium, chromium, nickel and zinc) and ash that also contains high concentrations of heavy metals (zinc, lead, or arsenic).



References

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- Indiana Department of Environmental Management (IDEM). 2000. IDEM Guidance Document: Disposal of Tire Fire Debris. OLQ General ID#0106-01-SW. October 31, 2000.
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- California Integrated Waste Management Board (CA IWMB). 1996. Evaluation of Employee Health Risk From Open Tire Burning. LEA Advisory # 46 – November 6, 1997. Publication No. 232-97-019. Available from the web at: www.ciwmb.ca.gov/LEAAdvisory/46/default.htm.
- USEPA Office of Air Quality Planning and Standards. 1997. National Ambient Air Quality Standards (NAAQS).

Who to Call for More Information and Additional Resources

- Building and Fire Research Laboratory, NIST. Gaithersburg, MD. Phone: 301-975-5900
- NOAA HAZMAT/SSC, General contact number: 206-526-6317
- USEPA
- International Association of Fire Chiefs. Fairfax, VA. Phone: 703-273-0911
- National Fire Prevention Association. Quincy, MA. Phone: 617 770-3000
- Local Fire Departments
- State Fire Marshall
- Local Emergency Planning Commissions



Table 14. Tire fires and the potential uses of products and strategies listed in the Selection Guide.

	Use on the fire (to put out or increase effectiveness of the burn)	Use to stop flow of pyrolytic oils (produced by fire)	Long Term Cleanup
Water	n	r	?
Sorbents	n (c)	n	n
Bioremediation Agents	N/A	N/A	n
Dispersants	r (d)	N/A	N/A
Elasticity Modifiers	r	?	N/A
Emulsion Treating Agents	? (e)	N/A	N/A
Fire-Fighting Foams		n	N/A
In Situ Burning	n (b1)	? (b2)	?
Solidifiers	?	n	?
Surface Collecting Agents	N/A	?	?
Surface Washing Agents	N/A	n (sw)	?
Shoreline Pre-Treatment Agents	N/A	?	?
Oil Tracking	N/A	n (ot)	n

- (s) Wet sorbents have been used to prevent the advance of forest fires
- (d) Dispersants may function as vapor suppressants (?); when mixed with water they might act like the wetting agents in Class A fire fighting foams?
- (e) Emulsion Treating Agents may function as to assist the burn of pyrolytic oils if ISB is considered as an option for removal (?)
- (b1) In Situ Burning can be used to create fire breaks and igniters may assist in a more complete combustion of the tire piles (?)
- (b2) In Situ Burning may be able to be used on pyrolytic oils (?)
- (sw) Surface Washing Agents can be used for spot cleanup on paved areas
- (ot) Various Oil Tracking methods should be used when pyrolytic oils enter surface or ground waters

KEY

Considered to provide value as a response ⁿ option for this situation.

May provide value as a response option in this situation.

r Not considered a viable response option in this situation.

j Insufficient information- impact or effectiveness of the method could not be evaluated

N/A Response option not applicable for this situation

?