40863

NATIONAL PRESTO INDUSTRIES, INC. SITE
EAU CLAIRE, WISCONSIN

WORK PLAN

PRE-DESIGN PILOT STUDIES
LAGOON NO. 1 AND MELBY ROAD DISPOSAL SITE

PROJECT #497-8
AUGUST 1993

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I. INTRODUCTION

The National Presto Industries, Inc. (NPI) site comprises approximately 320 acres in Eau Claire, Wisconsin and is not presently an active manufacturing facility. The site was originally owned by the United States Government and operated between 1940 and 1947 by its contractors, the U.S. Rubber Company (Uniroyal) as a small arms ammunition plant, and Western Electric (AT&T) as a radar tube manufacturing plant. NPI purchased the site from the government in 1947. Between 1947 and 1954, NPI used the facility to produce consumer products, projectile fuzes, and military aircraft parts. Since 1954, all manufacturing activities at the NPI site have been dedicated to defense work for the Department of Defense (DOD). Between 1954 and 1959, the facility produced military aircraft parts and between 1966 and 1980 the facility produced 8-inch and 105 mm projectiles for the Department of the Army (DOA). Active production ceased in February 1980.

When high volume projectile production began in 1966, a wastewater disposal system was devised using a series of lagoons. Lagoon No. 1 was an existing gravel pit that had been used for stormwater percolation and to dispose of waste streams and wastewater generated at the NPI site. It is believed that these wastes were consistent with operations conducted at the NPI site, which included plating, degreasing, metal fabricating, machining, and painting. Lagoon No. 2 was constructed in 1966 and Lagoons 3 an 4 were constructed in 1969. Lagoon No. 1 was used as a settling pond and Lagoons 2, 3, and 4 were used as percolation ponds. There were no federal or state discharge permit requirements in existence at the time that the lagoons were constructed. A WPDES discharge permit was issued for the lagoons in 1976.

Waste forge compound, which in its virgin state consists of approximately equal parts of asphalt, graphite and mineral oil, is the primary waste material present in Lagoon No. 1. Volatile organic compounds (VOCs) and metals became incorporated into the waste forge compound during the forging operations. Waste forge compound with a low solids content flowed by gravity and was

pumped to Lagoon No. 1 with process wastewaters between 1966 and 1980. The waste forge compound and wastewater stream discharged to Lagoon No. 1 contained VOCs (primarily 1,1,1-trichloroethane) and metals which were introduced during the manufacturing process.

From 1966 to 1970, waste forge compound with a higher solids content was heated in a basement collection sump so that it could be pumped into drums. The drums were hauled to the Melby Road Disposal Site where the waste forge compound was emptied into trenches. Disposal of waste forge compound at the Melby Road Disposal Site ceased in 1970 after a reclamation and recycling program was developed and initiated by NPI. The Melby Road Disposal Site trenches were covered and the area was regraded in 1970.

The results of source characterization during the Remedial Investigation (RI) indicate the presence of VOCs and/or metals at the Melby Road Disposal Site and Lagoon No. 1. The most commonly found VOCs were 1,1,1-trichloroethane (TCA), trichloroethylene (TCE), tetrachloroethylene (PCE), 1,1-dichloroethylene (1,1-DCE), 1,2-dichloroethylene (1,2-DCE), and 1,1-dichloroethane (1,1-DCA).

The objective of the Lagoon No. 1 pilot study is to determine the feasibility of blending the waste forge compound for use as a secondary fuel at a regulated cement kiln. The objective of the Melby Road Disposal Site study is to attempt to define the extent of the contamination, the source of the TCA plume and hot spots, and the possibility of contaminants volatilizing from the waste forge compound and causing continuing groundwater contamination.

II. PROJECT TEAM

Work activities will be coordinated by Eder Associates Consulting Engineers, P.C. (Eder). The Lagoon No.1 pilot-scale study will be conducted by Waste Research & Reclamation (WRR), and observed by Eder and USEPA/WDNR personnel. Trench and test pit excavating and backfilling at the Melby Road Disposal Site will be performed by a qualified contractor retained by NPI.

Eder will direct the Health and Safety Plan (HASP) to be followed by all personnel involved in the work including employees and agents of NPI, their contractors, and regulatory agencies. Eder will perform the air monitoring required by the HASP and the waste inspection, field analysis, and excavated waste sampling required by this Work Plan. Laboratory analyses will be performed by Enseco-Wadsworth/ALERT Laboratories, Inc. (Canton, Ohio). Sampling and analysis will be performed in accordance with the Sampling and Analysis Plan (Appendix A).

III. MELBY ROAD DISPOSAL SITE

As the FS was being prepared for the NPI site, it became apparent that the Melby Road Disposal Site was not characterized to the extent required to effectively develop and evaluate potential remedial alternatives. Data gaps existed with respect to the vertical and areal extent of contamination and questions remained regarding the specific source of VOCs in groundwater. In addition, historical aerial photographs recently obtained from the Eau Claire County Health Department revealed the waste disposal area to be larger than originally delineated based on earlier photographs. Consequently, it is necessary to conduct additional field work, including sampling and laboratory analyses at the Melby Road Disposal Site to fully determine the nature and extent of waste disposal and soil contamination, and to collect data to support the remedial alternative evaluation. The following discussion presents the proposed additional work.

Using a CAT 245 Trackhoe excavator or equivalent, a 24 foot deep inspection trench will be excavated, starting at the eastern portion of the waste forge compound disposal area (extent estimated from available information), and proceeding first northwest and then due west, as indicated on Figure 1. A second inspection trench will be excavated through the soil gas hot spot located in the northeast corner of the Melby Road Disposal Site. A third trench will bisect the southeast soil gas hotspot. Additional trenches or test pits will be excavated to determine the extent of the disposal trenches and contamination. These excavations will be located along the approximate boundaries of the disposal area shown on Figure 1, and as determined in field. Test pits may be excavated in place of trenches if it would be more efficient to use pits to determine the extent of the contamination. Field decisions would be based on headspace screening data and physical characteristics of the material observed in the inspection excavations. The excavated wastes and soil will be described with respect to color, texture, appearance, mineralogy, and moisture and sampled by Eder at the surface and analyzed in accordance with the Sampling and Analysis Plan (SAP). The inspection excavations will be excavated by scraping successive layers to the practicable reach of the excavating machine, and the excavated materials will be stockpiled

for backfilling. The excavation faces will be scaled to provide a stable edge. All excavated material will be backfilled into the inspection excavations in the order in which it was removed to the extent practicable. If any wastes are excavated and subsequently backfilled, the location will be indicated in the field notebook. All excavations will be backfilled at the end of the work day. Excavation depth will be measured using a steel tape where practical.

Waste forge compound will be visually inspected and sampled by WRR to determine its suitability for burning as a secondary fuel, either as a liquid or a solid. Representative samples will be collected and analyzed by WRR for the parameters indicated in Section IV.

Soil samples will be initially collected during the excavation work at 5-foot depth intervals vertically and 10-foot intervals horizontally and the headspace analyzed for TCA, TCE, and PCE using a portable GC. The sampling frequency may be adjusted, based on field observations, such as homogeneity of the subsurface material. Sampling and analysis will be performed in accordance with the SAP. Soil samples will be collected from the excavated material and submitted for laboratory analysis of VOCs to develop a correlation between headspace readings and contaminant concentrations. The number of samples to be collected for laboratory analysis will be determined based on field observations, such as visibly different waste materials.

Soil borings will be drilled to the water table and soil and waste samples collected to develop a vertical profile of the extent of the contamination after the excavation work is complete and the excavations are backfilled. Based on the current soil gas data, soil borings will be drilled in the three soil gas hot spots and in several other locations to develop the vertical profile. The actual number and location of the soil borings will be determined based on field observations and existing RI data. If high headspace readings are found to persist to the bottom of the excavations, soil borings will be drilled to the water table adjacent to the points of highest headspace readings to develop a vertical profile. Continuous sampling will be conducted throughout the depth of the waste (identified during the excavation work) using a hollow stem auger with a 24 inch split spoon. Samples would be collected at 5-foot intervals using split spoons from the soil column extending from the lower extent of the wastes to the water table. Waste samples will be visually

WORK PLAN

PRE-DESIGN PILOT STUDIES
LAGOON NO. 1 AND MELBY ROAD DISPOSAL SITE

eder associates
environmental scientists and engineers

identified and each sample will be described with respect to color, texture, appearance, mineralogy, moisture, and grain size. If wastes are found which are visually different than the wastes sampled and analyzed during the RI, then a laboratory analysis plan will be developed and reviewed with the EPA and WDNR for their approval. The soil samples will be field screened for headspace TCA, TCE, and PCE. At least three soil samples from each boring with detectable headspace levels representative of high, intermediate, and low concentrations will be sent to the laboratory for VOC analysis. If applicable, at least two soil samples with non-detectable headspace concentrations from each boring will be submitted for confirmatory laboratory analysis of VOCs. Additional confirming soil samples will be taken for laboratory analyses of VOCs, as necessary to develop a correlation between headspace readings and the contaminant concentrations.

At least one sample of the waste forge compound will be collected from the split spoon for headspace analysis. A 40 milliliter VOA vial would be filled halfway and capped. The relative concentration of TCA and TCE in the headspace will be measured with the field GC, by withdrawing an aliquot from the headspace for analysis after 30 minutes, and 1, 2, 4, 8 and 24 hours (and possibly longer) at the temperature of the in-place waste, which will be determined using a thermometer. The headspace will be purged using ultra zero air after each aliquot is withdrawn to determine the offgas concentration during the time interval. After purging, the vial will be recapped with a new septum. An aliquot will then be withdrawn and analyzed using the GC to obtain a time "zero" headspace reading for the next time interval. This would provide a semi-quantitative determination of the amount of TCA and TCE that volatilizes from the waste forge compound over time.

Fugitive dust control will be performed as needed during waste material handling. The application of water sprays will be carefully controlled to suppress airborne dust without causing runoff. Excavated waste material will be stockpiled on double polyethylene sheeting. Stockpiles will be covered with single polyethylene sheeting during inclement weather, which will be weighted with soil to keep the sheeting in place, and placed so that runoff remains on-site. Sheeting will be a minimum 6 mil thickness. Where seams are required, adjacent sheets will

overlap by at least 6 inches and will be joined with folded seams and sealing tape. The seams on successive layers will be staggered by a distance of at least 6 feet.

Stockpiled materials will be carefully removed from the sheeting using the backhoe. Stockpile residues will be removed manually using brooms and shovels to prevent damage to the sheeting. Sheeting may be reused at successive trench excavations, provided it is intact. Damaged sheeting and sheeting from the last excavation will be disposed of off-site.

All components of the excavating equipment that come in contact with the waste forge compound will be decontaminated upon leaving the NPI site using a steam cleaner. Rinse water will be contained and pumped into drums and placed in Lagoon No. 1. Steam cleaners and pumps will either be self powered or electric powered with a generator.

Equipment involved in the Lagoon No. 1 pilot study will be decontaminated near Lagoon No. 1. A decontamination station will be constructed near the Melby Road Disposal Site entrance to decontaminate equipment entering and leaving the work area. The station will be sized to accommodate the equipment, and will consist of a bermed area lined with double polyethylene sheeting of minimum 6 mil thickness. Where seams are required, adjacent sheets will overlap by at least six inches and will be joined with folded seams and sealing tape. The seams on successive layers will be staggered by a distance of at least six feet. The floor will be sloped to a collection sump. The sump contents will be transferred to and placed in Lagoon No. 1. After the last decontamination, the station will be closed by removing the sheeting, and grading the station level.

IV. LAGOON NO.1

During the preparation of the Feasibility Study for the NPI site, NPI received a proposal from Waste Research & Reclamation (WRR) to remove and dispose of the Lagoon No. 1 waste forge compound by pumping, blending with waste oils and solvents and using it as a secondary fuel in an off-site cement kiln. WRR's proposal was based on the laboratory analyses of samples of Lagoon No. 1 waste forge compound and their previous experience with the material during the time that projectiles were produced at the NPI site.

A 20,000-gallon prototype pilot study of this alternative will be conducted. The objective of the pilot scale study is to determine the pumpability and consistency of the waste forge compound, and the feasibility of fuel blending and burning at an approved Boiler and Industrial Furnace (BIF) regulated cement kiln. The pilot scale study will be conducted by WRR and observed by Eder and USEPA/WDNR personnel.

WRR will place an 11-foot diameter by 10-foot high steel cylinder into the lagoon in the area between sampling reference points S1 and R2 used in WRR's May 1992 depth survey of Lagoon No. 1, as indicated on Figure 2. The cylinder will be equipped with two hydraulically operated slide gate openings located 1 foot above the bottom. The cylinder will have a work platform with guard rails, and a pump hoist tripod. The cylinder will be secured to the shore by guy wires to assure stability during the operation.

The cylinder will be placed on the lagoon bottom at a location where the waste forge compound is approximately 6 feet deep, and the 2-foot surface water layer will be pumped from the cylinder back into the lagoon. The two hydraulically operated slide gates will be opened to allow additional waste forge compound to enter the cylinder. A 4-inch hydraulically driven centrifugal pump will be lowered into the waste forge compound and the waste forge compound will be pumped to a tanker truck through a combination of 6-inch flexible hose and thin wall irrigation

pipe to reduce friction loss. The material will be transported from the NPI site to WRR in 4,000 gallon loads for testing. The tests conducted by WRR to assess the suitability of burning the waste forge compound as fuel for a BIF-regulated cement kiln will include entrained solids (volumetrically), fuel value (bomb calorimeter), entrained water (Carl Fischer titration), chloride and ash (bomb calorimeter). Three samples of waste forge compound will be collected and sent to Enseco-Wadsworth/ALERT Laboratory for Priority Pollutant analysis using CLP protocol. Waste forge compound sampling and analysis will be performed in accordance with the SAP. The samples will be collected either by probing (using a hollow metal rod or a single use weighted PVC bailer) through the waste forge compound in the cylinder, or by disconnecting the hose from the tanker to transfer some material to sample containers. The samples will be collected when the waste forge compound is pumped for the first, third, and fifth 4000-gallon loads.

The waste forge compound will be blended at WRR with waste solvents and oils to reduce its viscosity and screened through a vibrating screen to remove debris larger than 1/8 inch, which would foul the BIF feed nozzles, if necessary. The blended fuel will be shipped by tanker truck, either directly to the cement kiln, or to WRR's rail site in Altoona, Wisconsin, transferred to a tank car and shipped by rail to the cement kiln.

The cement kiln facility has not been determined, however, the following facilities are available. The facility selected would be operated in compliance with applicable environmental regulations and authorized to burn CERCLA wastes.

Facility	EPA ID#
SYSTECH:	
Alpena, MI	MID981200835
Fredonia, KS	KSD980633259
Greencastle, IN	IND006419212
Paulding, OH	OHD005048947

CADENCE:	
Louisville, NE	NED007260672
Foreman, AR	ARD981512270
Knoxville, TN	TND106203375
Chanute, KS	KSD031203318
Fairborn, OH	OHD981195779
MARINE SHALE:	
Baton Rouge, LA	LAD981057706
CEMTECH:	
Festus, MO	MOD050232560
CP RECYCLING:	
Cape Girardeau, MO	MOD981127319
Logansport, IN	IND005081542
CONTINENTAL:	
Hannibal, MO	MOD054018288

V. SECURITY

All excavations at the Melby Road Disposal Site are intended to be closed at the end of the work day. However, if an open excavation remains at the end of the work day (e.g., from equipment breakdown), a security guard will be posted at the open excavation to prevent unauthorized entry to the work site during the time that the work is suspended. NPI will be immediately notified if unauthorized entry of the work site has occurred.

VI. AIR MONITORING

Air monitoring to be performed during the Lagoon No.1 pilot study and the Melby Road Disposal Site excavation work is presented in Section 5 of the HASP. Real-time air monitoring will be performed at the perimeter of the exclusion zone and at the site boundary of each area. Approximate site boundaries are indicated on Figure 3.

Hourly real-time measurements of organic vapor concentrations will be made using a photoionization detector or a flame ionization detector. In addition, hourly real-time measurements of particulate concentrations will be made during the Melby Road Disposal Site excavation work using a light scattering aerosol monitor. Real-time air monitoring locations will be at four locations on the perimeter of the exclusion zones and at the site boundaries (one location upwind and two locations downwind).

Ambient air sampling will be performed at the boundary of the Melby Road Disposal Site during the excavation operation. Two ambient air monitoring stations will be located downwind and one station upwind. Approximate sampling locations are indicated on Figure 3. These locations were selected based on the prevailing wind direction, which is from the south-southwest between May and September. The ambient air monitoring will include respirable particulates (PM_{10}) and Total Suspended Particulates (TSP) for metals, and volatile organic compounds (VOCs) and polynuclear aromatic hydrocarbons (PAHs). The reference methods are indicated in Section II of the Sampling and Analytical Plan (SAP). Each ambient air monitoring station will consist of the equipment specified in the USEPA methods to measure TSP, PM_{10}, VOCs and PAHs. The SAP contains standard operating procedures (SOPs) for each method. A generator will be set up at each station immediately downwind of the air monitoring equipment. The sampling media from each station will be submitted to Ross Analytical Services, Inc. of Strongsville, Ohio for analysis.

Ambient air quality will be monitored each day for the duration of the trench and test pit operations at the Melby Road Disposal Site. Background ambient air monitoring will be conducted for an eight-hour period on the day before the excavation activity begins. If it is necessary to leave excavations open overnight, ambient air quality will be monitored for the overnight period. The overnight sampling run will begin after work activity stops for the day and will continue until work begins the next day. The ambient air monitoring results will be evaluated in relation to wind speed, wind direction, temperature, relative humidity, and barometric pressure. These meteorological data will be obtained hourly for the Chippewa Valley Regional Airport weather station (telephone number: 715-835-3163).

The residences in closest proximity to the Melby Road Disposal Site work area are located north of Melby Road. The two downwind air monitoring stations (based on the prevailing wind direction) are located along the Melby Road fenceline. The ambient air monitoring stations may be moved if there are sustained changes in wind direction during the field work. However, it will not be necessary to move the sampling trains in response to periodic shifts in wind direction because the ambient air quality data collected at the NPI site property line along Melby Road will be sufficient to evaluate off-site impacts.

Real-time air sampling can be conducted at locations in addition to those specified in this Work Plan as conditions warrant. For example, if sustained elevated organic vapor or particulate concentrations are measured near the work area, additional readings will be taken as the air sampling personnel moves away from the work area in the downwind direction (based on weather conditions recorded at the airport) towards the NPI site property line (the Melby Road fenceline) to evaluate the dissipation of contaminant concentrations in the air.

The excavation activity will be suspended if the real-time measurements of particulate or organic vapor concentrations (at the Melby Road fenceline) are sustained at levels above the following action levels during three consecutive hourly sampling events:

- PM_{10} > 450 ug/m^3
- organic vapors > 5 ppm above background levels

The PM_{10} action level is based on the National Ambient Air Quality Standard of 150 ug/m^3 (24 hour average) and prorated for an eight-hour work day. If the work is suspended due to high particulate concentrations at the NPI site boundary, water sprays will be used to reduce particulate levels in the air. Then, excavation will proceed using water to control particulate releases. If the work is suspended due to high organic vapor concentrations at the NPI site boundary, mitigation measures will be discussed with USEPA and WDNR, and appropriate measures will be implemented before proceeding with the excavation work.

VII. REPORT

A report will be prepared addressing the feasibility of the fuel blending operations at Lagoon No. 1, such as:

The pumpability and materials handling aspects of removing the waste forge compound from the lagoon.

Feasibility of using the blended waste forge compound as a cement kiln fuel.

Screening to remove particles greater than 1/8" in size (either before or after fuel blending), which would block the BIF feed nozzles.

The ratio of waste forge compound to waste fuel.

Waste forge compound separation during transportation.

Water entrainment in the waste forge compound.

Verification of the cost and time necessary to conduct the waste forge compound removal.

An estimate of how much material would remain in the lagoon at completion.

The time of year during which the work should be done.

The effect of the new EPA air emission guidelines on the cement kilns and any special materials handling considerations developed as a result of the study.

The report will summarize the findings of the excavation and sampling at the Melby Road Disposal Site, and address the following outstanding technical issues:

The volume of waste contained at the Melby Road Disposal Site.

The depth to which the soil vapors or contaminated soil extend beneath the waste forge compound disposal trenches.

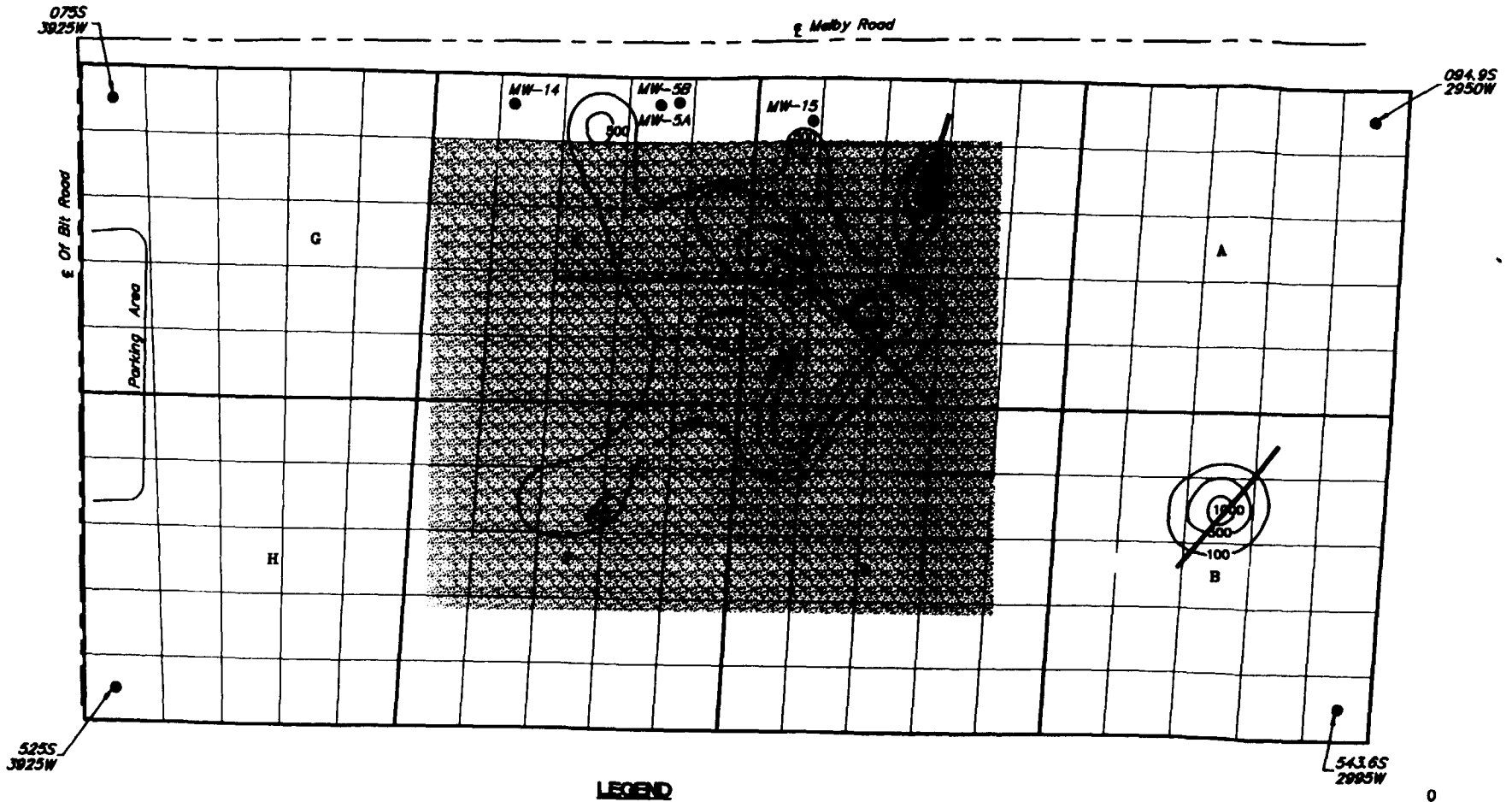
The source of the TCA plume in the groundwater leaving the Melby Road Disposal Site.

The source of the concentrated TCA soil vapors detected during the RI.

Evaluate the suitability of the waste forge compound in the trenches as a secondary fuel source, either as a liquid or a solid.

eder associates consulting engineers, p.c.

FIGURE 1



GRID NUMBERING SYSTEM KEY

C-1	A-21	A-16	A-11	A-6	A-1
C-2	A-22	A-17	A-12	A-7	A-2
C-3	A-23	A-18	A-13	A-8	A-3
C-4	A-24	A-19	A-14	A-9	A-4
C-5	A-25	A-20	A-15	A-10	A-5
D-1	B-21	B-16	B-11	B-6	B-1

SK4678AM
070783

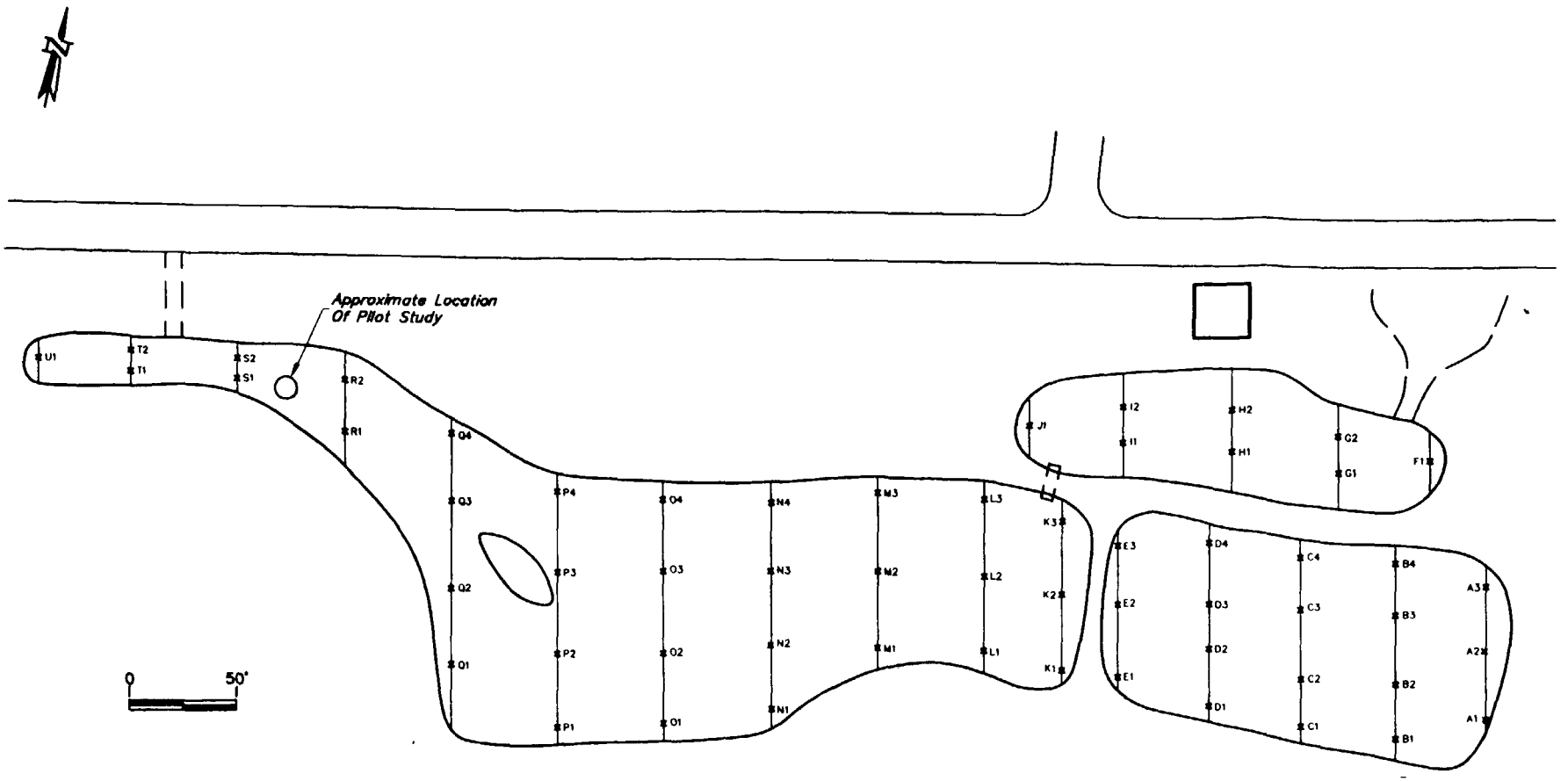
LEGEND

- Test Trench Location
- Existing Monitoring Well
- —1000— Contours Of 1,1,1-Trichloroethane Concentration In Soil Vapor Samples (PPB)
- Area Of Buried Waste Forge Compound Trenches (Approximate)
- Grid Coordinate Reference Point (Staked)

0 80'

SCALE IN FEET

MELBY ROAD DISPOSAL SITE
PRE-DESIGN PILOT STUDY
NATIONAL PRESTO INDUSTRIES, INC. SITE
EAU CLAIRE, WISCONSIN



LEGEND

× *Approximate Sampling Reference Points*

LAGOON No. 1
PRE-DESIGN PILOT STUDY
NATIONAL PRESTO INDUSTRIES, INC. SITE
EAU CLAIRE, WISCONSIN

SK467BAN
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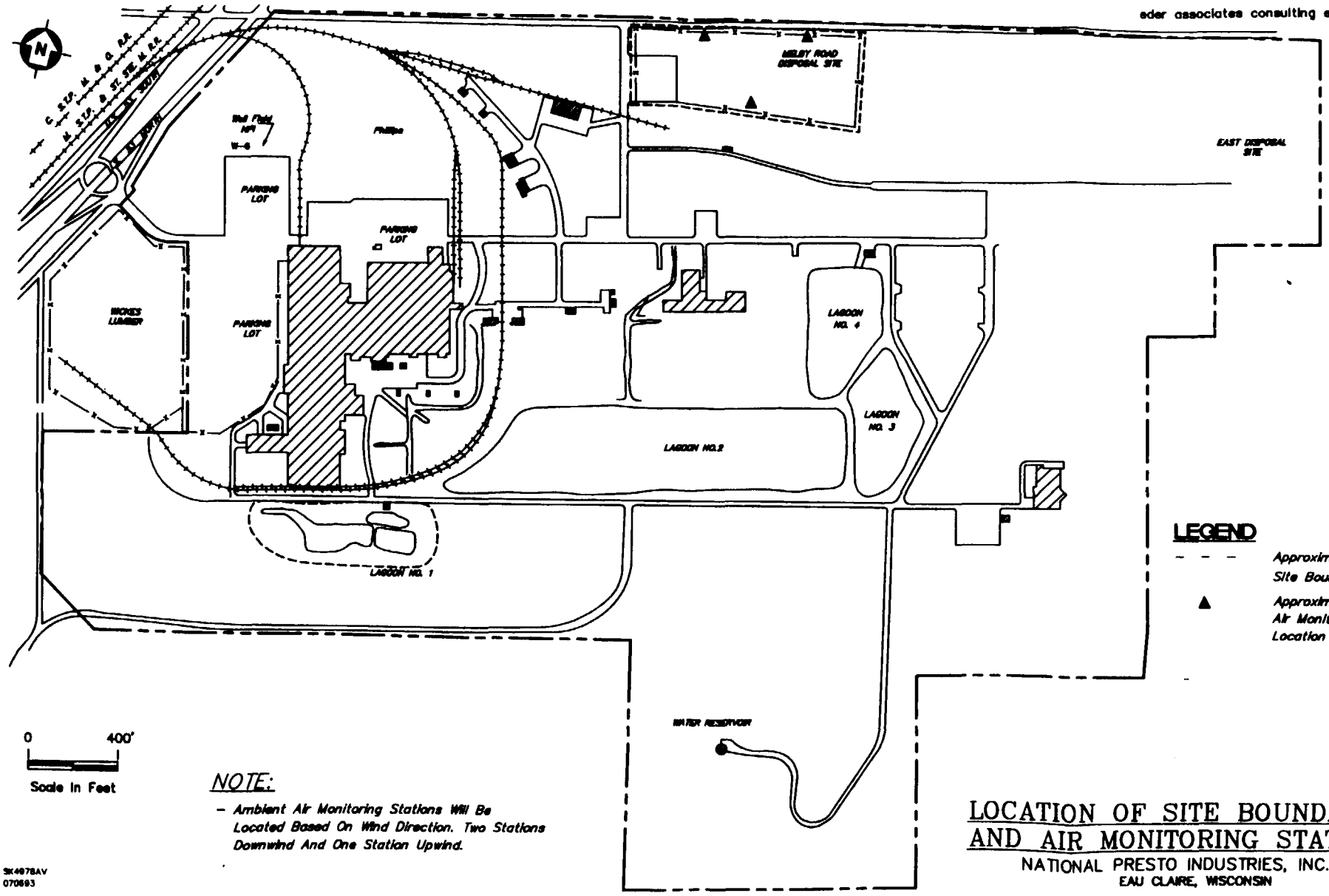
FIGURE 3



LEGEND

- - - Approximate work Site Boundary

▲ Approximate Ambient Air Monitoring Location

NOTE:

- Ambient Air Monitoring Stations Will Be Located Based On Wind Direction. Two Stations Downwind And One Station Upwind.

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LOCATION OF SITE BOUNDARIES AND AIR MONITORING STATIONS

NATIONAL PRESTO INDUSTRIES, INC. SITE

EAU CLAIRE, WISCONSIN

APPENDIX A

SAMPLING AND ANALYSIS PLAN

NATIONAL PRESTO INDUSTRIES, INC. SITE
EAU CLAIRE, WISCONSIN

SAMPLING AND ANALYSIS PLAN

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I. INTRODUCTION

This Sampling and Analysis Plan (SAP) covers the Field Sampling Plan (FSP) and the Quality Assurance Project Plan (QAPP) that will be implemented for the Pre-Design Pilot Studies at the Melby Road Disposal Site and Lagoon No. 1

The FSP defines the sampling and data-gathering methods to be used in the field investigation. The QAPP describes the policy, organization, functional activities, and quality assurance and quality control protocols to assure the integrity of samples and accuracy of analyses.

The SAP presents the sampling procedures and methodologies for field measurements and sample analyses to be performed during the excavation of inspection trenches and test pits at the National Presto Industries, Inc. (NPI) site in Eau Claire, Wisconsin. The QAPP is provided to ensure that all information, data and resulting decisions are technically sound, statistically valid and properly documented. The Lagoon No. 1 pilot study is primarily a material handling study related to pumpability, waste forge compound transfer logistics, and fuel blending. The sampling protocol outlined in the Work Plan is designed to collect representative samples for the Lagoon No. 1 pilot study, based on previous site investigations conducted by Waste Research and Reclamation, Inc. (WRR). In addition, three samples of waste forge compound from Lagoon No. 1 will be collected for laboratory analysis of Priority Pollutants.

Eder Associates Consulting Engineers, P.C. (Eder) will be responsible for project coordination and overall Quality Assurance (QA). Eder will be responsible for the quality control (QC) of excavated waste and soil sampling, field analysis, ambient air sampling, and for air monitoring to be performed under the HASP. Eder will coordinate laboratory analyses of these samples. Chemical analysis of soil samples will be performed by Enseco-Wadsworth/ALERT laboratory (North Canton, Ohio), analysis of ambient air samples will be performed by Ross Analytical Services, Inc. (Strongsville, Ohio), and the physical testing required for the Lagoon No.1 pilot

study will be performed by WRR. The laboratories will be responsible for laboratory QC, data quality review, performance auditing and systems auditing. Final data quality validation will be performed by Eder.

II. FIELD SAMPLING PLAN

General

All field measurements, observations, remarks and site conditions will be documented in a bound field notebook by the field teams. The information will include weather conditions, sampling date, time, name of sampling individual, depth, location including sketch and other information of sufficient detail to allow the sample location to be relocated at a later time. Any deviation from the procedures in the FSP will be noted in the field notebook along with the reason for the deviation. The date and time of field equipment calibration, duplicate sample collection and field blank collection will be documented in the field notebook.

Lagoon No. 1 Waste Forge Compound Sampling

Three samples of Lagoon No. 1 waste forge compound will be collected during the pilot study and sent to Enseco-Wadsworth/ALERT laboratory for Priority Pollutant analysis using CLP protocol. The Priority Pollutants include TCL volatile organics, semi-volatile organics, pesticides and PCBs, and TAL metals and cyanide. The samples will be collected either by probing (using a hollow metal rod or a single use weighted PVC bailer) through the waste forge compound in the 11-foot diameter cylinder used by WRR, or by disconnecting the hose from the tanker to transfer some material into sample containers. Either method should minimize sample disturbance and volatilization from the sample. The samples will be collected when the waste forge compound is pumped for the first, third, and fifth 4000-gallon loads. Quality control samples (matrix spike and duplicate samples) will also be collected with the first waste forge compound sample and sent to the laboratory.

The samples will be placed in precleaned glass jars with Teflon lids furnished by the laboratory. The sample containers will be labeled as follows:

- project name and number
- sample identification number
- sample date and time
- required analyses
- initials or name of person collecting sample

Sample containers to be shipped to the laboratory will immediately be placed in an insulated overpack with frozen plastic blocks and will be shipped by overnight courier.

Excavated Waste and Soil Sampling

Stockpiled excavated wastes and soil will be sampled at land surface using precleaned stainless steel trowels. The sampling equipment will be washed with a solution of Alconox detergent and distilled water and double rinsed with distilled water prior to each sampling. Each sample will be placed in two containers. One container will be field screened for the presence of volatile organic compounds (VOCs) as described below in "Portable Gas Chromatograph Screening". The second container will be completely filled, and securely closed for possible confirmatory laboratory analysis. Selected samples will be shipped to the laboratory for analysis, based on field observations, such as high headspace readings and visibly different material.

To minimize any uncertainty related to sample depth and volatile hydrocarbon loss, soil borings will be drilled to the water table and soil and waste samples collected to develop a vertical profile of the extent of the contamination after the excavation work is complete and the excavations are backfilled. Based on the current soil gas data, soil borings will be drilled in the three soil gas hot spots and in several other locations to develop the vertical profile. The actual number and location of the soil borings will be determined based on field observations and existing RI data. If high headspace readings are found to persist to the bottom of the excavations, soil borings will be drilled to the water table adjacent to the points of highest headspace readings to develop a vertical profile. Continuous sampling will be conducted throughout the depth of the waste (identified during the excavation work) using a hollow stem auger with a 24-inch split spoon.

Samples would be collected at 5-foot intervals using split spoons from the soil column extending from the lower extent of the wastes to the water table. Split spoons will be washed with detergent and rinsed with distilled water between samples. Waste and soil samples will be visually identified and each sample will be described with respect to color, texture, appearance, mineralogy, moisture, and grain size. If wastes are found which are visibly different than the wastes sampled and analyzed during the RI, then a laboratory analysis plan will be developed and reviewed with the EPA and WDNR for their approval. The soil samples will be field screened for headspace TCA, TCE, and PCE. At least three soil samples from each boring with detectable headspace levels representative of high, intermediate, and low concentrations will be sent to the laboratory for VOC analysis. At least two soil samples with non-detectable headspace concentrations (if applicable) from each boring will be submitted for confirmatory laboratory analysis of VOCs. Additional confirming soil samples will be taken for laboratory analyses of VOCs, as necessary to develop a correlation between headspace readings and the contaminant concentrations. Laboratory analyses would be performed in accord with CLP protocol.

For GC quality control, one duplicate sample will be collected for every 10 samples and one rinse blank will be collected daily. The rinse blank will be prepared by collecting the final distilled water rinseate from the sampling equipment.

Sample containers will be precleaned glass jars with Teflon lids furnished by the laboratory. The sample containers will be labeled as follows:

- project name and number
- sample identification number
- sample date and time
- required analyses
- initials or name of person collecting the sample

Sample containers to be shipped to the laboratory will immediately be placed in an insulated overpack with frozen plastic blocks and will be shipped each day by overnight courier.

Portable Gas Chromatograph Screening

A Photovac Model 10S50 portable gas chromatograph (GC) will be used to screen select samples collected in the field. The following steps will be used to screen the samples using the GC. An approved standard operating procedure (SOP) for field screening is included in Appendix A.

- Preparation of Calibration Standards
    - Chemicals purchased from a supplier of analytical grade chemical standards.
    - Two serial dilutions are performed with distilled water.
    - Lowest standard determines GC sensitivity.
    - Limit of detection established.
    - Mixed calibration standard prepared.
- Instrument Set-Up
    - Carrier gas flow rate 5-15 milliliters/minute
    - Column temperature 30 to 50°C
    - Analysis time 2 minutes to 1 hour.
    - Signal gain setting 20 to 100
    - Retention time window 2-10%
    - Chromatograph column is C-Sil 5 CB
    - Carrier gas is hydrocarbon-free air

- Soil Sample Preparation and Analysis

  - Transfer a 20 gram soil sample to a 40 milliliter VOA vial.

  - 10 milliliters of distilled water and several glass beads added to vial, vial capped, shaken for 30 seconds.

  - Place vial in a water bath at 35°C for 30 minutes.

  - Withdraw 100 microliters headspace with a 100 microliter syringe.

  - Inject the sample into the GC and analyze.

- Waste Forge Compound Sample Preparation

  - Collect the sample of the waste forge compound from the split spoon for headspace analysis.

  - Measure the in place temperature of the waste forge compound by removing a sample of the waste forge compound from the split spoon and recording its temperature using a thermometer.

  - Fill a 40 milliliter VOA vial halfway and cap.

  - Maintain the sample at the temperature of the in-place waste.

  - Withdraw an aliquot from the headspace for analysis after 30 minutes, and 1, 2, 4, 8 and 24 hours, and possibly longer.

  - Withdraw 100 microliters of headspace with a 100 microliter syringe.

- Inject the sample into the GC and analyze.
- Purge the headspace using ultrazero air after each aliquot is withdrawn.
- Recap the VOA vial with a new septum.
- Withdraw an aliquot from the headspace and analyze using the GC to obtain a time "zero" reading for the next time interval.
- Repeat the process at the designated times (i.e. - 1, 2, 4, 8 hours . . .).

Maintenance

- Set carrier gas flow rate each day.
- Run ambient air blank daily to determine if column condition is acceptable.
- Inject a 100 microliter headspace calibration standard whenever it is necessary to assure accuracy after the GC is warmed up and a stable baseline is achieved.
- GC library updated with new retention times and peak areas.
- Run standards and blanks every 15 samples or more frequently as conditions dictate.
- Headspace from highly contaminated samples are diluted using hydrocarbon-free air.

Sample Shipment

Samples to be analyzed in the laboratory will be cooled in accordance with analytical method requirements and shipped on a daily basis.

A chain-of-custody record will be filled out and will accompany each sample shipment to establish the documentation necessary to trace sample possession from the time of collection to laboratory analysis. A record will contain, at a minimum, the following information:

- sample identification
- date and time of sample collection
- location and method of sample collection
- total number of samples collected
- laboratory name and analyses required
- project number and project name
- remarks and/or applicable comments
- sampler signature

The samples will be delivered to the person in the laboratory authorized to receive and process samples in accordance with the procedure described in the previously approved laboratory quality assurance plan. In general, the lab will: inspect the condition of each sample and the sample container seal; reconcile the sample container labeling with that on the chain-of-custody record; assign a laboratory number; log in the sample in the laboratory log book; and store the sample in a secured sample storage room or cabinet until assigned for analysis. Any discrepancies between sample container labeling and the chain-of-custody record will be resolved with the sample collection team before the sample is assigned for analysis.

Laboratory Analysis

The confirmatory samples will be analyzed using CLP protocol and in accordance with USEPA regulations for volatile organics in accordance with the previously approved QAPP.

Quality control including calibration procedures; preventive maintenance; data reduction, validation and reporting; performance and system audits; and corrective action will be provided in accordance with the previously approved QAPP.

Air Monitoring

Real-time air monitoring will be performed during the Lagoon No. 1 pilot study and the Melby Road Disposal Site excavation work using a photoionization detector or a flame ionization detector to measure organic vapor concentrations. In addition, real-time measurements of particulate concentrations will be made during the Melby Road Disposal Site excavation work using a light scattering aerosol monitor. Real-time air samples will be monitored at four locations on the perimeter of the exclusion zones and at the site boundaries (one location upwind and two locations downwind). In addition to the real-time air monitoring, ambient air monitoring will be conducted at the Melby Road Disposal Site perimeter during the excavation operation.

Real-time air sampling can be conducted at locations in addition to those specified in the Work Plan as conditions warrant. For example, if sustained elevated organic vapor or particulate concentrations are measured near the work area, additional readings will be taken as the air sampling personnel moves away from the work area in the downwind direction (based on weather conditions recorded at the airport) towards the NPI site property line (the Melby Road fenceline) to evaluate the dissipation of contaminant concentrations in the air.

The following sections describe the air sampling instruments and how they are operated.

Photoionization Detector (PID)

A MicroTip PID will be used to monitor real-time organic vapor concentrations. The MicroTip will be zeroed and calibrated prior to use. The maximum MicroTip reading will be recorded for each instantaneous measurement.

Flame Ionization Detector (FID)

A Foxboro OVA-FID will be used to monitor real-time organic vapor concentrations. The OVA will be zeroed and calibrated prior to use. The maximum OVA reading will be recorded for each instantaneous measurement.

Real-Time Aerosol Monitoring

A MiniRAM real-time aerosol monitor will be used to monitor airborne particulates with a diameter less than 10 microns (PM_{10}). The use of the MiniRAM, in conjunction with the dust suppression operation will aid in controlling fugitive dust emissions. The instrument will be zeroed and periodically calibrated in accordance with the manufacturer's instructions. The MiniRAM readings will be recorded and averaged over 15 minute timeframes.

Ambient Air Monitoring

Ambient air monitoring will be conducted at the boundary of the Melby Road Disposal Site during the excavation operation, one location upwind and two locations downwind, as indicated in Figure 3 of the Work Plan. These locations were selected based on the prevailing wind direction, which is from the south-southwest between May and September. The ambient air monitoring will include respirable particulates (PM_{10}) and Total Suspended Particulates (TSP) for lead and zinc, and volatile organic compounds (VOCs) and polynuclear aromatic hydrocarbons (PAHs). The following reference methods will be used:

Parameter	Reference Method
PM_{10}	40 CFR 50 Appendix J
TSP/Metals	40 CFR 50 Appendix B and G
Volatile Hydrocarbons	TO-2
Polynuclear Aromatic Hydrocarbons	TO-13

Standard operating procedures (SOPs) for each method are included in Appendix B. USEPA Method TO-2 measures non-polar VOCs with boiling points in the range of -15° to 120°C, including those compounds listed in Table 1. USEPA Method TO-13 measures the PAH compounds listed in Table 2.

Each ambient air monitoring station will consist of the equipment specified in the USEPA methods to measure TSP, PM_{10}, VOCs and PAHs. A generator will be set up at each station immediately downwind of the air monitoring equipment. The sampling media from each station will be submitted to Ross Analytical Services, Inc. of Strongsville, Ohio for analysis.

Ambient air quality will be monitored each day for the duration of the trench and test pit operations at the Melby Road Disposal Site. Background ambient air monitoring will be conducted for an eight-hour period on the day before the excavation activity begins. If it is necessary to leave excavations open overnight, ambient air quality will be monitored for the overnight period. The overnight sampling run will begin after work activity stops for the day and will continue until work begins the next day. The wind speed, wind direction, temperature, relative humidity, and barometric pressure. These meteorological data will be obtained hourly for the Chippewa Valley Regional Airport weather station (telephone number: 715-835-3163).

The residences in closest proximity to the Melby Road Disposal Site work area are located north of Melby Road. The two downwind air monitoring stations (based on the prevailing wind direction) are located along the Melby Road fenceline. The ambient air monitoring stations may

be moved if there are sustained changes in wind direction during the field work. However, it will not be necessary to move the sampling trains in response to periodic shifts in wind direction because the ambient air quality data collected at the NPI site property line along Melby Road will be sufficient to evaluate off-site impacts.

III. QUALITY ASSURANCE PROJECT PLAN

The Quality Assurance Project Plan (QAPP) for the Lagoon No. 1 and Melby Road Disposal Site pre-design pilot studies will use the previously approved QAPP for the NPI Site Remedial Investigation/Feasibility Study (November 1987) and its amendment for Field Screening for Volatile Compounds in Water and Soil Samples Using the PhotoVac 10S50 Gas Chromatograph (August 1991). The field screening SOP is attached.

By reference the QAPP incorporates:

- Project Organization and Responsibility
- Quality Assurance Objectives for Precision, Accuracy, Completeness, Representativeness and Comparability
- Sampling Procedures
- Sample Custody
- Data Reduction, Validation and Reporting
- Corrective Action

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TABLE 1

PARTIAL LIST OF VOLATILE ORGANIC COMPOUNDS
THAT CAN BE MEASURED USING USEPA METHOD T-02

Compound
Vinyl Chloride
Acrylonitrile
Vinylidene Chloride
Methylene Chloride
Allyl Chloride
Chloroform
1,2-Dichloroethane
1,1,1-Trichloroethane
Benzene
Carbon Tetrachloride
Toluene

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TABLE 2

POLYNUCLEAR AROMATIC HYDROCARBONS THAT CAN BE MEASURED USING USEPA METHOD TO-13

Acenaphthene
Acenaphthylene
Anthracene
Benzo(a)anthracene
Benzo(a)pyrene
Benzo(b)fluoranthene
Benzo(e)pyrene
Benzo(g,h,i)perylene
Benzo(k)fluoranthene
Chrysene
Dibenzo(a,h)anthracene
Fluoranthene
Fluorene
Indeno(1,2,3-cd)pyrene
Naphthalene
Phenanthrene
Pyrene

APPENDIX A

STANDARD OPERATING PROCEDURE
FOR FIELD SCREENING USING
PORTABLE GAS CHROMATOGRAPH

NATIONAL PRESTO INDUSTRIES, INC.
EAU CLAIRE, WISCONSIN

FIELD SCREENING PROCEDURE FOR VOLATILE COMPOUNDS IN WATER AND SOIL SAMPLES USING THE PHOTOVAC 10S50 GAS CHROMATOGRAPH

FILE #497-04

AUGUST 1991

EDER ASSOCIATES CONSULTING ENGINEERS, P.C.

Ann Arbor, Michigan
Locust Valley, New York
Madison, Wisconsin
Augusta, Georgia

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FIELD SCREENING PROCEDURE FOR VOLATILE COMPOUNDS IN WATER AND SOIL SAMPLES USING THE PHOTOVAC 10S50 GAS CHROMATOGRAPH

I. Introduction

The Photovac 10S50 Portable Gas Chromatograph is an effective tool for field screening both water and soil samples for the presence of various volatile organic compounds. It is used in situations where the contaminant(s) of interest is (are) known and limited to one or only a few different compounds. Standards containing the compound(s) suspected of being present at a particular site are prepared at known concentrations, and these are used to determine if the compound is present in the sample at detectable concentrations. The method is based on the principle that a solution contained within a confined space will come to an equilibrium with the headspace above it. If volatile compounds are contained within a water solution in an enclosed vessel, the compounds will volatilize until an equilibrium is established. In general, the concentration of the volatile compound in the headspace above the solution should be directly proportional to the concentration of the compound in the solution, as long as the temperature of the vessel and other factors remain constant.

Using this method, relative compound specific concentrations of volatiles in water and soil samples can be determined to assist in decision making and directing field work. Under certain conditions, approximate concentrations of water samples can be determined. However, laboratory analysis must be completed on some of the samples to determine the accuracy of this methodology for a site specific matrix. The steps which are followed to carry out field screening with the portable GC are outlined below.

II. Preparation of Calibration Standards

The compounds of interest are obtained in their pure or "neat" form whenever possible, or as a high concentration solution in Methanol if the neat compound is not available. Compounds are purchased from a supplier of analytical grade chemical standards.

A small amount of the neat standard is diluted in Methanol to produce a high level standard, usually on the order of 2,000 parts per million (ppm). At least two successive serial dilutions are performed into distilled water, to bring the standard into the low parts per billion (ppb) range. The lowest of these standards is used to determine the sensitivity of the GC's photoionization detector to that particular compound. This will assist in determining the approximate limit of detection possible for that compound under ideal conditions. (The limit of detection is also highly dependent upon the condition of the column; if the column becomes contaminated by a sample, the limit of detection could be greatly increased.)

Once a limit of detection has been established, a mixed calibration standard containing all of the compounds of interest at suitable levels will be prepared. The concentration levels of compounds in the mixed standard are such that the peaks of all compounds are clearly visible during a single analysis, yet not off-scale. (No gain adjustments should be necessary in order to see any of the peaks.) Sharp peaks will be adjusted in concentration so that they are in the range of half-scale to full scale in height. Broader peaks will be at least one-quarter-scale in height, but are generally less than half-scale.

A mixed calibration standard which is ten times more concentrated will also be prepared. This will be used in the case of column contamination or a loss of sensitivity of the instrument.

III. Instrument Set-Up

The field GC must be specifically set up to analyze for the compounds of interest at a particular site. The instrument settings will be determined by the sensitivity of the detector to the compounds, the compounds' elution rate, and the detection limit required. Variables include: carrier gas flow rate (typically between 5-15 milliliters (mls)/minute); column temperature (typically 30°C to 50°C); analysis time (from 2 minutes to 1 hour); signal gain setting (typically 20 to 100); and retention time window (typically 2-10 %). The settings for all of these parameters (except retention time window) are listed in the report printed out with each individual chromatogram.

The chromatographic column used is a CP-Sil 5 CB. This is a wide bore capillary column coated with a 2 micrometer (um) stationary phase of 100 % Dimethyl Polysiloxane. The carrier gas used is hydrocarbon-free (Ultra-zero) air, and it is delivered to the GC through Teflon tubing.

IV. Sample Preparation and Analysis

A. Water Samples

Water samples are placed into 40 ml VOA vials with 0.125 inch Teflon-lined silicone septa. The vials are filled with 20 mls of sample, and then placed in a constant temperature water bath set at 35°C. After 30 minutes, the samples are ready for analysis.

Immediately after a vial is removed from the water bath, 100 microliters (uls) of headspace is withdrawn from the vial through the septum with a 100 ul syringe. The sample is then injected into the GC and analyzed.

B. Soil Samples

Soil samples require more preparation than water samples

because volatile compounds can be trapped in the sample soil matrix and some organic compounds will have a tendency to adsorb to the soil. For this reason, the soil is mixed with water and glass beads to break up the soil and assist in extracting some of the compounds into the water phase, so that they are more easily volatilized.

Soil samples are collected in soil sample jars, which are filled to the top of the container. 20.0 grams of the sample is transferred to a 40 milliliter (ml) VOA vial, breaking up the soil in the process. 10.0 mls of distilled water and several glass beads are added to the vial, which is then capped and shaken for approximately 30 seconds. The vial is then placed in a constant temperature water bath set at 35°C. After 30 minutes the sample is ready to be analyzed.

Immediately after the vial is removed from the water bath, 100 uls of headspace is withdrawn from the vial through the septum, and injected into the GC.

V. Daily Procedures and Maintenance

Samples must be injected into the field GC manually; therefore, the operator will be present for each injection of sample or standard. Any problems with the instrument are detected almost immediately.

Each day the carrier gas flow rate will be set using a dual flowmeter with Teflon tubing. After the instrument and the internal column oven have been allowed time to stabilize (30 minutes), an ambient air blank will be run to determine if the column condition is acceptable. (If the ambient air appears to be contaminated, ultra-zero air can be used.) If the column appears to be contaminated, one of two field corrective measures can be implemented: the operator can try to "bake out" the column by

increasing the oven temperature and the carrier gas flow rate; or the operator can turn the signal gain to a lower setting and use a higher concentration standard. Baking out the column is the preferred method, if time allows. Increasing the signal gain will lower the sensitivity of the GC, resulting in a higher detection limit.

When the GC has warmed up and a stable baseline has been achieved, 100 ul of the calibration standard headspace will be injected (after it has been in the constant temperature water bath set at the appropriate temperature for 30 minutes). The appropriate GC library will be updated with the new retention times and peak areas of the compounds. A standard will then be run every fifteen samples, or more frequently as conditions dictate. Blank injections will also be done every fifteen samples, or more frequently if highly contaminated samples are encountered.

If a sample is highly contaminated, the headspace of the sample is diluted using Ultra-zero air. A one-liter bag made of an inert material (Tedlar) is filled with Ultra-zero air through a stainless steel valve in the bag. The volume of sample headspace necessary to give the desired dilution is then injected into the bag via a septum fitting. The mixture is allowed to equilibrate for at least one minute. A 100 ul volume is then withdrawn from the bag and injected into the GC for analysis.

Several other measures must be taken to insure reliable results. Most importantly, the integrity of the gas-tight syringes used for injections must be maintained. The syringe plungers loosen up after prolonged use; after this occurs, the teflon plunger tip must be replaced or the syringes can no longer be used. The injection port septa in the GC must be changed on a regular basis to reduce contamination and to prevent a hole from developing in the center of the septa. A hole in the septa causes an air pressure leak and affects the integrity of the chromatographic

results. Polyethylene balls are placed on the surface of the water in the water bath (in place of a lid) in order to maintain the water temperature more precisely, especially in extremely cold weather.

APPENDIX B

STANDARD OPERATING PROCEDURE FOR AMBIENT AIR SAMPLING METHODS

METHOD FOR THE DETERMINATION OF VOLATILE ORGANIC COMPOUNDS IN AMBIENT AIR BY CARBON MOLECULAR SIEVE ADSORPTION AND GAS CHROMATOGRAPHY/MASS SPECTROMETRY (GC/MS)

1. Scope

1.1 This document describes a procedure for collection and determination of selected volatile organic compounds which can be captured on carbon molecular sieve (CMS) adsorbents and determined by thermal desorption GC/MS techniques.

1.2 Compounds which can be determined by this method are nonpolar and nonreactive organics having boiling points in the range -15 to +120°C. However, not all compounds meeting these criteria can be determined. Compounds for which the performance of the method has been documented are listed in Table 1. The method may be extended to other compounds but additional validation by the user is required. This method has been extensively used in a single laboratory. Consequently, its general applicability has not been thoroughly documented.

2. Applicable Documents

2.1 ASTM Standards

D 1356 Definitions of Terms Related to Atmospheric Sampling and Analysis.

E 355 Recommended Practice for Gas Chromatography Terms and Relationships.

2.2 Other Documents

Ambient Air Studies (1,2).

U.S. EPA Technical Assistance Document (3).

3. Summary of Method

3.1 Ambient air is drawn through a cartridge containing ~0.4 of a carbon molecular sieve (CMS) adsorbent. Volatile organic compounds are captured on the adsorbent while major inorganic atmospheric constituents pass through (or are only partially retained). After sampling, the cartridge is returned to the laboratory for analysis.

3.2 Prior to analysis the cartridge is purged with 2-3 liters of pure, dry air (in the same direction as sample flow) to remove adsorbed moisture.

3.3 For analysis the cartridge is heated to 350°-400°C, under helium purge and the desorbed organic compounds are collected in a specially designed cryogenic trap. The collected organics are then flash evaporated onto a capillary column GC/MS system (held at -70°C). The individual components are identified and quantified during a temperature programmed chromatographic run.

3.4 Due to the complexity of ambient air samples, only high resolution (capillary column) GC techniques are acceptable for most applications of the method.

4. Significance

4.1 Volatile organic compounds are emitted into the atmosphere from a variety of sources including industrial and commercial facilities, hazardous waste storage and treatment facilities, etc. Many of these compounds are toxic; hence knowledge of the concentration of such materials in the ambient atmosphere is required in order to determine human health impacts.

4.2 Traditionally air monitoring methods for volatile organic compounds have relied on carbon adsorption followed by solvent desorption and GC analysis. Unfortunately, such methods are not sufficiently sensitive for ambient air monitoring, in most cases, because only a small portion of

the sample is injected onto the GC system. Recently on-line thermal desorption methods, using organic polymeric adsorbents such as Tenax® GC, have been used for ambient air monitoring. The current method uses CMS adsorbents (e.g. Spherocarb®) to capture highly volatile organics (e.g. vinyl chloride) which are not collected on Tenax®. The use of on-line thermal desorption GC/MS yields a sensitive, specific analysis procedure.

5. Definitions

Definitions used in this document and any user prepared SOPs should be consistent with ASTM D1356 (4). All abbreviations and symbols are defined with this document at the point of use.

6. Interferences

6.1 Only compounds having a mass spectrum and GC retention time similar to the compound of interest will interfere in the method. The most commonly encountered interferences are structural isomers.

6.2 Contamination of the CMS cartridge with the compound(s) of interest can be a problem in the method. The user must be careful in the preparation, storage, and handling of the cartridges through the entire process to minimize contamination.

7. Apparatus

7.1 Gas Chromatograph/Mass Spectrometry system - must be capable of subambient temperature programming. Unit mass resolution to 800 amu. Capable of scanning 30-300 amu region every 0.5-0.8 seconds. Equipped with data system for instrument control as well as data acquisition, processing and storage.

7.2 Thermal Desorption Injection Unit - Designed to accommodate CMS cartridges in use (See Figure 3) and including cryogenic trap (Figure 5) and injection valve (Carle Model 5621 or equivalent).

7.3 Sampling System - Capable of accurately and precisely drawing an air flow of 10-500 ml/minute through the CMS cartridge. (See Figure 2a or b.)

7.4 Dewar flasks - 500 mL and 5 liter.

7.5 Stopwatches.

7.6 Various pressure regulators and valves - for connecting compressed gas cylinders to GC/MS system.

7.7 Calibration gas - In aluminum cylinder. Prepared by user or vendor. For GC/MS calibration.

7.8 High pressure apparatus for preparing calibration gas cylinders (if conducted by user). Alternatively, custom prepared gas mixtures can be purchased from gas supply vendors.

7.9 Friction top can (e.g. one-gallon paint can) - With layer of activated charcoal to hold clean CMS cartridges.

7.10 Thermometer - to record ambient temperature.

7.11 Barometer (optional).

7.12 Dilution bottle - Two-liter with septum cap for standard preparation.

7.13 Teflon stirbar - 1 inch long

7.14 Gas tight syringes - 10-500 µl for standard injection onto GC/MS system and CMS cartridges.

7.15 Liquid microliter syringes - 5-50 µL for injecting neat liquid standards into dilution bottle.

7.16 Oven - 60 $\pm$ 5°C for equilibrating dilution bottle.

7.17 Magnetic stirrer.

7.18 Variable voltage transformers - (120 V and 1000 VA) and electrical connectors (or temperature controllers) to heat cartridge and cryogenic loop.

7.19 Digital pyrometer - 30 to 500°C range.

7.20 Soap bubble flow meter - 1, 10 and 100 mL calibration points.

7.21 Copper tubing (1/8 inch) and fittings for gas inlet lines.

7.22 GC column - SE-30 or alternative coating, glass capillary or fused silica.

7.23 Psychrometer (optional).

7.24 Filter holder - stainless steel or aluminum (to accommodate 1 inch diameter filter). Other sizes may be used if desired. (optional)

8. Reagents and Materials

8.1 Empty CMS cartridges - Nickel or stainless steel (See Figure 1).

8.2 CMS Adsorbent, 60/80 mesh- Spherocarb® from Analabs Inc., or equivalent.

8.3 Glasswool - silanized.

8.4 Methylene chloride - pesticide quality, or equivalent.

8.5 Gas purifier cartridge for purge and GC carrier gas containing charcoal, molecular sieves, and a drying agent. Available from various chromatography supply houses.

8.6 Helium - Ultra pure, (99.9999%) compressed gas.

8.7 Nitrogen - Ultra pure, (99.9999%) compressed gas.

8.8 Liquid nitrogen or argon (50 liter dewar).

8.9 Compressed air, if required - for operation of GC oven door.

8.10 Perfluorotributylamine (FC-43) for GC/MS calibration.

8.11 Chemical Standards - Neat compounds of interest. Highest purity available.

9. Cartridge Construction and Preparation

9.1 A suitable cartridge design in shown in Figure 1. Alternate designs have been reported (1) and are acceptable, provided the user documents their performance. The design shown in Figure 1 has a built-in heater assembly. Many users may choose to replace this heater design with a suitable separate heating block or oven to simplify the cartridge design.

9.2 The cartridge is assembled as shown in Figure 1 using standard 0.25 inch O.D. tubing (stainless steel or nickel), 1/4 inch to 1/8 inch reducing unions, 1/8 inch nuts, ferrules, and endcaps. These parts are rinsed with methylene chloride and heated at 250°C for 1 hour prior to assembly.

9.3 The thermocouple bead is fixed to the cartridge body, and insulated with a layer of Teflon tape. The heater wire (constructed from a length of thermocouple wire) is wound around the length of the cartridge and wrapped with Teflon tape to secure the wire in place. The cartridge is then wrapped with woven silica fiber insulation (Zetex or equivalent). Finally the entire assembly is wrapped with fiber glass tape.

9.4 After assembly one end of the cartridge is marked with a serial number to designate the cartridge inlet during sample collection.

9.5 The cartridges are then packed with ~0.4 grams of CMS adsorbent. Glasswool plugs (~0.5 inches long) are placed at each end of the cartridge to hold the adsorbent firmly in place. Care must be taken to insure that no strands of glasswool extend outside the tubing, thus causing leakage in the compression endfittings. After loading the endfittings (reducing unions and end caps) are tightened onto the cartridge.

9.6 The cartridges are conditioned for initial use by heating at 400°C overnight (at least 16 hours) with a 100 mL/minute purge of pure nitrogen. Reused cartridges need only to be heated for 4 hours and should be reanalyzed before use to ensure complete desorption of impurities.

9.7 For cartridge conditioning ultra-pure nitrogen gas is passed through a gas purifier to remove oxygen,moisture and organic contaminants. The nitrogen supply is connected to the unmarked end of the cartridge and the flow adjusted to ~50 mL/minute using a needle valve. The gas flow from the inlet (marked) end of the cartridge is vented to the atmosphere.

9.8 The cartridge thermocouple lead is connected to a pyrometer and the heater lead is connected to a variable voltage transformer (Variac) set at 0 V. The voltage on the Variac is increased to ~15 V and adjusted over a 3-4 minute period to stabilize the cartridge temperature at 380-400°C.

9.9 After 10-16 hours of heating (for new cartridges) the Variac is turned off and the cartridge is allowed to cool to ~30°C, under continuing nitrogen flow.

9.10 The exit end of the cartridge is capped and then the entire cartridge is removed from the flow line and the other endcap immediately installed. The cartridges are then placed in a metal friction top (paint) can containing ~2 inches of granulated activated charcoal (to prevent contamination of the cartridges during storage) in the bottom, beneath a retaining screen. Clean paper tissues (e.g. Kimwipes) are placed in can to avoid damage to the cartridges during shipment.

9.11 Cartridges are stored in the metal can at all times except when in use. Adhesives initially present in the cartridge insulating materials are "burnt off" during initial conditioning. Therefore, unconditioned cartridges should not be placed in the metal can since they may contaminate the other cartridges.

9.12 Cartridges are conditioned within two weeks of use. A blank from each set of cartridges is analyzed prior to use in field

sampling. If an acceptable blank level is achieved, that batch of cartridges (including the cartridge serving as the blank) can be used for field sampling.

10. Sampling

10.1 Flow Rate and Total Volume Selection

10.1.1 Each compound has a characteristic retention volume (liters of air per unit weight of adsorbent). However, all of the compounds listed in Table 1 have retention volumes (at 37°C) in excess of 100 liters/cartridge (0.4 gram CMS cartridge) except vinyl chloride for which the value is ~30 liters/cartridge. Consequently, if vinyl chloride or similarly volatile compounds are of concern the maximum allowable sampling volume is approximately 20 liters. If such highly volatile compounds are not of concern, samples as large as 100 liters can be collected.

10.1.2 To calculate the maximum allowable sampling flow rate the following equation can be used:

$$Q_{Max} = \frac{V_{Max}}{t} \times 1000$$

where

Q_{Max} is the calculated maximum sampling rate in mL/minute.

t is the desired sampling time in minutes.

V_{Max} is the maximum allowable total volume based on the discussion in 10.1.1.

10.1.3 For the cartridge design shown in Figure 1 Q_{Max} should be between 20 and 500 mL/minute. If Q_{Max} lies outside this range the sampling time or total sampling volume must be adjusted so that this criterion is achieved.

10.1.4 The flow rate calculated in 10.1.3 defines the maximum allowable flow rate. In general, the user should collect additional samples in parallel, at successive 2- to 4-fold lower flow rates. This practice serves as a quality control procedure to check on component breakthrough and related sampling and adsorption problems, and is further discussed in the literature (5).

10.2 Sample Collection

10.2.1 Collection of an accurately known volume of air is critical to the accuracy of the results. For this reason the use of mass flow controllers, rather than conventional needle valves or orifices is highly recommended, especially at low flow rates (e.g. less than 100 milliliters/minute). Figure 2a illustrates a sampling system based on mass flow controllers which readily allows for collection of parallel samples. Figure 2b shows a commercially available sampling system based on needle valve flow controllers.

10.2.2 Prior to sample collection the sampling flow rate is calibrated near the value used for sampling, with a "dummy" CMS cartridge in place. Generally calibration is accomplished using a soap bubble flow meter or calibrated wet test meter connected to the flow exit, assuming the entire flow system is sealed. ASTM Method D 3686 (4) describes an appropriate calibration scheme, not requiring a sealed flow system downstream of the pump.

10.2.3 The flow rate should be checked before and after each sample collection. Ideally, a rotometer or mass flow meter should be included in the sampling system to allow periodic observation of the flow rate without disrupting the sampling process.

10.2.4 To collect an air sample the cartridges are removed from the sealed container just prior to initiation of the collection process.

10.2.5 The exit (unmarked) end of the cartridge is connected to the sampling apparatus. The endcap is left on the sample inlet and the entire system is leak checked by activating the sampling pump and observing that no flow is obtained over a 1 minute period. The sampling pump is then shut off.

10.2.6 The endcap is removed from the cartridge, a particulate filter and holder are placed on the inlet end of the cartridge, and the sampling pump is started. In many situations a particulate filter is not necessary since the compounds of interest are in the vapor state. However, if, large amounts of particulate matter are encountered, the filter may be useful to prevent contamination of the cartridge. The following parameters are recorded on an appropriate data sheet (Figure 4): date, sampling location, time, ambient temperature, barometric pressure, relative humidity, dry gas meter reading (if applicable), flow rate, rotometer reading (if applicable), cartridge number, pump, and dry gas meter serial number.

10.2.7 The samples are collected for the desired time, periodically recording the variables listed above. At the end of the sampling period the parameters listed in 10.2.6 are recorded and the flow rate is checked. If the flows at the beginning and end of the sampling period differ by more than 10%, the cartridge should be marked as suspect.

10.2.8 The cartridges are removed (one at a time), the endcaps are replaced, and the cartridges are placed into the original container. The friction top can is sealed and packaged for immediate shipment to the analytical laboratory.

10.2.9 The average sample rate is calculated and recorded for each cartridge according to the following equation:

$$Q_A = \frac{Q_1 + Q_2 + \ldots Q_N}{N}$$

where

Q_A = Average flow rate in ml/minute.
$Q_1, Q_2, \ldots Q_N$ = Flow rates determined at beginning, end, and immediate points during sampling.

N = Number of points averaged.

10.2.10 The total volumetric flow is obtained directly from the dry gas meter or calculated and recorded for each cartridge using the following equation:

$$V_m = \frac{T \times Q_A}{1000}$$

where

V_m = Total volume sampled in liters at measured temperature and pressure.
T = Sampling time = $T_2 - T_1$, minutes.

10.2.11 The total volume sampled (V_s) at standard conditions, 760 mm Hg and 25°C, is calculated from the following equation:

$$V_s = V_m \times \frac{Pa}{760} \times \frac{298}{273 + ta}$$

where

Pa = Average barometric pressure, mm Hg
ta = Average ambient temperature, °C.

11. Sample Analysis

11.1 Sample Purging

11.1.1 Prior to analysis all samples are purged at room temperature with pure, dry air or nitrogen to remove water vapor. Purging is accomplished as described in 9.7 except that the gas flow is in the same direction as sample flow (i.e. marked end of cartridge is connected to the flow system).

11.1.2 The sample is purged at 500 mL/minute for 5 minutes. After purging the endcaps are immediately replaced. The cartridges are returned to the metal can or analyzed immediately.

11.1.3 If very humid air is being sampled the purge time may be increased to more efficiently remove water vapor. However, the sum of sample volume and purge volume must be less than 75% of the retention volume for the most volatile component of interest.

11.2 GC/MS Setup

11.2.1 Considerable variation from one laboratory to another is expected in terms of instrument configuration. Therefore, each laboratory must be responsible for verifying that their particular system yields satisfactory results. Section 14 discusses specific performance criteria which should be met.

11.2.2 A block diagram of the analytical system required for analysis of CMS cartridges is depicted in Figure 3. The thermal desorption system must be designed to accommodate the particular cartridge configuration. For the CMS cartridge design shown in Figure 1, the cartridge heating is accomplished as described in 9.8. The use of a desorption oven, in conjunction with a

simplier cartridge design is also acceptable. Exposure of the sample to metal surfaces should be minimized and only stainless steel or nickel should be employed. The volume of tubing leading from the cartridge to the GC column must be minimized and all areas must be well-swept by helium carrier gas.

11.2.3 The GC column oven must be capable of being cooled to -70°C and subsequently temperature programmed to 150°C.

11.2.4 The specific GC column and temperature program employed will be dependent on the compounds of interest. Appropriate conditions are described in the literature (2). In general, a nonpolar stationary phase (e.g. SE-30, OV-1) temperature programmed from -70 to 150°C at 8°/minute will be suitable. Fused silica, bonded-phase columns are preferable to glass columns since they are more rugged and can be inserted directly into the MS ion source, thereby eliminating the need for a GC/MS transfer line. Fused silica columns are also more readily connected to the GC injection valve (Figure 3). A drawback of fused silica, bonded-phase columns is the lower capacity compared to coated, glass capillary columns. In most cases the column capacity will be less than 1 microgram injected for fused silica columns.

11.2.5 Capillary column dimensions of 0.3 mm ID and 50 meters long are generally appropriate although shorter lengths may be sufficient in many cases.

11.2.6 Prior to instrument calibration or sample analysis the GC/MS system is assembled as shown in Figure 3. Helium purge flow (through the cartridge) and carrier flow are set at approximately 50 mL/minute and 2-3 mL/minute respectively. When a cartridge is not in place a union is placed in the helium purge line to ensure a continuous inert gas flow through the injection loop.

11.2.7 Once the column and other system components are assembled and the various flows established the column temperature is increased to 250°C for approximately four hours (or overnight if desired) to condition the column.

11.2.8 The MS and data system are set up according to the manufacturer's instructions. Electron impact ionization (70eV) and an electron multiplier gain of approximately 5×10^4 should be employed. Once the entire GC/MS system has been setup the system is calibrated as described in Section 11.3. The user should prepare a detailed standard operating procedure (SOP) describing this process for the particular instrument being used.

11.3 GC/MS Calibration

11.3.1 Tuning and mass standardization of the MS system is performed according to manufacturer's instructions and relevant user prepared SOPs. Perfluorotributylamine (FC-43) should generally be employed as the reference compound. The material is introduced directly into the ion source through a molecular leak. The instrumental parameters (e.g., lens voltages, resolution, etc.) should be adjusted to give the relative ion abundances shown in Table 2, as well as acceptable resolution and peak shape. If these approximate relative abundances cannot be achieved, the ion source may require cleaning according to manufacturer's instructions. In the event that the user's instrument cannot achieve these relative ion abundances, but is otherwise operating properly, the user may adopt another set of relative abundances as performance criteria. However, these alternate values must be repeatable on a day-to-day basis.

11.3.2 After the mass standardization and tuning process has been completed and the appropriate values entered into the data system, the user should then calibrate the entire GC/MS system by introducing known quantities of the components of interest into the system. Three alternate procedures may be employed for the calibration process including 1) direct injection of dilute vapor phase standards, prepared in a dilution bottle or compressed gas cylinder, onto the GC column, 2) injection of dilute vapor phase standards into a flowing inert gas stream directed onto a CMS cartridge, and 3) introduction of permeation or diffusion tube standards onto a CMS cartridge. Direct injection of a compressed gas cylinder (aluminum) standard containing trace levels of the compounds of interest has been found to be the most convenient practice since such standards are stable over a several month period. The standards preparation processes for the various approaches are described in Section 13. The following paragraphs describe the instrument calibration process for these approaches.

11.3.3 If the system is to be calibrated by direct injection of a vapor phase standard, the standard, in either a compressed gas cylinder or dilution flask, is obtained as described in Section 13. The MS and data system are setup for acquisition, but the ionizer filament is shut off. The GC column oven is cooled to -70°C, the injection valve is placed in the load mode, and the cryogenic loop is immersed in liquid nitrogen or liquid argon. Liquid argon is required for standards prepared in nitrogen or air, but not for standards prepared in helium. A known volume of the standard (10-1000 mL) is injected through the cryogenic loop at a rate of 10-100 mL/minute.

11.3.4 Immediately after loading the vapor phase standard, the injection valve is placed in the inject mode, the GC program and system clock are started, and the cryogenic loop is heated to 60°C by applying voltage (15-20 volts) to the thermocouple wire heater surrounding the loop. The voltage is adjusted to maintain a loop temperature of 60°C. An automatic temperature controller can be used in place of the manual control system. After elution of unretained components (~3 minutes after injection) the ionizer filament is turned on and data acquisition is initiated. The helium purge line (set at 50 mL/minute) is connected to the injection valve and the valve is returned to the load mode. The loop temperature is increased to 150 °C, with helium purge, and held at this temperature until the next sample is to be loaded.

11.3.5 After the last component of interest has eluted, acquisition is terminated and the data is processed as described in Section 11.3.8. The standard injection process is repeated using different standard concentrations and/or volumes to cover the analytical range of interest.

11.3.6 If the system is to be calibrated by analysis of standard CMS cartridges, a series of cartridges is prepared as described in Sections 13.2 or 13.3. Prior to analysis the cartridges are stored (no longer than 48 hours) as described in Section 9.10. For analysis the injection valve is placed in the load mode and the cryogenic loop is immersed in liquid nitrogen (or liquid argon if desired). The CMS cartridge is installed in the helium purge line (set at 50 mL/minute) so that the helium flow through the cartridge is opposite to the direction of sample flow and the purge gas is directed through the cryogenic loop and vented to the

atmosphere. The CMS cartridge is heated to 370-400°C and maintained at this temperature for 10 minutes (using the temperature control process described in Section 9.8). During the desorption period, the GC column oven is cooled to -70°C and the MS and data system are setup for acquisition, but the ionizer filament is turned off.

11.3.7 At the end of the 10 minute desorption period, the analytical process described in Sections 11.3.4 and 11.3.5 is conducted. During the GC/MS analysis heating of the CMS cartridge is discontinued. Helium flow is maintained through the CMS cartridge and cryogenic loop until the cartridge has cooled to room temperature. At that time, the cryogenic loop is allowed to cool to room temperature and the system is ready for further cartridge analysis. Helium flow is maintained through the cryogenic loop at all times, except during the installation or removal of a CMS cartridge, to minimize contamination of the loop.

11.3.8 Data processing for instrument calibration involves determining retention times, and integrated characteristic ion intensities for each of the compounds of interest. In addition, for at least one chromatographic run, the individual mass spectra should be inspected and compared to reference spectra to ensure proper instrumental performance. Since the steps involved in data processing are highly instrument specific, the user should prepare a SOP describing the process for individual use. Overall performance criteria for instrument calibration are provided in Section 14. If these criteria are not achieved, the user should refine the instrumental parameters and/or operating procedures to meet these criteria.

11.4 Sample Analysis

11.4.1 The sample analysis is identical to that described in Sections 11.3.6 and 11.3.7 for the analysis of standard CMS cartridges.

11.4.2 Data processing for sample data generally involves 1) qualitatively determining the presence or absence of each component of interest on the basis of a set of characteristic ions and the retention time using a reversed-search software routine, 2) quantification of each identified component by integrating the intensity of a characteristic ion and comparing the value to that of the calibration standard, and 3) tentative identification of other components observed using a forward (library) search software routine. As for other user specific processes, a SOP should be prepared describing the specific operations for each individual laboratory.

12. Calculations

12.1 Calibration Response Factors

12.1.1 Data from calibration standards is used to calculate a response factor for each component of interest. Ideally the process involves analysis of at least three calibration levels of each component during a given day and determination of the response factor (area/nanogram injected) from the linear least squares fit of a plot of nanograms injected versus area (for the characteristic ion). In general, quantities of components greater than 1,000 nanograms should not be injected because of column overloading and/or MS response nonlinearity.

12.1.2 In practice the daily routine may not always allow analysis of three such calibration standards. In this situation calibration data from consecutive days may be pooled to yield a response factor, provided that analysis of replicate standards of the same concentration are shown to agree within 20% on the consecutive days. In all cases one given standard

concentration, near the midpoint of the analytical range of interest, should be injected at least once each day to determine day-to-day precision of response factors.

12.1.3 Since substantial nonlinearity may be present in the calibration curve, a nonlinear least squares fit (e.g. quadratic) should be employed. This process involves fitting the data to the following equation:

$$Y = A + BX + CX^2$$

where

Y = peak area
X = quantity of component injected nanograms
A, B, and C are coefficients in the equation.

12.2 Analyte Concentrations

12.2.1 Analyte quantities on a sample cartridge are calculated from the following equation:

$$Y_A = A + BX_A + CX^2$$

where Y_A is the area of the analyte characteristic ion for the sample cartridge.
X_A is the calculated quantity of analyte on the sample cartridge, in nanograms.
A, B, and C are the coefficients calculated from the calibration curve described in Section 12.1.3.

12.2.2 If instrumental response is essentially linear over the concentration range of interest, a linear equation (C=0 in the equation above) can be employed.

12.2.3 Concentration of analyte in the original air sample is calculated from the following equation:

$$C_A = \frac{X_A}{V_s}$$

where

C_A is the calculated concentration of analyte in ng/L.

V_s and X_A are as previously defined in Section 10.2. and 12.2.1, respectively.

13. Standard Preparation

13.1 Standards for Direct Injection

13.1.1 Standards for direct injection can be prepared in compressed gas cylinders or in dilution vessels. The dilution flask protocol has been described in detail in another method and is not repeated here (6). For the CMS method where only volatile compounds (boiling point <120°C) are of concern, the preparation of dilute standards in 15 liter aluminum compressed gas cylinders has been found to be most convenient. These standards are generally stable over at least a 3-4 month period and in some cases can be purchased from commercial suppliers on a custom prepared basis.

13.1.2 Preparation of compressed gas cylinders requires working with high pressure tubing and fittings, thus requiring a user prepared SOP which ensures that adequate safety precautions are taken. Basically, the preparation process involves injecting a predetermined amount of neat liquid or gas into an empty high pressure cylinder of known volume, using gas flow into the cylinder to complete the transfer.

The cylinder is then pressurized to a given value (500-1000 psi). The final cylinder pressure must be determined using a high precision gauge after the cylinder has thermally equilibrated for a 1-2 hour period after filling.

13.1.2 The concentration of components in the cylinder standard should be determined by comparison with National Bureau of Standards reference standards (e.g. SRM 1805-benzene in nitrogen) when available.

13.1.3 The theoretical concentration (at 25°C and 760 mm pressure) for preparation of cylinder standards can be calculated using the following equation:

$$C_T = \frac{V_I \times d}{V_c} \times \frac{14.7}{P_c + 14.7} \times 24.4 \times 1000$$

where C_T is the component concentration, in ng/mL at 25°C and 760 mm Hg pressure.

V_I is the volume of neat liquid component injected, in µL.

V_c is the internal volume of the cylinder, in L.

d is the density of the neat liquid component, in g/mL.

P_c is the final pressure of the cylinder standards, in pounds per square inch gauge (psig).

13.2 Preparation of Spiked Traps by Vapor Phase Injection

This process involves preparation of a dilution flask or compressed gas cylinder containing the desired concentrations of the compound(s) of interest and injecting the desired volume of vapor into a flowing gas stream which is directed onto a clean CMS cartridge. The procedure is described in detail in another method within the Compendium (6) and will not be repeated here.

13.3 Preparation of Spiked Traps Using Permeation or Diffusion Tubes

13.3.1 A flowing stream of inert gas containing known amounts of each compound of interest is generated according to ASTM Method D3609 (4). Note that a method of accurately maintaining temperature within ± 0.1°C is required and the system generally must be equilibrated for at least 48 hours before use.

13.3.2 An accurately known volume of the standard gas stream (usually 0.1-1 liter) is drawn through a clean CMS cartridge using the sampling system described in Section 10.2.1, or a similar system. However, if mass flow controllers are employed, they must be calibrated for the carrier gas used in Section 13.3.1 (usually nitrogen). Use of air as the carrier gas for permeation systems is not recommended, unless the compounds of interest are known to be highly stable in air.

13.3.3 The spiked traps are then stored or immediately analyzed as in Sections 11.3.6 and 11.3.7.

14. Performance Criteria and Quality Assurance

This section summarizes the quality assurance (QA) measures and provides guidance concerning performance criteria which should be achieved within each laboratory. In many cases the specific QA procedures have been described within the appropriate section describing the particular activity (e.g. parallel sampling).

14.1 Standard Operating Procedures (SOPs)

14.1.1 Each user should generate SOPs describing the following activities as accomplished in their laboratory: 1) assembly, calibration and operation of the sampling system, 2) preparation, handling and storage of CMS cartridges, 3) assembly and operation of GC/MS system including the thermal desorption apparatus and data system, and 4) all aspects of data recording and processing.

14.1.2 SOPs should provide specific stepwise instructions and should be readily available to, and understood by the laboratory personnel conducting the work.

14.2 CMS Cartridge Preparation

14.2.1 Each batch of CMS cartridges, prepared as described in Section 9, should be checked for contamination by analyzing one cartridge, immediately after preparation. While analysis can be accomplished by GC/MS, many laboratories may chose to use GC/FID due to logistical and cost considerations.

14.2.2 Analysis by GC/FID is accomplished as described for GC/MS (Section 11) except for use of FID detection.

14.2.3 While acceptance criteria can vary depending on the components of interest, at a minimum the clean cartridge should be demonstrated to contain less than one-fourth of the minimum level of interest for each component. For most compounds the blank level should be less than 10 nanograms per cartridge in order to be acceptable. More rigid criteria may be adopted, if necessary, within a specific laboratory. If a cartridge does not meet these acceptance criteria, the entire lot should be rejected.

14.3 Sample Collection

14.3.1 During each sampling event at least one clean cartridge will accompany the samples to the field and back to the laboratory, having been placed in the sampler but without sampling air, to serve as a field blank. The average amount of material found on the field blank cartridges may be subtracted from the amount found on the actual samples. However, if the blank level is greater than

25% of the sample amount, data for that component must be identified as suspect.

14.3.2 During each sampling event at least one set of parallel samples (two or more samples collected simultaneously) should be collected, preferably at different flow rates as described in Section 10.1.4. If agreement between parallel samples is not generally within ±25% the user should collect parallel samples on a much more frequent basis (perhaps for all sampling points). If a trend of lower apparent concentrations with increasing flow rate is observed for a set of parallel samples one should consider using a reduced sampling rate and longer sampling interval, if possible. If this practice does not improve the reproducibility further evaluation of the method performance for the compound of interest might be required.

14.3.3 Backup cartridges (two cartridges in series) should be collected with each sampling event. Backup cartridges should contain less than 10% of the amount of components of interest found in the front cartridges, or be equivalent to the blank cartridge level, whichever is greater.

14.4 GC/MS Analysis

14.4.1 Performance criteria for MS tuning and mass standardization have been discussed in Section 11.2 and Table 2. Additional criteria can be used by the laboratory, if desired. The following sections provide performance guidance and suggested criteria for determining the acceptability of the GC/MS system.

14.4.2 Chromatographic efficiency should be evaluated daily by the injection of calibration standards. A reference compound(s) should be chosen from the calibration standard and plotted on an expanded time scale so that its width at 10% of the peak height can be calculated, as shown in Figure 6. The width of the peak at 10% height should not exceed 10 seconds. More stringent criteria may be required for certain applications. The asymmetry factor (see Figure 6) should be between 0.8 and 2.0. The user should also evaluate chromatographic performance for any polar or reactive compounds of interest, using the process described above. If peaks are observed that exceed the peak width or asymmetry factor criteria above, one should inspect the entire system to determine if unswept zones or cold spots are present in any of the fittings or tubing and/or if replacement of the GC column is required. Some laboratories may chose to evaluate column performance separately by direct injection of a test mixture onto the GC column. Suitable schemes for column evaluation have been reported in the literature (7).

14.4.3 The detection limit for each component is calculated from the data obtained for calibration standards. The detection limit is defined as

$$DL = A + 3.3S$$

where

DL is the calculated detection limit in nanograms injected.

A is the intercept calculated in Section 12.1.3.

S is the standard deviation of replicate determinations of the lowest level standard (at least three such determinations are required). The lowest

level standard should yield a signal to noise ratio (from the total ion current response) of approximately 5.

14.4.4 The relative standard deviation for replicate analyses of cartridges spiked at approximately 10 times the detection limit should be 20% or less. Day to day relative standard deviation for replicate cartridges should be 25% or less.

14.4.5 A useful performance evaluation step is the use of an internal standard to track system performance. This is accomplished by spiking each cartridge, including blank, sample, and calibration cartridges with approximately 100 nanograms of a compound not generally present is ambient air (e.g. perfluorotoluene). Spiking is readily accomplished using the procedure outlined in Section 13.2, using a compressed gas standard. The integrated ion intensity for this compound helps to identify problems with a specific sample. In general the user should calculate the standard deviation of the internal standard response for a given set of samples analyzed under identical tuning and calibration conditions. Any sample giving a value greater than $\pm$ 2 standard deviations from the mean (calculated excluding that particular sample) should be identified as suspect. Any marked change in internal standard response may indicate a need for instrument recalibration.

14.5 Method Precision and Recovery

14.5.1 Recovery and precision data for selected volatile organic compounds are presented in Table 1. These data were obtained using ambient air, spiked with known amounts of the compounds in a dynamic mixing system (2).

14.5.2 The data in Table 1 indicate that in general recoveries better than 75% and precision (relative standard deviations) of 15-20% can be obtain .. However, selected compounds (e.g. carbon tetrachloride and

benzene) will have poorer precision and/or recovery. The user must check recovery and precision for any compounds for which quantitative data are needed.

References

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2. Riggin R. M. and L. E. Slivon. Determination of Volatile Organic Compounds in Ambient Air Using Carbon Molecular Sieve Adsorbants, Special Report on Contract 68-02-3745 (WA-7), U.S. Environmental Protection Agency, Research Triangle Park, North Carolina, September, 1983.

3. Riggin, R. M., "Technical Assistance Document for Sampling and Analysis of Toxic Organic Compounds in Ambient Air", EPA-600/4-83-027, U.S. Environmental Protection Agency, Research Triangle Park, North Carolina, 1983.

4. Annual Book of ASTM Standards, Part 11.03, "Atmospheric Analysis: Occupational Health and Safety", American Society for Testing and Materials, 1983.

5. Walling, J. F., Berkley, R. E., Swanson, D. H., and Toth, F. J. "Sampling Air for Gaseous Organic Chemical-Applications to Tenax", EPA-600/7-54-82-059, U.S. Environmental Protection Agency, Research Triangle Park, North Carolina, 1982.

6. This Methods Compendium - Tenax Method (TO 1).

7. Grob, K., Jr., Grob, G., and Grob, K., "Comprehensive Standardized Quality Test for Glass Capillary Columns", J. Chromatog., 156 1-20, 1978.

TABLE 1. VOLATILE ORGANIC COMPOUNDS FOR WHICH THE CMS ADSORPTION METHOD HAS BEEN EVALUATED

Compound	Retention Time, Minutes[a]	Characteristic Mass Fragment Used For Quantification	Method Performance Data[b]		
			Concentration, ng/L	Percent Recovery	Standard Deviation
Vinyl Chloride	6.3	62	17	74	19
Acrylonitrile	10.8	53	20	85	18
Vinylidene Chloride	10.9	96	36	94	19
Methylene Chloride	11.3	84	28	93	16
Allyl Chloride	11.4	76	32	72	19
Chloroform	13.8	83	89	91	12
1,2-Dichloroethane	14.5	62	37	85	11
1,1,1-Trichloroethane	14.7	97	100	75	9.1
Benzene	15.4	78	15	140	37
Carbon Tetrachloride	15.5	117	86	55	2.9
Toluene	18.0	91	4.1	98	5.4

a) GC conditions as follows:

Column - Hewlett Packard, crosslinked methyl silicone, 0.32 mm ID x 50 mm long, thick film, fused silica.

Temperature Program - 70°C for 2 minutes then increased at 8°C/minute to 120°C.

b) From Reference 2. For spiked ambient air.

TABLE 2. SUGGESTED PERFORMANCE CRITERIA FOR RELATIVE ION ABUNDANCES FROM FC-43 MASS CALIBRATION

M/E	% Relative Abundance
51	1.8 ± 0.5
69	100
100	12.0 ± 1.5
119	12.0 ± 1.5
131	35.0 ± 3.5
169	3.0 ± 0.4
219	24.0 ± 2.5
264	3.7 ± 0.4
314	0.25 ± 0.1

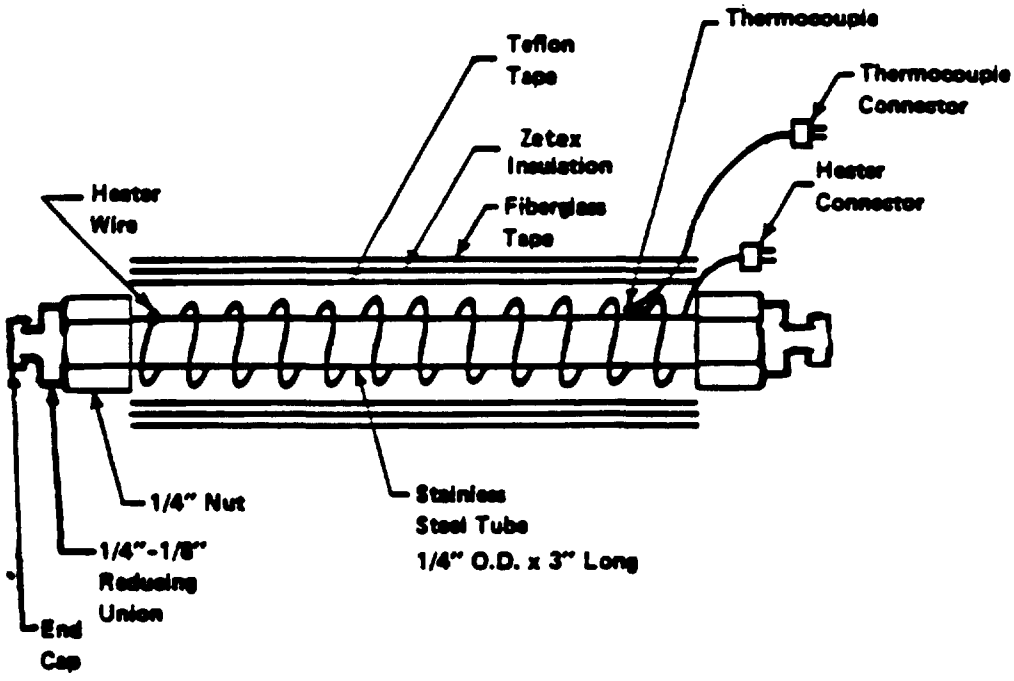
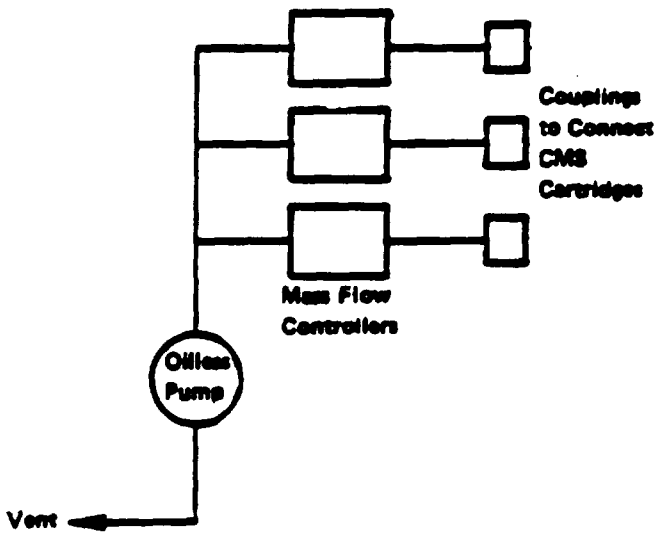
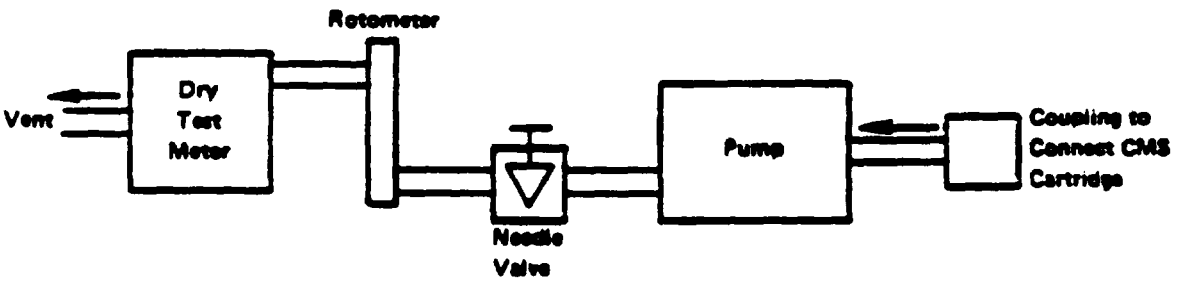


FIGURE 1. DIAGRAM SHOWING CARBON MOLECULAR SIEVE TRAP (CMS) CONSTRUCTION



(a) Mass Flow Control



(b) Needle Valve Control

FIGURE 2. TYPICAL SAMPLING SYSTEM CONFIGURATIONS

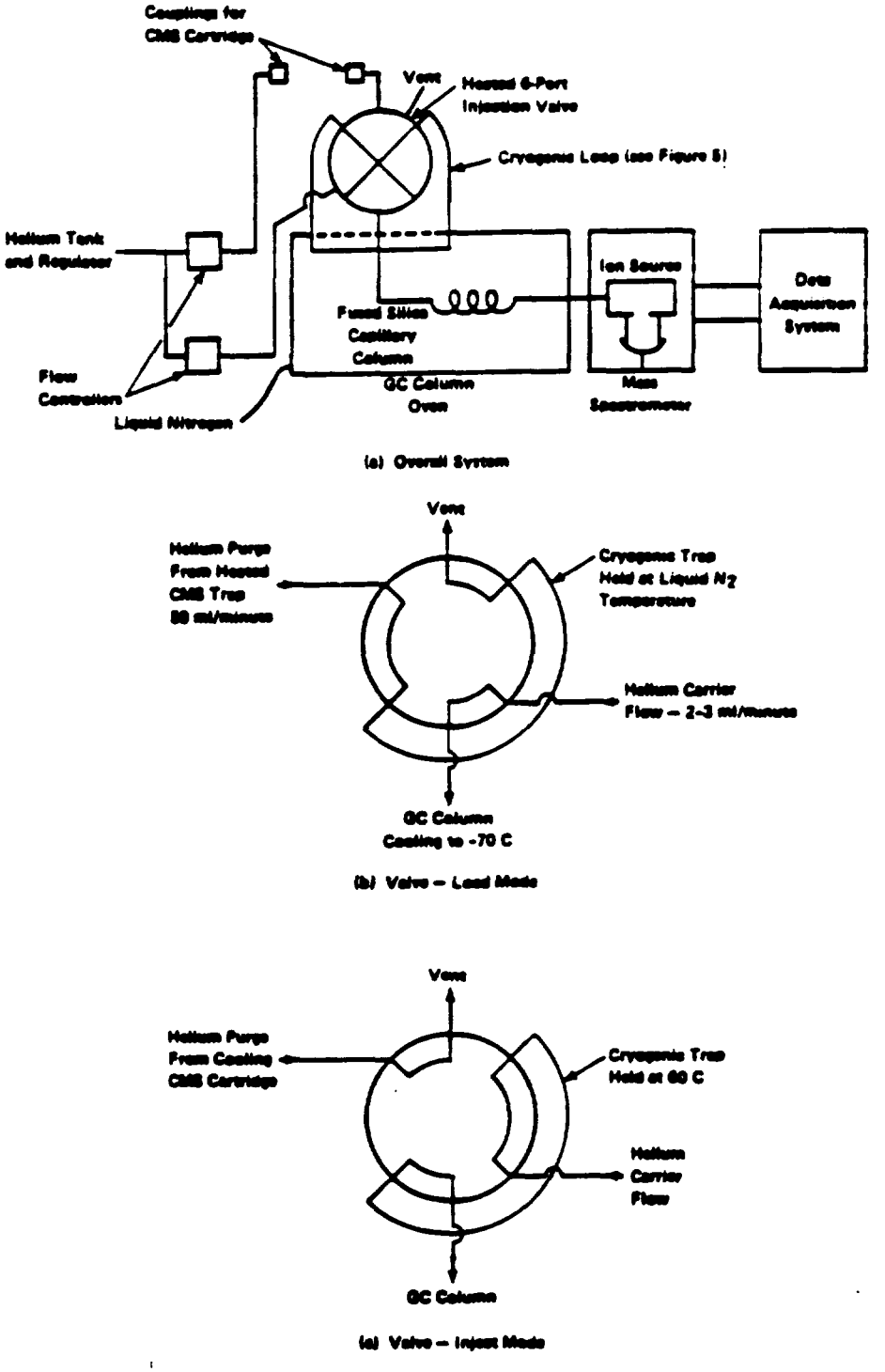


FIGURE 3. GC/MS ANALYSIS SYSTEM FOR CMS CARTRIDGES

SAMPLING DATA SHEET
(One Sample Per Data Sheet)

PROJECT: _____ DATE(S) SAMPLED: _____

SITE: _____ TIME PERIOD SAMPLED: _____

LOCATION: _____ OPERATOR: _____

INSTRUMENT MODEL NO: _____ CALIBRATED BY: _____

PUMP SERIAL NO: _____

SAMPLING DATA

Sample Number: _____

Start Time: _____ Stop Time: _____

Time	Dry Gas Meter Reading	Rotameter Reading	Flow Rate,*Q ml/Min	Ambient Temperature °C	Barometric Pressure, mmHg	Relative Humidity, %	Comments
1.							
2.							
3.							
4.							
N.							

Total Volume Data**

V_m = (Final - Initial) Dry Gas Meter Reading, or = _____ Liters

$$\frac{Q_1 + Q_2 + Q_3 \ldots Q_N}{N} \times \frac{1}{1000 \times (\text{Sampling Time in Minutes})} = \_\_\_\_\_ \text{ Liters}$$

* Flowrate from rotameter or soap bubble calibrator (specify which).
** Use data from dry gas meter if available.

FIGURE 4. EXAMPLE SAMPLING DATA SHEET

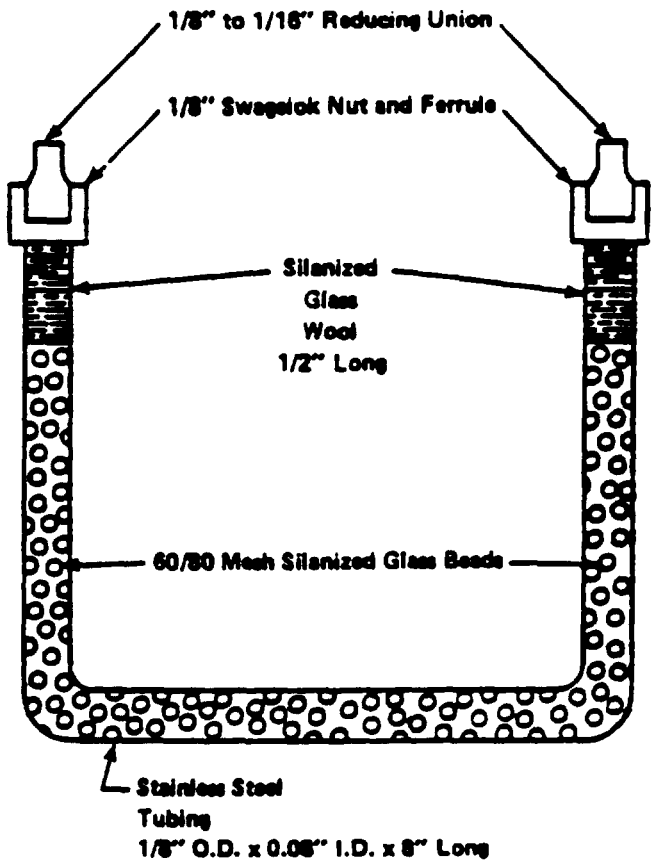
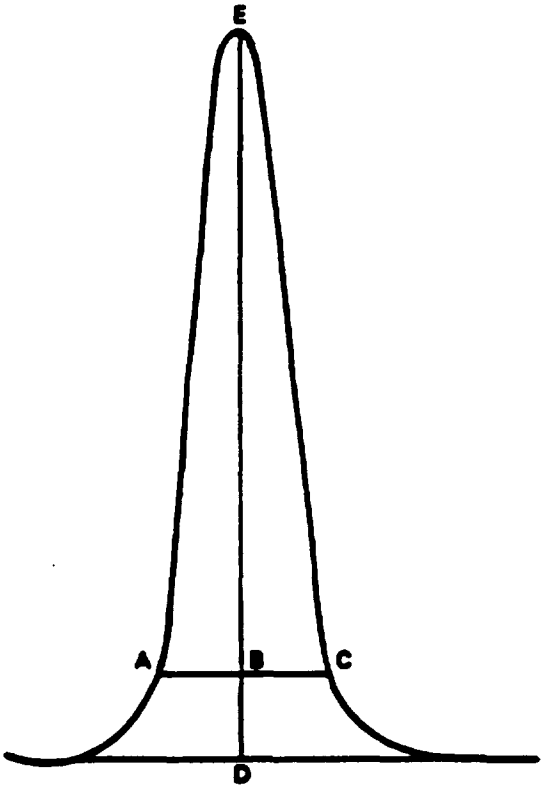


FIGURE 5. CRYOGENIC TRAP DESIGN



$$\text{Asymmetry Factor} = \frac{BC}{AB}$$

Example Calculation:

Peak Height = DE = 100 mm
10% Peak Height = BD = 10 mm
Peak Width at 10% Peak Height = AC = 23 mm
AB = 11 mm
BC = 12 mm

Therefore: Asymmetry Factor = $\frac{12}{11} = 1.1$

FIGURE 6. PEAK ASYMMETRY CALCULATION

METHOD TO-13 -/

THE DETERMINATION OF BENZO(a)PYRENE [B(a)P] AND OTHER POLYNUCLEAR AROMATIC HYDROCARBONS (PAHs) IN AMBIENT AIR USING GAS CHROMATOGRAPHIC (GC) AND HIGH PERFORMANCE LIQUID CHROMATOGRAPHIC (HPLC) ANALYSIS

1. Scope

1.1 Polynuclear aromatic hydrocarbons (PAHs) have received increased attention in recent years in air pollution studies because some of these compounds are highly carcinogenic or mutagenic. In particular, benzo[a]pyrene (B[a]P) has been identified as being highly carcinogenic. To understand the extent of human exposure to B[a]P, and other PAHs, a reliable sampling and analytical method has been established. This document describes a sampling and analysis procedure for B[a]P and other PAHs involving a combination quartz filter/adsorbent cartridge with subsequent analysis by gas chromatography (GC) with flame ionization (FI) and mass spectrometry (MS) detection (GC/FI and GC/MS) or high resolution liquid chromatography (HPLC). The analytical methods are a modification of EPA Test Method 610 and 625, Methods for Organic Chemical Analysis of Municipal and Industrial Wastewater, and Methods 8000, 8270, and 8310, Test Methods for Evaluation of Solid Waste.

1.2 Fluorescence methods were among the very first methods used for detection of B[a]P and other PAHs as a carcinogenic constituent of coal tar (1-7). Fluorescent methods are capable of measuring subnanogram quantities of PAHs, but tend to be fairly non-selective. The normal spectra obtained tended to be intense and lacked resolution. Efforts to overcome this difficulty led to the use of ultraviolet (UV) absorption spectroscopy as the detection method coupled with pre-speciated techniques involving liquid chromatography (LC) and thin layer chromatography (TLC) to isolate specific PAHs, particularly B[a]P (8). As with fluorescence spectroscopy, the individual spectra for various PAHs are unique, although portions of spectra for different compounds may be the same. As with fluoresence techniques, the possibility of spectra overlap required complete separation of sample components to insure accurate measurement of component levels. Hence, the use of UV absorption coupled

with pre-speciation involving LC and TLC and fluorescence spectroscopy has declined and is now being replaced with the more sensitive high performance liquid chromatography (9) with UV/fluorescence detection and highly sensitive and specific gas chromatograph with either flame ionization detector or coupled with mass spectroscopy (10-11).

1.3 The choice of GC and HPLC as the recommended procedures for analysis of B[a]P and other PAHs are influenced by their sensitivity and selectivity, along with their ability to analyze complex samples. This method provides for both GC and HPLC approaches to the determination of B[a]P and other PAHs in the extracted sample.

1.4 The analytical methodology is well defined, but the sampling procedures can reduce the validity of the analytical results. Recent studies (12-15) have indicated that non-volatile PAHs (vapor pressure $<10^{-8}$ mm Hg) may be trapped on the filter, but post-collection volatilization problems may distribute the PAHs down stream of the the filter to the back-up adsorbent. A wide variety of adsorbents such as Tenax GC, XAD-2 resin and polyurethane foam (PUF) have been used to sample B[a]P and other PAH vapors. All adsorbents have demonstrated high collection efficiency for B[a]P in particular. In general, XAD-2 resin has a higher collection efficiency (16-17) for volatile PAHs than PUF, as well as a higher retention efficiency. However, PUF cartridges are easier to handle in the field and maintain better flow characteristics during sampling. Likewise, PUF has demonstrated its capability in sampling organochlorine pesticides and polychlorinated biphenyls (Compendium Methods TO4 and TO10 respectively), and polychlorinated dibenzo-p-dioxins (Compendium Method TO9). However, PUF has demonstrated a lower recovery efficiency and storage capability for naphthalene and B[a]P, respectively, than XAD-2. There have been no significant losses of PAHs, up to 30 days of storage at 0°C, using XAD-2. It also appears that XAD-2 resin has a higher collection efficiency for volatile PAHs than PUF, as well as a higher retention efficiency for both volatile and reactive PAHs. Consequently, while the literature cites weaknesses and strengths of using either XAD-2 or PUF, this method covers both the utilization of XAD-2 and PUF as the adsorbent to address post-collection volatilization problems associated with B[a]P and other reactive PAHs.

1.5 This method covers the determination of B[a]P specificially by both GC and HPLC and enables the qualitative and quantitative analysis of the other PAHs. They are:

Acenaphthene	Benzo(k)fluoranthene
Acenaphthylene	Chrysene
Anthracene	Dibenzo(a,h)anthracene
Benzo(a)anthracene	Fluoranthene
Benzo(a)pyrene	Fluorene
Benzo(b)fluoranthene	Indeno(1,2,3-cd)pyrene
Benzo(e)pyrene	Naphthalene
Benzo(g,h,i)perylene	Phenanthrene
	Pyrene

The GC and HPLC methods are applicable to the determination of PAHs compounds involving two-member rings or higher. Nitro-PAHs have not been fully evaluated using this procedure; therefore, they are not included in this method. When either of the methods are used to analyze unfamiliar samples for any or all of the compounds listed above, compound identification should be supported by both techniques.

1.6 With careful attention to reagent purity and optimized analytical conditions, the detection limits for GC and HPLC methods range from 1 ng to 10 pg which represents detection of B[a]P and other PAHs in filtered air at levels below 100 pg/m^3. To obtain this detection limit, at least 100 m^3 of air must be sampled.

2. Applicable Documents

2.1 ASTM Standards

2.1.1 Method D1356 - Definitions of Terms Relating to Atmospheric Sampling and Analysis.

2.1.2 Method E260 - Recommended Practice for General Gas Chromatography Procedures.

2.1.3 Method E355 - Practice for Gas Chromatography Terms and Relationships.

2.1.4 Method E682 - Practice for Liquid Chromatography Terms and Relationships.

2.1.5 Method D-1605-60 - Standard Recommended Practices for Sampling Atmospheres for Analysis of Gases and Vapors.

2.2 Other Documents

2.2.1 Existing Procedures (18-25)

2.2.2 Ambient Air Studies (26-28)

2.2.3 U.S. EPA Technical Assistance Document (29-32)

2.2.4 General Metal Works Operating Procedures for Model PS-1 Sampler, General Metal Works, Inc., Village of Cleves, Ohio.

3. Summary of Method

3.1 Filters and adsorbent cartridges (containing XAD-2 or PUF) are cleaned in solvents and vacuum-dried. The filters and adsorbent cartridges are stored in screw-capped jars wrapped in aluminum foil (or otherwise protected from light) before careful installation on a modified high volume sampler.

3.2 Approximately 325 m^3 of ambient air is drawn through the filter and adsorbent cartridge using a calibrated General Metal Works Model PS-1 Sampler, or equivalent (breakthrough has not shown to be a problem with sampling volumes of 325 m^3).

3.3 The amount of air sampled through the filter and adsorbent cartridge is recorded, and the filter and cartridge are placed in an appropriately labeled container and shipped along with blank filter and adsorbent cartridges to the analytical laboratory for analysis.

3.4 The filters and adsorbent cartridge are extracted by Soxhlet extraction with appropriate solvent. The extract is concentrated by Kuderna-Danish (K-D) evaporator, followed by silica gel clean-up using column chromatography to remove potential interferences prior to analysis.

3.5 The eluent is further concentrated by K-D evaporator, then analyzed by either gas chromatograhy equipped with FI or MS detection or high performance liquid chromatography (HPLC). The analytical system is verified to be operating properly and calibrated with five concentration calibration solutions, each analyzed in triplicate.

3.6 A preliminary analysis of the sample extract is performed to check the system performance and to ensure that the samples are within the calibration range of the instrument. If necessary, recalibrate the instrument, adjust the amount of the sample injected, adjust the calibration solution concentration, and adjust the data processing system to reflect observed retention times, etc.

3.7 The samples and the blanks are analyzed and used (along with the amount of air sampled) to calculated the concentratuon of B[a]P in ambient air.

3.8 Other PAHs can be determined both qualitatively and quantitatively through optimization of the GC or HPLC procedures.

4. Significance

4.1 Several documents have been published which describe sampling and analytical approaches for benzo[a]pyrene and other PAHs, as outlined in Section 2.2. The attractive features of these methods have been combined in this procedure. This method has been validated in the laboratory; however, one must use caution when employing it for specific applications.

4.2 The relatively low level of B[a]P and other PAHs in the environment requires use of high volume (~6.7 cfm) sampling techniques to acquire sufficient sample for analysis. However, the volatility of certain PAHs prevents efficient collection on filter media alone. Consequently, this method utilizes both a filter and a backup adsorbent cartridge which provide for efficient collection of most PAHs.

5. Definitions

Definitions used in this document and in any user-prepared standard operating procedures (SOPs) should be consistent with ASTM Methods D1356, D1605-60, E260, and E255. All abbreviations and symbols are defined within this document at point of use.

5.1 Sampling efficiency (SE) - ability of the sampling medium to trap vapors of interest. %SE is the percentage of the analyte of interest colleted and retained by the sampling medium when it is introduced as a vapor in air or nitrogen into the air sampler and the sampler is operated under normal conditions for a period of time equal to or greater than that required for the intended use.

5.2 Retention time (RT) - time to elute a specific chemical from a chromatographic column. For a specific carrier gas flow rate, RT is measured from the time the chemical is injected into the gas stream until it appears at the detector.

5.3 High Performance Liquid Chromatography - an analytical method based on separation of compounds of a liquid mixture through a liquid chromatographic column and measuring the separated components with a suitable detector.

5.4 Gradient elution - defined as increasing the strength of the mobile phase during a chromatographic analysis. The net effect of gradient elution is to shorten the retention time of compounds strongly retained on the analytical column. Gradient elution may be stepwise on continuous.

5.5 Method detection limit (MDL) - the minimum concentration of a substance that can be measured and reported with confidence and that the value is above zero.

5.6 Kuderna-Danish apparatus - the Kuderna-Danish (KD) appartus is a system for concentrating materials dissolved in volatile solvents.

5.7 Reverse phase liquid chromatography - reverse phase liquid chromatography involves a non-polar absorbent (C-18,ODS) coupled with a polar solvent to separate non-polar compounds.

5.8 Guard column - guard columns in HPLC are usually short (5cm) columns attached after the injection port and before the analytial column to prevent particles and strongly retained compounds from accumulating on the analytical column. The guard column should always be the same stationary phase as the analytical column and is used to extend the life of the analytical column.

5.9 MS-SIM - the GC is coupled to a select ion mode (SIM) detector where the instrument is programmed to acquire data for only the target compounds and to disregard all others. This is performed using SIM coupled to retention time discriminators. The SIM analysis procedure provides quantitative results.

5.10 Sublimation - Sublimation is the direct passage of a substance from the solid state to the gaseous state and back into the solid form without at any time appearing in the liquid state. Also applied to the conversion of solid to vapor without the later return to solid state, and to a conversion directly from the vapor phase to the solid state.

5.11 Surrogate standard - A surrogate standard is a chemically inert compound (not expected to occur in the environmental sample) which is added to each sample, blank and matrix spiked sample before extraction and analysis. The recovery of the surrogate standard is used to monitor unusual matrix effects, gross sample processing errors, etc. Surrogate recovery is evaluated for acceptance by determining whether the measured concentration falls within acceptable limits.

5.12 Retention time window - Retention time window is determined for each analyte of interest and is the time from injection to elution of a specific chemical from a chromatographic column. The window is determined by three injections of a single component standard over a 72-hr period as plus or minus three times the standard deviation of the absolute retention time for that analyte.

6. Interferences

6.1 Method interferences may be caused by contaminants in solvents, reagents, glassware, and other sample processing hardware that result in discrete artifacts and/or elevated baselines in the detector profiles. All of these materials must be routinely demonstrated to be free from interferences under the conditions of the analysis by running laboratory reagent blanks.

6.1.1 Glassware must be scrupulously cleaned (33). Clean all glassware as soon as possible after use by rinsing with the last solvent used in it. This should be followed by detergent washing with hot water, and rinsing with tap water and reagent water. It should then be drained dry, solvent rinsed with acetone and spectrographic grade hexane. After drying and rinsing, glassware should be sealed and stored in a clean environment to prevent any accumulation of dust or other contaminants. Glassware should be stored inverted or capped with aluminum foil.

6.1.2 The use of high purity water, reagents and solvents helps to minimize interference problems. Purification of solvents by distillation in all-glass systems may be required.

6.1.3 Matrix interferences may be caused by contaminants that are coextracted from the sample. Additional clean-up by column chromatography may be required (see Section 12.4).

6.2 The extent of interferences that may be encountered using liquid chromatographic techniques has not been fully assessed. Although GC and HPLC conditions described allow for unique resolution of the specific PAH compounds covered by this method, other PAH compounds may interfere. The use of column chromatography for sample clean-up prior to GC or HPLC analysis will eliminate most

of these interferences. The analytical system must, however, be routinely demonstrated to be free of internal contaminants such as contaminated solvents, glassware, or other reagents which may lead to method interferences. A laboratory reagent blank is run for each batch of reagents used to determine if reagents are contaminant-free.

6.3 Although HPLC separations have been improved by recent advances in column technology and instrumentation, problems may occur with baseline noise, baseline drift, peak resolution and changes in sensitivity. Problems affecting overall system performance can arise (34). The user is encouraged to develop a standard operating procedure (SOP) manual specific for his laboratory to minimize problems affecting overall system performance.

6.4 Concern during sample transport and analysis is mentioned. Heat, ozone, NO_2 and ultraviolet (UV) light may cause sample degradation. These problems should be addressed as part of the user prepared standard operating procedure manual. Where possible, incandescent or UV-shield fluorescent lighting should be used during analysis.

7. Safety

7.1 The toxicity or carcinogenicity of each reagent used in this method has not been precisely defined; however, each chemical compound should be treated as a potential health hazard. From this viewpoint, exposure to these chemicals must be reduced to the lowest possible level by whatever means available. The laboratory is responsible for maintaining a current awareness file of Occupational Safety and Health Administration (OSHA) regulations regarding the safe handling of the chemicals specified in this method. A reference file of material data handling sheets should also be made available to all personnel involved in the chemical analysis. Additional references to laboratory safety are available and have been identified for the analyst (35-37).

7.2 Benzo[a]pyrene has been tentatively classified as a known or suspected, human or mammalian carcinogen. Many of the other PAHs have been classified as carcinogens. Care must be exercised when

working with these substances. This method does not purport to address all of the safety problems associated with its use. It is the responsibility of whoever uses this method to consult and establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use. The user should be thoroughly familiar with the chemical and physical properties of targeted substances (Table 1.0 and Figure 1.0).

7.3 Treat all selective polynuclear aromatic hydrocarbons as carcinogens. Neat compounds should be weighed in a glove box. Spent samples and unused standards are toxic waste and should be disposed according to regulations. Regularly check counter tops and equipment with "black light" for fluorescence as an indicator of contamination.

7.4 Because the sampling configuration (filter and backup adsorbent) has demonstrated greater than 95% collection efficiency for targeted PAHs, no field recovery evaluation will occur as part of this procedure.

8. Apparatus

8.1 Sample Collection

8.1.1 General Metal Works (GMW) Model PS-1 Sampler, or equivalent [General Metal Works, Inc., 145 South Miami Ave., Village of Cleves, Ohio, 45002, (800-543-7412)].

8.1.2 At least two Model PS-1 sample cartridges and filters assembled for PS-1 sampler.

8.1.3 GMW Model PS-1 calibrator and associated equipment - General Metal Works, Inc., Model GMW-40, 145 South Miami Ave., Village of Cleves, Ohio, 45002, (800-543-7412).

8.1.4 Ice chest - to store samples at 0°C after collection.

8.1.5 Data sheets for each sample for recording the location and sample time, duration of sample, starting time, and volume of air sampled.

8.1.6 Airtight, labeled screw-capped container sample cartridges (wide mouth, preferrably glass with Teflon seal or other non-contaminating seals) to hold filter and adsorbent cartridge during transport to analytical laboratory.

8.1.7 Portable Tripod Sampler (optional) - user prepared (38).

8.2 Sample Clean-up and Concentration

8.2.1 Soxhlet extractors capable of extracting GMW Model PS-1 filter and adsorbent cartridges (2.3" x 5" length), 500 mL flask, and condenser.

8.2.2 Pyrex glass tube furnace system for activating silica gel at 180°C under purified nitrogen gas purge for an hour, with capability of raising temperature gradually.

8.2.3 Glass vial, 40 mL.

8.2.4 Erlenmeyer flask, 50 mL - best source. [Note: Reuse of glassware should be minimized to avoid the risk of cross-contamination. All glassware that is used, especially glassware that is reused, must be scrupulously cleaned as soon as possible after use. Rinse glassware with the last solvent used in it and then with high-purity acetone and hexane. Wash with hot water containing detergent. Rinse with copious amount of tap water and several portions of distilled water. Drain, dry, and heat a muffle furnace at 400°C for 2 to 4 hours. Volumetric glassware must not be heated in a muffle furnace; rather, it should be rinsed with high-purity acetone and hexane. After the glassware is dry and cool, rinse it with hexane, and store it inverted or capped with solvent-rinsed aluminum foil in a clean environment.]

8.2.5 Polyester gloves for handling cartridges and filters.

8.2.6 Minivials - 2 mL, borosilicate glass, with conical reservoir and screw caps lines with Teflon-faced silicone disks, and a vial holder.

8.2.7 Stainless steel Teflon® coated spatulas and spoons.

8.2.8 Kuderna-Danish (KD) apparatus - 500 mL evaporation flask (Kontes K-570001-500 or equivalent), 10 mL graduated concentrator tubes (Knotes K-570050-1025 or equivalent) with ground-glass stoppers, and 3-ball macro Snyder Column (Kontes K-5700010500, K-50300-0121, and K-569001-219, or equivalent).

8.2.9 Adsorption columns for column chromatography - 1-cm x 10-cm with stands.

8.2.10 Glove box for working with extremely toxic standards and reagents with explosion-proof hood for venting fumes from solvents, reagents, etc.

8.2.11 Vacuum Oven - Vacuum drying oven system capable of maintaining a vacuum at 240 torr (flushed with nitrogen) overnight.

8.2.12 Concentrator tubes and a nitrogen evaporation apparatus with variable flow rate - best source.

8.2.13 Laboratory refrigerator with chambers operating at 0°C and 4°C.

8.2.14 Boiling chips - solvent extracted, 10/40 mesh silicon carbide or equivalent.

8.2.15 Water bath - heated, with concentric ring cover, capable of temperature control (± 5°C).

8.2.16 Vortex evaporator (optional).

8.3 Sample Analysis

8.3.1 Gas Chromatography with Flame Ionization Detection (FID).

8.3.1.1 Gas chromatography: Analytical system complete with gas chromatography suitable for on-column injections and all required accessories, including detectors, column supplies, recorder, gases, and syringes. A data system for measuring peak areas and/or peak heights is recommended.

8.3.1.2 Packed Column: 1.8-m x 2-mm I.D. glass column packed with 3% OV-17 on Chromosorb W-AW-DMCS (100/120 mesh) or equivalent (Supelco Inc., Supelco Park, Bellefonte, Pa. Supelco SPB-5).

8.3.1.3 Capillary Column: 30-m x 0.25-mm ID fused silica column coated with 0.25 u thickness 5% phenyl, 90% methyl siloxane (Supelco Inc., Supelco Park, Bellefonte, Pa.).

8.3.1.4 Detector: Flame Ionization (FI)

8.3.2 Gas Chromatograph with Mass Spectroscopy Detection Coupled with Data Processing System (GC/MS/DS).

8.3.2.1 The GC must be equipped for temperature programming, and all required accessories must be available, including syringes, gases, and a capillary column. The GC injection port must be designed for capillary columns. The use of splitless injection techniques is recommended. On-column injection techniques can be used but they may severely reduce column lifetime for nonchemically bonded columns. In this protocol, a 1-3 uL injection volume is used consistently. With some GC injection ports, however, 1 uL injections may produce some improvement in precision and chromatographic

separation. A 1 uL injection volume may be used if adequate sensitivity and precision can be achieved. [NOTE: If 1 uL is used as the injection volume, the injection volumes for all extracts, blanks, calibration solutions and performance check samples must be 1 uL.]

8.3.2.2 Gas Chromatograph-Mass Spectrometer Interface. The gas chromatograph is usually coupled directly to the mass spectrometer source. The interface may include a diverter valve for shunting the column effluent and isolating the mass spectrometer source. All components of the interface should be glass or glass-lined stainless steel. The interface components should be compatible with 320°C temperatures. Cold spots and/or active surfaces (adsorption sites) in the GC/MS interface can cause peak tailing and peak broadening. It is recommended that the GC column be fitted directly into the MS source. Graphic ferrules should be avoided in the GC injection area since they may adsorb PAHs. Vespel® or equivalent ferrules are recommended.

8.3.2.3 Mass Spectrometer. The static resolution of the instrument must be maintained at a minimum of 10,000 (10 percent valley). The mass spectrometer should be operated in the selected ion mode (SIM) with a total cycle time (including voltage reset time) of one second or less (Section 14.2).

8.3.2.4 Mass spectrometer: Capable of scanning from 35 to 500 amu every 1 sec or less, using 70 volts (nominal) electron energy in the electron impact ionization mode. The mass spectrometer must be capable of producing a mass spectrum for decafluorotriphenylphosphine (DFTPP) which meets all of the criteria (Section 14.5.1).

8.3.2.5 Data System. A dedicated computer data system is employed to control the rapid multiple ion monitoring process and to acquire the data. Quantification data (peak areas or peak heights) and multi-ion detector (MID) traces (displays of intensities of each m/z being monitored

as a function of time) must be acquired during the analyses. Quantifications may be reported based upon computer-generated peak areas or upon measured peak heights (chart recording). The detector zero setting must allow peak-to-peak measurement of the noise on the baseline.

8.3.2.6 GC Column. A fused silica column (50-m x 0.25-mm I.D.) HP Ultra #2 crosslinked 5% phenyl methylsilicone, 0.25 um film thickness (Hewlett-Packard Co., Crystal Lake, IL) is utilized to separate individual PAHs. Other columns may be used for determination of PAHs. Minimum acceptance criteria must be determined as per Section 14.2. At the beginning of each 12-hour period (after mass resolution has been demonstrated) during which sample extracts or concentration calibration solutions will be analyzed, column operating conditions must be attained for the required separation on the column to be used for samples.

8.3.2.7 Balance - Mettler balance or equivalent.

8.3.2.8 All required syringes, gases, and other pertinent supplies to operate the GC/MS system.

8.3.2.9 Pipettes, micropipettes, syringes, burets, etc., to make calibration and spiking solutions, dilute samples if necessary, etc., including syringes for accurately measuring volumes such as 25 uL and 100 uL.

8.3.3 High Performance Liquid Chromatography (HPLC) System.

8.3.3.1 Gradient HPLC system - Consisting of acetonitrile and water phase reservoirs; mixing chamber; a high pressure pump; an injection valve (automatic sampler with an optional 25 uL loop injector); a Vydac C-18 bonded phase reverse phase (RP) column, (The Separations Group, P.O. Box 867, Hesperia, CA 92345) or equivalent (25-cm x 4.6-mm ID); a variable wavelength UV/Fluorescence detector and a data system or strip chart recorder. A Spectra Physics 8100 liquid chromatograph multi-microprocessor controlled, with ternary gradient pumping system, constant flow, autosampler injector (10 uL injection loop), and column oven (optional).

8.3.3.2 Guard column - 5-cm guard column pack with Vydac reverse phase C-18 material.

8.3.3.3 Reverse phase analytical column - Vydac or equivalent C-18 bonded phase RP column (The Separation Group, P.O. Box 867, Hesperia, Ca., 92345), 4.6-mm x 25-cm, 5-micron particle diameter.

8.3.3.4 LS-4 fluorescence spectrometer, Perkin Elmer, separate excitation and emission, monochromator positioned by separate microprocessor-controlled flow cell and wavelength programming ability (optional).

8.3.3.5 Ultraviolet/visible detector, Spectra Physics 8440, deuterium Lamp, capable of programmable wavelengths (optional).

8.3.3.6 Dual channel Spectra Physics 4200 Computing Integrator, measures peak areas and retention times from recorded chromatographs. IBM PC XT will Spectra Physics Labnet system for data collection and storage (optional).

9. Reagents and Materials

9.1 Sample Collection

9.1.1 Acid-washed quartz fiber filter - 105 mm micro quartz fiber binderless filter (General Metal Works, Inc., Cat. No. GMW QMA-4, 145 South Miami Ave., Village of Cleves, Ohio, 45002 [800-543-7412] or Supelco Inc., Cat. No. 1-62, Supelco Park, Bellefonte, PA, 16823-0048).

9.1.2 Polyurethane foam (PUF) - 3 inch thick sheet stock, polyether type (density 0.022 g/cm^3) used in furniture upholstering (General Metal Works, Inc., Cat. No. PS-1-16, 145 South Miami Ave., Village of Cleves, Ohio, 45002 [800-543-7412] or Supelco Inc., Cat. No. 1-63, Supelco Park, Bellefonte, PA, 16823-0048).

9.1.3 XAD-2 resin - Supelco Inc., Cat. No. 2-02-79, Supelco Park, Bellefonte, PA, 16823-0048.

9.1.4 Hexane-rinsed aluminum foil - best source.

9.1.5 Hexane-reagent grade, best source.

9.2 Sample Clean-up and Concentration

9.2.1 Soxhlet Extraction

9.2.1.1 Methylene chloride - chromatographic grade, glass-distilled, best source.

9.2.1.2 Sodium sulfate, anhydrous - (ACS) granular anhydrous (purified by washing with methylene chloride followed by heating at 400°C for 4 hrs in a shallow tray).

9.2.1.3 Boiling chips - solvent extracted, approximately 10/40 mesh (silicon carbide or equivalent).

9.2.1.4 Nitrogen - high purity grade, best source.

9.2.1.5 Ether - chromatographic grade, glass-distilled, best source.

9.2.1.6 Hexane - chromatographic grade, glass-distilled, best source.

9.2.1.7 Dibromobiphenyl - chromatographic grade, best source. Used for internal standard.

9.2.1.8 Decafluorobiphenyl - chromatographic grade, best source. Used for internal standard.

9.2.2 Solvent Exchange

9.2.2.1 Cyclohexane - chromatographic grade, glass-distilled, best source.

9.2.3 Column Clean-up

Method 610

9.2.3.1 Silica gel - high purity grade, type 60, 70-230 mesh; extracted in a Soxhlet apparatus with methylene chloride for 6 hours (minimum of 3 cycles per hour) and activated by heating in a foil-covered glass container for 24 hours at 130°C.

9.2.3.2 Sodium sulfate, anhydrous - (ACS) granular anhydrous (See Section 9.2.1.2).

9.2.3.3 Pentane - chromatographic grade, glass-distilled, best source.

Lobar Prepacked Column

9.2.3.4 Silica gel lobar prepacked column - E. Merck, Darmstadt, Germany [Size A(240-10) Lichroprep Si (40-63 um)].

9.2.3.5 Precolumn containing sodium sulfate - American Chemical Society (ACS) granular anhydrous (purified by washing with methylene chloride followed by heating at 400°C for 4 hours in a shallow tray).

9.2.3.6 Hexane - chromatographic grade, glass-distilled, best source.

9.2.3.7 Methylene chloride - chromatographic grade, glass-distilled, best source

9.2.3.8 Methanol - chromatographic grade, glass-distilled, best source.

9.3 Sample Analysis

9.3.1 Gas Chromatography Detection

9.3.1.1 Gas cylinders of hydrogen and helium - ultra high purity, best source.

9.3.1.2 Combustion air - ultra high purity, best source.

9.3.1.3 Zero air - Zero air may be obtained from a cylinder or zero-grade compressed air scrubbed with Drierite® or silica gel and 5A molecular sieve or activated charcoal, or by catalytic cleanup of ambient air. All zero air should be passed through a liquid argon cold trap for final cleanup.

9.3.1.4 Chromatographic-grade stainless steel tubing and stainless steel plumbing fittings - for interconnections. [Alltech Applied Science, 2051 Waukegan Road, Deerfield, IL, 60015, (312) 948-8600]. [Note: All such materials in contact with the sample, analyte, or support gases prior to analysis should be stainless steel or other inert metal. Do not use plastic or Teflon® tubing or fittings.]

9.3.1.5 Native and isotopically labeled PAHs isomers for calibration and spiking standards-[Cambridge Isotopes, 20 Commerce Way, Woburn, MA, 01801 (617-547-1818)]. Suggested isotopically labeled PAH isomers are:

- o perylene - d_{12}
- o chrysene - d_{12}
- o acenaphthene - d_{10}
- o naphthalene - d_8
- o phenanthrene - d_{10}

9.3.1.6 Decafluorotriphenylphosphine (DFTPP) - best source, used for tuning GC/MS.

9.3.2 High Performance Liquid Chromatography Detection

9.3.2.1 Acetonitrile - chromatographic grade, glass-distilled, best source.

9.3.2.2 Boiling chips - solvent extracted, approximatley 10/40 mesh (silicon carbide or equivalent).

9.3.2.3 Water - HPLC Grade. Water must not have an interference that is observed at the minimum detectable limit (MDL) of each parameter of interest.

9.3.2.4 Decafluorobiphenyl - HPLC grade, best source (used for internal standard).

10. Preparation of Sample Filter and Adsorbent

10.1 Sampling Head Configuration

10.1.1 The sampling head (Figure 2) consist of a filter holder compartment followed by a glass cartridge for retaining the adsorbent.

10.1.2 Before field use, both the filter and adsorbent must be cleaned to <10 ng/apparatus of B[a]P or other PAHs.

10.2 Glass Fiber Filter Preparation

10.2.1 The glass fiber filters are baked at 600°C for five hours before use. To insure acceptable filters, they are extracted with methylene chloride in a Soxhlet apparatus, similar to the cleaning of the XAD-2 resin (see Section 10.3).

10.2.2 The extract is concentrated and analyzed by either GC or HPLC. A filter blank of <10 ng/filter of B[a]P or other PAHs is considered acceptable for field use.

10.3 XAD-2 Adsorbent Preparation

10.3.1 For initial cleanup of the XAD-2, a batch of XAD-2 (approximately 60 grams) is placed in a Soxhlet apparatus [see Figure 3(a)] and extracted with methylene chloride for 16 hours at approximately 4 cycles per hour.

10.3.2 At the end of the initial Soxhlet extraction, the spent methylene chloride is discarded and replaced with fresh reagent. The XAD-2 resin is once again extracted for 16 hours at approximately 4 cycles per hour.

10.3.3 The XAD-2 resin is removed from the Soxhlet apparatus, places in a vacuum oven connected to an ultra-purge nitrogen gas stream and dries at room temperature for approximately 2-4 hours (until no solvent odor is detected).

10.3.4 A nickel screen (mesh size 200/200) is fitted to the bottom of a hexane-rinsed glass cartridge to retain the XAD-2 resin.

10.3.5 The Soxhlet extracted/vacuum dried XAD-2 resin is placed into the sampling cartridge (using polyester gloves) to a depth of approximately 2 inches. This should require approximately 55 grams of adsorbent.

10.3.6 The glass module containing the XAD-2 adsorbent is wrapped with hexane-rinsed aluminum foil, placed in a labeled container and tightly sealed with Teflon® tape.

10.3.7 At least one assemble cartridge from each batch must be analyzed, as a laboratory blank, using the procedures described in Section 13, before the batch is considered acceptable for field use. A blank of <10 ng/cartridge of B[a]P on other PNA's is considered acceptable.

10.4 PUF Sampling Cartridge Preparation

10.4.1 The PUF adsorbent is a polyether-type polyurethane foam (density No. 3014 or 0.0225 g/cm^3) used for furniture upholstery.

10.4.2 The PUF inserts are 6.0-cm diameter cylindrical plugs cut from 3-inch sheet stock and should fit, with slight compression, in the glass cartridge, supported by the wire screen (see Figure 1). During cutting, the die is rotated at high speed (e.g., in a drill press) and continuously lubricated with water.

10.4.3 For initial cleanup, the PUF plug is placed in a Soxhlet apparatus [see Figure 3(a)] and extracted with acetone for 14-24 hours at approximately 4 cycles per hour. [Note: When cartridges are reused, 5% diethyl ether in n-hexane can be used as the cleanup solvent.]

10.4.4 The extracted PUF is placed in a vacuum oven connected to a water aspirator and dried at room temperature for approximately 2-4 hours (until no solvent odor is detected).

10.4.5 The PUF is placed into the glass sampling cartridge using polyester gloves. The module is wrapped with hexane-rinsed aluminum foil, placed in a labeled container, and tightly sealed.

10.4.6 At least one assembled cartridge from each batch must be analyzed, as a laboratory blank, using the procedures described in Section 13, before the batch is considered acceptable for field use. A blank level of <10 ng/plug for single compounds is considered to be acceptable.

11. Sample Collection

11.1 Description of Sampling Apparatus

11.1.1 The entire sampling system can be a modification of a traditional high volume sampler (see Figure 4) or a portable sampler (see Figure 5). A unit specifically designed for this method is commercially available (Model PS-1 - General Metal Works, Inc., Village of Cleves, Ohio).

11.1.2 The sampling module consists of a glass sampling cartridge and an air-tight metal cartridge holder, as outlined in Section 10.1. The adsorbent (XAD-2 or PUF) is retained in the glass sampling cartridge.

11.2 Calibration of Sampling System

Each sampler is to be calibrated: 1) when new; 2) after major repairs or maintenance; 3) whenever any audit point deviates from the calibration curve by more than 7%; 4) when a different sample collection media, other than that which the sampler was originally calibrated to, will be used for sampling; or 5) at the frequency specified in the user Standard Operating Procedure (SOP) manual in which the samplers are utilized.

11.2.1 Calibration of Flow Rate Transfer Standard

Calibration of the modified high volume air sampler in the field is performed using a calibrated orifice flow rate transfer standard. The flow rate transfer standard must be certified in the laboratory against a positive displacement rootsmeter (see Figure 6). Once certified, the recertification is performed rather infrequently if the orifice is protected from damage. Recertification of the orifice flow rate transfer standard is performed once per year utilizing a set of five (5) multihole resistance plates. [Note: The 5 multihole resistance plates are used to change the flow through the orifice so that several points can be obtained for the orifice calibration curve.]

11.2.1.1 Record the room temperature (t_l in °C) and barometric pressure (P_b in mm Hg) on Orifice Calibration Data Sheet (see Figure 7). Calculate the room temperature in °K (absolute temperature) and record on Orifice Calibration Data Sheet.

$$t_l \text{ in K} = 273° + t_l \text{ in °C}$$

11.2.1.2 Set up laboratory orifice calibration equipment as illustrated in Figure 6. Check the oil level of the rootsmeter prior to starting. There are three oil level indicators, one at the clear plastic end, and two sight glasses, one at each end of the measuring chamber.

11.2.1.3 Check for leaks by clamping both manometer lines blocking the orifice with cellophane tape, turning on the high volume motor, and noting any change in the rootsmeter's reading. If the rootsmeter's reading changes, then there is a leak in the system or in the tape. Eliminate the leak before proceeding. If the rootsmeter's reading remains constant, turn off the hi-vol motor, remove the cellophane tape, and unclamp both manometer lines.

11.2.1.4 Install the 5-hole resistance plate between the orifice and the filter adapter.

11.2.1.5 Turn manometer tubing connectors one turn counterclockwise. Make sure all connectors are open.

11.2.1.6 Adjust both manometer midpoints by sliding their movable scales until the zero point corresponds with the bottom of the meniscus. Gently shake or tap to remove any air bubbles and/or liquid remaining on tubing connectors. (If additional liquid is required for the water manometer, remove tubing connector and add clean water).

11.2.1.7 Turn on the hi-vol motor and let it run for five minutes to set the motor brushes.

11.2.1.8 Record both manometer readings-orifice water manometer (ΔH) and rootsmeter mercury manometer (ΔP). [Note: ΔH is the sum of the difference from zero (0) of the two column heights.]

11.2.1.9 Record the time, in minutes, required to pass a known volume of air (approximately 200-300 ft^3 of air for each resistance plate) through the rootsmeter by using the rootsmeter's digital volume dial and a stopwatch.

11.2.1.10 Turn off the high volume motor.

11.2.1.11 Replace the 5-hole resistance plate with the 7-hole resistance plate.

11.2.1.12 Repeat Sections 11.2.1.3 through 11.2.1.10.

11.2.1.13 Repeat for each resistance plate. Note results on Orifice Calibration Data Sheet (see Figure 7). Only a minute is needed for warm-up of the motor. Be sure to tighten the orifice enough to eliminate any leaks. Also check the gaskets for cracks. [Note: The placement of the orifice prior to the rootsmeter causes the pressure at the inlet of the rootsmeter to be reduced below atmospheric conditions, thus causing the measured volume to be incorrect. The volume measured by the rootsmeter must be corrected.]

11.2.1.14 Correct the measured volumes with the following formula and record the standard volume on the Orifice Calibration Data Sheet:

$$V_{std} = V_m \frac{P_1 - \Delta P}{P_{std}} \frac{T_{std}}{T_1}$$

where: V_{std} = standard volume (std m^3).
V_m = actual volume measured by the rootsmeter (m^3).
P_1 = barometric pressure during calibration (mm Hg).
ΔP = differential pressure at inlet to volume meter (mm Hg).
P_{std} = 760 mm Hg.
T_{std} = 298 K.
T_1 = ambient temperature during calibration (K).

11.2.1.15 Record standard volume on Orifice Calibration Data Sheet.

11.2.1.16 The standard flow rate as measured by the rootsmeter can now be calculated using the following formula:

$$Q_{std} = \frac{V_{std}}{\theta}$$

where: Q_{std} = standard volumetric flow rate, std m^3/min.
θ = elapsed time, min.

11.2.1.17 Record the standard flow rates to the nearest 0.01 std m^3/min.

11.2.1.18 Calculate and record $\sqrt{\Delta H(P_1/P_{std})\ (298/T_1)}$ value for each standard flow rate.

11.2.1.19 Plot each $\sqrt{\Delta H(P_1/P_{std})\ (298/T_1)}$ value (y-axis) versus its associated standard flow rate (x-axis) on arithmetic graph paper, draw a line of best fit between the individual plotted points and calculate the linear regression slope (M) and intercept (b).

11.2.1.20 Commercially available calibrator kits are available [General Metal Works Inc., Model GMW-40, 145 South Miami Avenue, Village of Cleves, Ohio, 45002 (1-800-543-7412)].

11.2.2 Calibration of The High Volume Sampling System Utilizing Calibrated Multi-point Flow Rate Transfer Standard

11.2.2.1 The airflow through the sampling system can be monitored by a venturi/magnehelic assembly, as illustrated in Figure 4 or by a u-tube assembly connected to the high volume portable design as illustrated in Figure 5. The field sampling system must be audited every six months using a flow rate transfer standard, as described in the U.S. EPA High Volume Sampling Method, 40 CFR 50, Appendix B. A single-point calibration must be performed before and after each sample collection, using a transfer standard calibrated as described in Section 11.2.1.

11.2.2.2 Prior to initial multi-point calibration, a "dummy" adsorbent cartridge and filter are placed in the sampling head and the sampling motor is activated. The flow control valve is fully opened and the voltage variator is adjusted so that a sample flow rate corresponding to 110% of the desired flow rate (typically 0.20 - 0.28 m^3/min) is indicated on the Magnehelic gauge (based on the previously obtained multi-point calibration curve). The

motor is allowed to warm up for 10 minutes and then the flow control valve is adjusted to achieve the desired flow rate. Turn off the sampler. The ambient temperature and barometric pressure should be recorded on the Field Calibration Data Sheet (Figure 9).

11.2.2.3 The flow rate transfer standard is placed on the sampling head, and a manometer is connected to the tap on the transfer standard using a length of tubing. Properly align the retaining rings with filter holder and secure by tightening the three screw clamps. Set the zero level of the manometer. Attach the magnehelic gage to the sampler venturi quick release connections. Adjust the zero (if needed) using the zero adjust screw on the face of the gage.

11.2.2.4 Turn the flow control valve to the fully open position and turn the sampler on. Adjust the flow control valve until a magnehelic reading of approximately 70 in. is obtained. Allow the magnehelic and manometer readings to stabilize and record these values.

11.2.2.5 Adjust the flow control valve and repeat until six or seven uniformally spaced magnehelic readings are recorded spanning the range of approximately 40-70 in. Record the readings on the Field Calibration Data Sheet (see Figure 9). [Note: Use of some filter/sorbent media combinations may restrict the airflow resulting in a maximum magnehelic reading of 60 in. or less. In such cases, a variable transformer should be placed in-line between the 110 volt power source and the sampler so that the line voltage can be increased sufficiently to obtain a maximum magnehelic reading approaching 70 in.].

11.2.2.6 Adjust the orifice manometer reading for standard temperature and pressure using the following equation:

$$X = \sqrt{\Delta H \frac{P_a}{P_{std}} \frac{T_{std}}{T_a}}$$

where: X = adjusted manometer reading to standard temperature and pressure (in. water).

ΔH = observed manometer reading (in water).

P_a = current barometric pressure (mm Hg).

P_{std} = 760 mm Hg.

T_a = current temperature (K), (K = °C + 273).

T_{std} = standard temperature (298 K).

11.2.2.7 Calculate the standard flow rate for each corrected manometer reading by the following equation:

$$Q_{std} = \frac{X - b}{M}$$

where:

Q_{std} = standard flow rate (m^3/min).

M = slope of flow rate transfer standard calibration curve.

X = corrected manometer reading from 11.2.2.6 (in water).

b = intercept of flow rate transfer standard calibration curve.

11.2.2.8 Adjust the magnehelic gage readings to standard temperature and pressure using the following equation:

$$M_{std} = \sqrt{\frac{(M)(P_a)}{P_{std}} \quad \frac{T_{std}}{T_a}}$$

where:

M_{std} = adjusted magnehelic reading to standard temperature and pressure (inches of water).

M = observed magnehelic reading (inches of water).

P_a = ambient atmospheric pressure (mm Hg).

P_{std} = standard pressure (760 mm Hg).

T_a = ambient temperature (K), (K = °C + 273).

T_{std} = standard temperature (298 K).

11.2.2.9 Plot each M_{std} value (y-axis) versus its associated Q_{std} standard (x-axis) on arithmetic graph paper. Draw a line of best fit between the individual plotted points. This is the calibration curve for the venturi. Retain with sampler.

11.2.2.10 Record the corresponding Q_{std} for each M_{std} under Q_{std} column on Field Calibration Data Sheet, Figure 9.

11.2.3 Single-point Audit of The High Volume Sampling System Utilizing Calibrated Flow Rate Transfer Standard

11.2.3.1 A single point flow audit check is performed before and after each sampling period utilizing the Calibration Flow Rate Transfer Standard (Section 11.2.1).

11.2.3.2 Prior to single point audit, a "dummy" adsorbent cartridge and filter are placed in the sampling head and the sampling motor is activated. The flow control valve is fully opened and the voltage variator is adjusted so that a

sample flow rate corresponding to 110% of the desired flow rate (typically 0.20-0.28 m^3/min) is indicated on the magnehelic gauge (based on the previously obtained multi-point calibration curve). The motor is allowed to warm up for 5 minutes and then the flow control valve is adjusted to achieve the desired flow rate. Turn off the sampler. The ambient temperature and barometric pressure should be recorded on a Field Test Data Sheet (Figure 10).

11.2.3.3 The flow rate transfer standard is placed on the sampling head.

11.2.3.4 Properly align the retaining rings with filter holder and secure by tightening the three screw clamps.

11.2.3.5 Using tubing, attach one manometer connector to the pressure tap of the transfer standard. Leave the other connector open to the atmosphere.

11.2.3.6 Adjust the manometer midpoint by sliding the movable scale until the zero point corresponds with the water meniscus. Gently shake or tap to remove any air bubbles and/or liquid remaining on tubing connectors. (If additional liquid is required, remove tubing connector and add clean water.)

11.2.3.7 Turn on high volume motor and let run for five minutes.

11.2.3.8 Record the pressure differential indicated, ΔH, in inches of water. Be sure stable ΔH has been established.

11.2.3.9 Record the observed magnehelic gauge reading, in inches of water. Be sure stable M has been established.

11.2.3.10 Using previously established Flow Rate Transfer Standard curve, calculate Q_{std} (see steps 11.2.2.6 - 11.2.2.7).

11.2.3.11 Using previously established venturi calibration curve, calculate the indicated Q_{std} (Section 11.2.2.9).

11.2.3.12 A multi-point calibration of the Flow Rate Transfer Standard against a primary standard, must be obtained annually, as outlined in Section 11.2.1.

11.2.3.13 Remove Flow Rate Transfer Standard and dummy adsorbent cartridge and filter assembly.

11.3 Sample Collection

11.3.1 After the sampling system has been assembled and flow checked as described in Sections 11.1 and 11.2, it can be used to collect air samples, as described in Section 11.3.2.

11.3.2 The samples should be located in an unobstructed area, at least two meters from any obstacle to air flow. The exhaust hose should be stretched out in the downwind direction to prevent recycling of air into the sample head.

11.3.3 With the empty sample module removed from the sampler, rinse all sample contact areas using reagent grade hexane in a Teflon® squeeze bottle. Allow the hexane to evaporate from the module before loading the samples.

11.3.4 Detach the lower chamber of the rinsed sampling module. While wearing disposable clean lint-free nylon or powder-free surgical gloves, remove a clean glass cartridge/sorbent from its container (wide mouthed glass jar with a Teflon®-lined lid) and unwrap its aluminum foil covering. The foil should be replaced back in the sample container to be re-used after the sample has been collected.

11.3.5 Insert the cartridge into the lower chamber and tightly reattach it to the module.

11.3.6 Using clean Teflon® tipped forceps, carefully place a clean fiber filter atop the filter holder and secure in place by clamping the filter holder ring over the filter using the three screw clamps. Insure that all module connections are tightly assembled. [Note: Failure to do so

could result in air flow leaks at poorly sealed locations which could affect sample representativeness]. Ideally, sample module loading and unloading should be conducted in a controlled environment or at least a centralized sample processing area so that the sample handling variables can be minimized.

11.3.7 With the module removed from the sampler and the flow control valve fully open, turn the pump on and allow it to warm-up for approximately 5 minutes.

11.3.8 Attach a "dummy" sampling module loaded with the exact same type of filter and sorbent media as that which will be used for sample collection.

11.3.9 With the sampler off, attach the Magnahelic gage to the sampler. Turn the sampler on and adjust the flow control valve to the desired flow (normally as indicated by the cfm) magnahelic gauge reading and reference by the calibration chart. [Note: Breakthrough has not been a problem for all PAHs outlined in Section 1.5 using this sampling method except anthracene and penanthrene]. Once the flow is properly adjusted, extreme care should be taken not to inadvertantly alter its setting.

11.3.10 Turn the smpler off and remove both the "dummy" module and the Magnahelic gauge. The sampler is now ready for field use.

11.3.11 The zero reading of the sampler Magnehelic is checked. Ambient temperature, barometric pressure, elapsed time meter setting, sampler serial number, filter number, and adsorbent sample number are recorded on the Field Test Data Sheet (see Figure 10). Attach the loaded sampler module to the sampler.

11.3.12 The voltage variator and flow control valve are placed at the settings used in Section 11.2.2, and the power switch is turned on. The elapsed time meter is activated and the start time is recorded. The flow (Magnehelic setting) is adjusted, if necessary, using the flow control valve.

11.3.13 The Magnehelic reading is recorded every six hours during the sampling period. The calibration curve

(Section 11.2.4) is used to calculate the flow rate. Ambient temperature, barometric pressure, and Magnehelic reading are recorded at the beginning and end of the sampling period.

11.3.14 At the end of the desired sampling period, the power is turned off. Carefully remove the sampling head containing the filter and adsorbent cartridge to a clean area.

11.3.15 While wearing disposable lint free nylon or surgical gloves, remove the sorbent cartridge from the lower module chamber and lay it on the retained aluminum foil in which the sample was originally wrapped.

11.3.16 Carefully remove the glass fiber filter from the upper chamber using clean Teflon® tiped forceps.

11.3.17 Fold the filter in half twice (sample side inward) and place it in the glass cartridge atop the sorbent.

11.3.18 Wrap the combined samples in aluminum foil and place them in their original glass sample container. A sample label should be completed and affixed to the sample container. Chain-of-custody should be maintained for all samples.

11.3.19 The glass containers should be stored in ice and protected from light to prevent possible photo-decomposition of collected analytes. If the time span between sample collection and laboratory analysis is to exceed 24 hours, sample must be kept refrigerated. [Note: Recent studies (13,16) have indicated that PUF does not retain, during storage, B[a]P as effectively as XAD-2. Therefore, sample holding time should not exceed 20 days.]

11.3.20 A final calculated sample flow check is performed using the calibration orifice, as described in Section 11.2.2. If calibration deviates by more than 10% from the initial reading, the flow data for that sample must be marked as suspect and the sampler should be inspected and/or removed from service.

11.3.21 At least one field filter/adsorbent blank will be returned to the laboratory with each group of samples. A field blank is treated exactly as a sample except that no air is drawn through the filter/adsorbent cartridge assembly.

11.3.22 Samples are stored at 0°C in an ice chest until receipt at the analytical laboratory, after which they are refrigerated at 4°C.

12. Sample Clean-up and Concentration

[Note: The following sample extraction, concentration, solvent exchange and analysis procedures are outlined for user convenience in Figure 11.]

12.1 Sample Identification

12.1.1 The samples are returned in the ice chest to the laboratory in the glass sample container containing the filter and adsorbent.

12.1.2 The samples are logged in the laboratory logbook according to sample location, filter and adsorbent cartridge number identification and total air volume sampled (uncorrected).

12.1.3 If the time span between sample registration and analysis is greater than 24-hrs., then the samples must be kept refrigerated. Minimize exposure of samples to fluorescence light. All samples should be extracted within one week after sampling.

12.2 Soxhlet Extraction and Concentration

12.2.1 Assemble the Soxhlet apparatus [see Figure 3(a)]. Immediately before use, charge the Soxhlet apparatus with 200 to 250 mL of methylene chloride and reflux for 2 hours. Let the apparatus cool, disassemble it, transfer the methylene chloride to a clean glass container, and retain it as a blank for later analysis, if required. Place the adsorbent and filter together in the Soxhlet apparatus (the use of an extraction thimble is optional) if using XAD-2 adsorbent in the sampling module. [Note: The filter and adsorbent are analyzed together in order to reach detection limits, avoid questionable interpretation of the data, and minimize cost.] Since methylene chloride is not a suitable solvent for PUF, 10% ether in hexane is employed to extract the PAHs from the PUF resin bed separate from the methylene chloride extraction of the accompanying filter rather than methylene chloride for the extraction of the XAD-2 cartridge.

12.2.1.1 Prior to extraction, add a surrogate standard to the Soxhlet solvent. A surrogate standard (i.e., a chemically inert compound not expected to

occur in an environmental sample) should be added to each sample, blank, and matrix spike sample just prior to extraction or processing. The recovery of the surrogate standard is used to monitor for unusual matrix effects, gross sample processing errors, etc. Surrogate recovery is evaluated for acceptance by determining whether the measured concentration falls within the acceptance limits. The following surrogate standards have been successfully utilized in determining matrix effects, sample process errors, etc. utilizing GC/FID, GC/MS or HPLC analysis.

Surrogate Standard	Concentration	Analytical Technique
Dibromobiphenyl	50 ng/uL	GC/FID
Dibromobiphenyl	50 ng/uL	GC/MS
Deuterated Standards	50 ng/uL	GC/MS
Decafluorobiphenyl	50 ng/uL	HPLC

[Note: The deuterated standards will be added in Section 14.3.2. Deuterated analogs of selective PAHs cannot be used as surrogates for HPLC analysis due to coelution problems.] Add the surrogate standard to the Soxhlet solvent.

12.2.1.2 For the XAD-2 and filter extracted together, add 300 mL of methylene chlorine to the apparatus and reflux for 18 hours at a rate of at least 3 cycles per hour.

12.2.1.3 For the PUF extraction separate from the filter, add 300 mL of 10 percent ether in hexane to the apparatus and reflux for 18 hours at a rate of at least 3 cycles per hour.

12.2.1.4 For the filter extraction, add 300 mL of methylene chloride to the apparatus and reflux for 18 hours at a rate of at least 3 cycles per hour.

12.2.2 Dry the extract from the Soxhlet extraction by passing it through a drying column containing about 10 grams of anhydrous sodium sulfate. Collect the dried extract in a Kuderna-Danish (K-D) concentrator assembly. Wash the

extractor flask and sodium sulfate column with 100 - 125 mL of methylene chloride to complete the quantitative transfer.

12.2.3 Assemble a Kuderna-Danish concentrator [see Figure 3(b)] by attaching a 10 mL concentrator tube to a 500 mL evaporative flask. [Note: Other concentration devices (vortex evaporator) or techniques may be used in place of the K-D as long as qualitative and quantitative recovery can be demonstrated.]

12.2.4 Add two boiling chips, attach a three-ball macro-Snyder column to the K-D flask, and concentrate the extract using a water bath at 60 to 65°C. Place the K-D apparatus in the water bath so that the concentrator tube is about half immersed in the water and the entire rounded surface of the flask is bathed with water vapor. Adjust the vertical position of the apparatus and the water temperature as required to complete the concentration in one hour. At the proper rate of distillation, the balls of the column actively chatter but the chambers do not flood. When the liquid has reached an approximate volume of 5 mL, remove the K-D apparatus from the water bath and allow the solvent to drain for at least 5 minutes while cooling.

12.2.5 Remove the Snyder column and rinse the flask and its lower joint into the concentrator tube with 5 mL of cyclohexane.

12.3 Solvent Exchange

12.3.1 Replace the K-D apparatus equipped with a Snyder column back on the water bath.

12.3.2 Increase the temperature of the hot water bath to 95-100°C. Momentarily, remove the Snyder column, add a new boiling chip, and attach a two-ball micro-Snyder column. Prewet the Snyder column, using 1 mL of cyclohexane. Place the K-D apparatus on the water bath so that the concentrator tube is partially immersed in the hot water. Adjust the vertical position of the apparatus and the water temperature, as required, to complete concentration in 15-20 minutes. At the proper rate of distillation, the balls of the column will actively chatter, but the chambers

will not flood. When the apparent volume of liquid reaches 0.5 mL, remove the K-D apparatus and allow it to drain and cool for at least 10 minutes.

12.3.3 When the apparatus is cool, remove the micro-Snyder column and rinse its lower joint into the concentrator tube with about 0.2 mL of cyclohexane. [Note: A 5 mL syringe is recommended for this operation]. Adjust the extract volume to exactly 1.0 mL with cyclohexane. Stopper the concentrator tube and store refrigerated at 4°C, if further processing will not be performed immediately. If the extract will be stored longer than 24 hours, it should be transferred to a Teflon®-sealed screw-cap vial.

12.4 Sample Cleanup By Solid Phase Exchange

Cleanup procedures may not be needed for relatively clean matrix samples. If the extract in Section 12.3.3 is clear, cleanup may not be necessary. If cleanup is not necessary, the cyclohexane extract (1 mL) can be analyzed directly by GC/FI detection, except the initial oven temperature begins at 30°C rather than 80°C for cleanup samples (see Section 13.3), or solvent exchange to acetonitrile for HPLC analysis. If cleanup is required, the procedures are presented using either handpack silica gel column as prescribed in Method 610 (see Section 18.0, citation No. 18 and 22) or the use of a Lobar prepacked silica gel column for PAH concentration and separation. Either approach can be employed by the user.

12.4.1 Method 610 Cleanup Procedure [see Figure 3(c)]

12.4.1.1 Pack a 6-inch disposable Pasture pipette (10 mm I.D. x 7 cm length) with a piece of glass wool. Push the wool to the neck of the disposable pipette. Add 10 grams of activated silica gel in methylene chloride slurry to the disposable pipette. Gently tap the column to settle the silica gel and elute the methylene chloride. Add 1 gram of anhydrous sodium sulfate to the top of the silica gel column.

12.4.1.2 Prior to initial use, rinse the column with methylene chloride at 1 mL/min for 1 hr to

remove any trace of contaminants. Preelute the column with 40 mL of pentane. Discard the eluate and just prior to exposure of the sodium sulfate layer to the air, transfer the 1 mL of the cyclohexane sample extract onto the column, using an additional 2 mL of cyclohexane to complete the transfer. Allow to elute through the column.

12.4.1.3 Just prior to exposure of the sodium sulfate layer to the air, add 25 mL of pentane and continue elution of the column. Discard the pentane eluate. [Note: The pentane fraction contains the aliphatic hydrocarbons collected on the filter/ adsorbent combination. If interested, this fraction may be analyzed for specific aliphatic organics.] Elute the column with 25 mL of methylene chloride/pentane (4 + 6) (V/V) and collect the eluate in a 500 mL K-D flask equipped with a 10 mL concentrator tube. [Note: This fraction contains the B[a]P and other moderately polar PAHs]. Elution of the column should be at a rate of about 2 mL/min. Concentrate the collected fraction to less than 10 mL by the K-D technique, as illustrated in Section 12.3 using pentane to rinse the walls of the glassware. The extract is now ready for HPLC or GC analysis. [Note: An additional elution through the column with 25 mL of methanol will collect highly polar oxygenated PAHs with more than one functional group. This fraction may be analyzed for specific polar PAHs. However, additional cleanup by solid phase extraction may be required to obtain both qualitative and quantitative data due to complexity of the eluant.]

12.4.2 Lobar Prepacked Column Procedure

12.4.2.1 The setup using the Lobar prepacked column consists of an injection port, septum, pump, precolumn containing sodium sulfate, Lobar prepacked column and solvent reservoir.

12.4.2.2 The column is cleaned and activated according to the following cleanup sequence:

Fraction	Solvent Composition	Volume (mL)
1	100% Hexane	20
2	80% Hexane/20% Methylene Chloride	10
3	50% Hexane/50% Methylene Chloride	10
4	100% Methylene Chloride	10
5	95% Methylene Chloride/5% Methanol	10
6	80% Methylene Chloride/20% Methanol	10

12.4.2.3 Reverse the sequence at the end of the run and run to the 100% hexane fraction in order to activate the column. Discard all fractions.

12.4.2.4 Pre-elute the column with 40 mL of hexane, which is also discharged.

12.4.2.5 Inject 1 mL of the cyclohexane sample extract, followed by 1 mL injection of blank cyclohexane.

12.4.2.6 Continue elution of the column with 20 mL of hexane, which is also discharged.

12.4.2.7 Now elute the column with 180 mL of a 40/60 mixture of methylene chloride/hexane respectively.

12.4.2.8 Collect approximately 180 mL of the 40/60 methylene chloride/hexane mixture in a K-D concentrator assembly.

12.4.2.9 Concentrate to less than 10 mL with the K-D assembly as discussed in Section 12.2.

12.4.2.10 The extract is now ready for either HPLC or GC analysis.

13. Gas Chromatography Analysis with Flame Ionization Detection

13.1 Gas chromatography (GC) is a quantitative analytical technique useful for PAH identification. This method provides the user the flexibility of column selection (packed or capillary) and detector [flame ionization (FI) or mass spectrometer (MS)] selection. The mass spectrometer provides for specific identification of B(a)P; however, with system optimization, other PAHs may be qualitatively and quantitatively detected using MS (see Section 14.0). This procedure provides for common GC separation of the PAHs with

subsequent detection by either FI or MS (see Figure 12.0). The following PAHs have been quantified by GC separation with either FI or MS detection:

Acenaphthene	Chrysene
Acenaphthylene	Dibenzo(a,h)anthracene
Anthracene	Fluoranthene
Benzo(a)anthracene	Fluorene
Benzo(a)pyrene	Indeno(1,2,3-cd)pyrene
Benzo(b)fluoranthene	Naphthalene
Benzo(e)pyrene	Phenanthrene
Benzo(g,h,i)perylene	Pyrene
Benzo(k)fluoranthene	

The packed column gas chromatographic method described here can not adequately resolve the following four pairs of compounds: anthracene and phenanthrene; chrysene and benzo(a)anthracene; benzo(b)fluoranthene and benzo(k)fluoranthene; and dibenzo(a,h) anthracene and indeno(1,2,3-cd)pyrene. The use of a capillary column instead of the packed column, also described in this method, should adequately resolve these PAHs. However, unless the purpose of the analysis can be served by reporting a quantitative sum for an unresolved PAH pair, either capillary gas chromatography/mass spectroscopy (Section 14.0) or high performance liquid chromatography (Section 15.0) should be used for these compounds. This section will address the use of GC/FI detection using packed or capillary columns.

13.2 To achieve maximum sensitivity with the GC/FI method, the extract must be concentrated to 1.0 mL, if not already concentrated to 1 mL. If not already concentrated to 1 mL, add a clean boiling chip to the methylene chloride extract in the concentrator tube. Attach a two-ball micro-Snyder column. Prewet the micro-Snyder column by adding about 2.0 mL of methylene chloride to the top. Place the micro K-D apparatus on a hot water bath (60 to 65°C) so that the concentrator tube is partially immersed in the hot water. Adjust the vertical position of the apparatus and the water temperature as required to complete the concentration in 5 to 10 minutes. At the proper rate of distillation the balls will actively chatter but the chambers will not flood. When the apparent volume of liquid reaches 0.5 mL, remove the K-D apparatus. Drain and cool for at least 10 minutes. Remove the micro-Snyder column and rinse its lower joint into the concentrator tube with a small volume of methylene chloride. Adjust the final volume to 1.0 mL and stopper the concentrator tube.

13.3 Assemble and establish the following operating parameters for the GC equipped with an FI detector:

	Capillary (A)	Capillary (B)	Packed
Identification	SPB-5 fused silica capillary, 0.25 um 5% phenyl, methyl siloxane bonded	SPB-5 fused silica capillary, 0.25 um 5% phenyl, methyl siloxane bonded	Chromosorb W-AW-DMCS (100/120 mesh) coated with 3% OV-17
Dimensions	30-m x 0.25-mm ID	30-m x 0.25-mm ID	1.8-m x 2-mm ID
Carrier Gas	Helium	Helium	Nitrogen
Carrier Gas Flow Rate	28-30 cm/sec (1 cm/minute)	28-30 cm/sec (1 cm/minute)	30-40 cm/minute
Column Program	35°C for 2 min; program at 8°C/min to 280°C and hold for 12 minutes	80°C for 2 min; program at 8°C/min to 280°C and hold for 12 minutes	Hold at 100°C for 4 minutes; program at 8°C/min to 280°C and hold for 15 minutes
Detector	Flame Ionization	Flame Ionization	Flame Ionization

(A) Without column cleanup (see Section 12.4)
(B) With column cleanup (see Section 12.4.1)

13.4 Prepare and calibrate the chromatographic system using either the external standard technique (Section 13.4.1) or the internal standard technique (Section 13.4.2). Figure 13.0 outlines the following sequence involving GC calibration and retention time window determination.

13.4.1 External Standard Calibration Procedure - For each analyte of interest, including surrogate compounds for spiking, if used, prepare calibration standards at a minimum of five concentration levels by adding volumes of one or more stock standards to a volumetric flask and diluting to volume with methylene chloride. [Note: All calibration standards of interest involving selected PAHs, of the same concentration, can be prepared in the same flask.]

13.4.1.1 Prepare stock standard solutions at a concentration of 100 ug/uL by dissolving 0.100 gram of assayed PAH material in methylene chloride and diluting to vol- in a 10 mL volumetric flask. [Note: Larger volumes can be used at the convenience of the analyst.]

13.4.1.2 When compound purity is assayed to be 98% or greater, the weight can be used without correction to calculate the concentration of the stock standard. [Note: Commercially prepared stock standards can be used at any concentration if they are certified by the manufacturer or by an independent source.] Transfer the stock standard solutions into Teflon®-sealed screw-cap bottles.

13.4.1.3 Store at 4°C and protect from light. Stock standards should be checked frequently for signs of degradation or evaporation, especially just prior to preparing calibration standards from them. Stock standard solutions must be replaced after one year, or sooner, if comparison with check standards indicates a problem.

13.4.1.4 Calibration standards at a minimum of five concentration levels should be prepared through dilution of the stock standards with methylene chloride. One of the concentration levels should be at a concentration near, but above, the method detection limit. The remaining concentration levels should correspond to the expected range of concentrations found in real samples or should define the working range of the GC. [Note: Calibration solutions must be replaced after six months, or sooner, if comparison with a check standard indicates a problem.]

13.4.1.5 Inject each calibration standard using the technique that will be used to introduce the actual samples into the gas chromatograph (e.g., 1- to 3-uL injections). [Note: The same amount must be injected each time.]

13.4.1.6 Tabulate peak height or area responses against the mass injected. The results can be used to prepare a calibration curve for each analyte. [Note: Alternatively, for samples that are introduced into the gas chromatograph using a syringe, the ratio of the response to the amount

injected, defined as the calibration factor (CF), can be calculated for each analyte at each standard concentration by the following equation:

$$\text{Calibration factor (CF)} = \frac{\text{Total Area of Peak}}{\text{Mass injected (in nanograms)}}$$

If the percent relative standard deviation (%RSD) of the calibration factor is less than 20% over the working range, linearity through the origin can be assumed, and the average calibration factor can be used in place of a calibration curve.]

13.4.1.7 The working calibration curve or calibration factor must be verified on each working day by the injection of one or more calibration standards. If the response for any analyte varies from the predicted response by more than ±20%, a new calibration curve must be prepared for that analyte. Calculate the percent variance by the following equation:

$$\text{Percent variance} = \frac{R_2 - R_1}{R_1} \times 100$$

where

R_2 = Calibration factor from succeeding analysis.

R_1 = Calibration factor from first analysis.

13.4.2 Internal Standard Calilbration Procedure - To use this approach, the analyst must select one or more internal standards that are similar in analytical behavior to the compounds of interest. The analyst must further demonstrate that the measurement of the internal standard is not affected by method or matrix interferences. Due to these limitations, no internal standard applicable to all samples can be suggested. [Note: It is recommended that the internal standard approach be used only when the GC/MS procedure is employed due to coeluting species.]

13.4.2.1 Prepare calibration standards at a minimum of five concentration levels for each analyte of interest by adding volumes of one or more stock standards to a volumetric flask.

13.4.2.2 To each calibration standard, add a known constant amount of one or more internal standard and dilute to volume with methylene chloride. [Note: One of the standards should be at a concentration near, but above, the method detection limit. The other concentrations should correspond to the expected range of concentrations found in real samples or should define the working range of the detector.]

13.4.2.3 Inject each calibration standard using the same introduction technique that will be applied to the actual samples (e.g., 1- to 3-uL injection).

13.4.2.4 Tabulate the peak height or area responses against the concentration of each compound and internal standard.

13.4.2.5 Calculate response factors (RF) for each compound as follows:

$$\text{Response Factor (RF)} = (A_s C_{is})/(A_{is} C_s)$$

where:

A_s = Response for the analyte to be measured (area units or peak height).

A_{is} = Response for the internal standard. (area units or peak height).

C_{is} = Concentration of the internal standard, (ug/L).

C_s = Concentration of the analyte to be measured, (ug/L).

13.4.2.6 If the RF value over the working range is constant (<20% RSD), the RF can be assumed to be invariant, and the average RF can be used for calculations. [Note: Alternatively, the results can be used to plot a calibration curve of response ratios, A_s/A_{is} versus RF.]

13.4.2.7 The working calibration curve or RF must be verified on each working day by the measurement of one or more calibration standards.

13.4.2.8 If the response for any analyte varies from the predicted response by more than ±20%, a new calibration curve must be prepared for that compound.

13.5 Retention Time Windows Determination

13.5.1 Before analysis can be performed, the retention time windows must be established for each analyte.

13.5.2 Make sure the GC system is within optimum operating conditions.

13.5.3 Make three injections of the standard containing all compounds for retention time window determination. [Note: The retention time window must be established for each analyte throughout the course of a 72-hr period.]

13.5.4 The retention window is defined as plus or minus three times the standard deviation of the absolute retention times for each standard.

13.5.5 Calculate the standard deviation of the three absolute retention times for each single component standard. In those cases where the standard deviation for a particular standard is zero, the laboratory must substitute the standard deviation of a close eluting, similar compound to develop a valid retention time window.

13.5.6 The laboratory must calculate retention time windows for each standard on each GC column and whenever a new GC column is installed. The data must be noted and retained in a notebook by the laboratory as part of the user SOP and as a quality assurance check of the analytical system.

13.6 Sample Analysis

13.6.1 Inject 1- to 3-uL of the methylene chloride extract from Section 13.2 (however, the same amount each time) using the splitless injection technique when using capillary column. [Note: Smaller (1.0 uL) volumes can be injected if automatic devices are employed.]

13.6.2 Record the volume injected and the resulting peak size in area units or peak height.

13.6.3 Using either the internal or external calibration procedure, determine the identity and quantity of each component peak in the sample chromatogram through retention time window and established calibration curve. Table 2 outlines typical retention times for selected PAHs, using both the packed and capillary column technique coupled with FI detection, while Figure 14.0 illustrates typical chromatogram for a packed column analysis.

13.6.3.1 If the responses exceed the linear range of the system, dilute the extract and reanalyze. It is recommended that extracts be diluted so that all peaks are on scale. Overlapping peaks are not always evident when peaks are off scale. Computer reproduction of chromatograms, manipulated to ensure all peaks are on scale over a 100-fold range, are acceptable if linearity is demonstrated. Peak height measurements are recommended over peak area integration when overlapping peaks cause errors in area integration.

13.6.3.2 Establish <u>daily</u> retention time windows for each analyte. Use the absolute retention time for each analyte from Section 13.5.4 as the midpoint of the window for that day. The daily retention time window equals the midpoint $\pm$ three times the standard deviation determined in Section 13.5.4.

13.6.3.3 Tentative identification of an analyte occurs when a peak from a sample extract falls within the daily retention time window. [Note: Confirmation may be required on a second GC column, or by GC/MS (if concentration permits) or by other recognized confirmation techniques if overlap of peaks occur.]

13.6.3.4 Validation of GC system qualitative performance is performed through the use of the midlevel standards. If the mid-level standard falls outside its daily retention time window, the system

is out of control. Determine the cause of the problem and perform a new calibration sequence (see Section 13.4).

13.6.3.5 Additional validation of the GC system performance is determined by the surrogate standard recovery. If the recovery of the surrogate standard deviates from 100% by not more than 20%, then the sample extraction, concentration, clean-up and analysis is certified. If it exceeds this value, then determine the cause of the problem and correct.

13.6.4 Determine the concentration of each analyte in the sample according to Sections 17.1 and 17.2.1.

14. Gas Chromatography with Mass Spectroscopy Detection

14.1 The analysis of the extracted sample for benzo[a]pyrene and other PAHs is accomplished by an electron impact gas chromatography/mass spectrometry (EI GC/MS) in the selected ion monitoring (SIM) mode with a total cycle time (including voltage reset time) of one second or less. The GC is equipped with an ultra No. 2 fused silica capillary column (50-m x 0.25-mm I.D.) with helium carrier gas for analyte separation. The GC column is temperature controlled and interfaced directly to the MS ion source.

14.2 The laboratory must document that the EI GC/MS system is properly maintained through periodic calibration checks. The GC/MS system should have the following specifications:

Mass range: 35-500 amu
Scan time: 1 sec/scan
GC Column: 50 m x 0.25 mm I.D. (0.25 um film thickness)
Ultra No. 2 fused silica capillary column or equivalent
Initial column temperature and hold time: 40°C for 4 min
Column temperature program: 40-270°C at 10°C/min
Final column temperature hold: 270°C (until benzo[g,h,i] perylene has eluted)
Injector temperature: 250-300°C
Transfer line temperature: 250-300°C
Source temperature: According to manufacturer's specifications
Injector: Grob-type, splitless
EI Condition: 70 eV
Mass Scan: Follow manufacturer instruction for select ion monitoring (SIM) mode.
Sample volume: 1-3 uL
Carrier gas: Helium at 30 cm/sec.

The GC/MS is tuned using a 50 ng/uL solution of decafluorotriphenylphosphine (DFTPP). The DFTPP permits the user to tune the mass spectrometer on a daily basis. If properly tuned, the DFTPP key ions and ion abundance criteria should be met as outlined in Table 3.

14.3 The GC/MS operating conditions are outlined in Table 4. The GC/MS system can be calibrated using the external standard technique (Section 14.3.1) or the internal standard technique (Section 14.3.2). Figure 15.0 outlines the following sequence involving the GC/MS calibration.

14.3.1 External standard calibration procedure.

14.3.1.1 Prepare calibration standard of B[a]P or other PAHs at a minimum of five concentration levels by adding volumes of one or more stock standards to a volumetric flask and diluting to volume with methylene chloride. The stock standard solution of B[a]P (1.0 ug/uL) must be prepared from pure standard materials or purchased as certified solutions.

14.3.1.2 Place 0.0100 grams of native B[a]P or other PAHs on a tared aluminum weighing disk and weigh on a Mettler balance.

14.3.1.3 Quantitatively, transfer to a 10 ml volumetric flask. Rinse the weighing disk with several small portions of methylene chloride. Ensure all material has been transferred.

14.3.1.4 Dilute to mark with methylene chloride.

14.3.1.5 The concentration of the stock standard solution of B[a]P or other PAHs in the flask is 1.0 ug/uL [Note: Commerically prepared stock standards may be used at any concentration if they are certified by the manufacturer or by an independent source.]

14.3.1.6 Transfer the stock standard solutions into Teflon®-sealed screw-cap bottles. Store at 4°C and protect from light. Stock standard solutions should be checked frequently for signs of degradation or evaporation, especially just prior to preparing calibration standards from them.

14.3.1.7 Stock standard solutions must be replaced after 1 yr or sooner if comparison with quality control check samples indicates a problem.

14.3.1.8 Calibration standards at a minimum of five concentration levels should be prepared. [Note: One of the calibration standards should be at a concentration near, but above the method detection limit; the others should correspond to the range of concenrations found in the sample but should not exceed the working range of the GC/MS system.] Accurately pipette 1.0 ml of the stock solution (1 ug/uL) into another 10 mL volumetric flask, dilute to mark with methylene chloride. This daughter solution contains 0.1 ug/uL of B[a]P or other PAHs.

14.3.1.9 Prepare a set of standard solutions by appropriately diluting, with methylene chloride, accurately measured volumes of the daughter solution (0.1 ug/uL).

14.3.1.10 Accurately pipette 100 uL, 300 uL, 500 uL, 700 uL and 1000 uL of the daughter solution (0.1 ug/uL) into each 10 mL volumetric flask, respectively. To each of these flasks, add an internal deuterated standard to give a final concentration of 40 ng/uL of the internal deuterated standard (Section 14.3.2.1). Dilute to mark with methylene chloride.

14.3.1.11 The concentration of B[a]P in each flask is 1 ng/uL, 3 ng/uL, 5 ng/uL, 7 ng/uL, and 10 ug/uL respectively. All standards should be stored at 4°C and protected from fluorescent light and should be freshly prepared once a week or sooner if check standards indicates a problem.

14.3.1.12 Analyze a constant volume (1-3 uL) of each calibration standard and tabulate the area responses of the primary characteristic ion of each standard against the mass injected. The results may be used to prepare a calibration curve for each compound. Alternatively, if the ratio of response

to amount injected (calibration factor) is a constant over the working range (<20% relative standard deviation, RSD), linearity through the origin may be assumed and the average ratio or calibration factor may be used in place of a calibration curve.

14.3.1.13 The working calibration curve or calibration factor must be verified on each working day by the measurement of one or more calibration standards. If the response for any parameter varies from the predicted response by more than ± 20%, the rest must be repeated using a fresh calibration standard. Alternatively, a new calibration curve or calibration factor must be prepared for that compound.

14.3.2 Internal standard calibration procedure.

14.3.2.1 To use this approach, the analyst must select one or more internal standards that are similar in analytical behavior to the compounds of interest. For analysis of B[a]P, the analyst should use perylene -d_{12}. The analyst must further demonstrate that the measurement of the internal standard is not affected by method or matrix interferences. The following internal standards are suggested at a concentration of 40 ng/uL for specific PAHs:

Perylene - d_{12}	Acenaphthene - d_{10}
Benzo(a)pyrene	Acenaphthene
Benzo(k)fluoranthene	Acenaphthylene
Benzo(g,h,i)perylene	Fluorene
Dibenzo(a,h)anthracene	
Indeno(1,2,3-cd)pyrene	Naphthalene - d_8
Chrysene - d_{12}	Naphthalene
Benzo(a)anthracene	Phenanthrene -d_{10}
Chrysene	
Pyrene	Anthracene
	Fluoranthene
	Phenanthrene

14.3.2.2 A mixture of the above deuterated compounds in the appropriate concentration range are commercially available (see Section 9.3.1.5).

14.3.2.3 Use the base.peak ion as the primary ion for quantification of the standards. If interferences are noted, use the next two most intense ions as the secondary ions. The internal standard is added to all calibration standards and all sample extracts analyzed by GC/MS. Retention time standards, column performance standards, and a mass spectrometer tuning standard may be included in the internal standard solution used.

14.3.2.4 Prepare calibration standards at a minimum of three concentration level for each parameter of interest by adding appropriate volumes of one or more stock standards to a volumetric flask. To each calibration standard or standard mixture, add a known constant amount of one or more of the internal deuterated standards to yield a resulting concentration of 40 ng/uL of internal standard and dilute to volume with methylene chloride. One of the calibration standards should be at a concentration near, but above, the minimum detection limit (MDL) and the other concentrations should correspond to the expected range of concentrations found in real samples or should define the working range of the GC/MS system.

14.3.2.5 Analyze constant amount (1-3 uL) of each calibration standard and tabulate the area of the primary characteristic ion against concentration for each compound and internal standard, and calculate the response factor (RF) for each analyte using the following equation:

$$RF = (A_s C_{is})/(A_{is} C_s)$$

Where:

A_s = Area of the characteristic ion for the analyte to be measured.

A_{is} = Area of the characteristic ion for the internal standard.

C_{is} = Concentration of the internal standard, (ng/uL).

C_s = Concentration of the analyte to be measured, (ng/uL).

If the RF value over the working range is a constant (<20% RSD), the RF can be assumed to be invariant and the average RF can be used for calculations. Alternatively, the results can be used to plot a calibration curve of response ratios, A_S/A_{IS}, vs. RF. Table 5.0 outlines key ions for selected internal deuterated standards.

14.3.2.6 The working calibration curve or RF must be verified on each working day by the measurement of one or more calibration standards. If the response for any parameter varies from the predicted response by more than $\pm$ 20%, the test must be repeated using a fresh calibration standard. Alternatively, a new calibration curve must be prepared.

14.3.2.7 The relative retention times for each compound in each calibration run should agree within 0.06 relative retention time units.

14.4 Sample Analysis

14.4.1 It is highly recommended that the extract be screened on a GC/FID or GC/PID using the same type of capillary column as in the GC/MS procedure. This will minimize contamination of the GC/MS system from unexpectedly high concentrations of organic compounds.

14.4.2 Analyze the 1 mL extract (see Section 13.2) by GC/MS. The recommended GC/MS operating conditions to be used are specified in Section 14.2.

14.4.3 If the response for any quantitation ion exceeds the initial calibration curve range of the GC/MS system, extract dilution must take place. Additional internal standard must be added to the diluted extract to maintain the required 40 ng/uL of each internal standard in the extracted volume. The diluted extract must be reanalyzed.

14.4.4 Perform all qualitative and quantitative measurements as described in Section 14.3. The typical characteristic ions for selective PAHs are outlined in Table 6.0. Store the extracts at 4°C, protected from light in screw-cap vials equipped with unpierced Teflon®-lined, for future analysis.

14.4.5 For sample analysis, the comparison between the sample and references spectrum must illustrate:

(1) Relative intensities of major ions in the reference spectrum (ions >10% of the most abundant ion) should be present in the sample spectrum.

(2) The relative intensities of the major ions should agree within ±20%. (Example: For an ion with an abundance of 50% in the standard spectrum, the corresponding sample ion abundance must be between 30 and 70%).

(3) Molecular ions present in the reference spectrum should be present in the sample spectrum.

(4) Ions present in the sample spectrum but not in the reference spectrum should be reviewed for possible background contaminatiuon or presence of coeluting compounds.

(5) Ions present in the reference spectrum but not in the sample spectrum should be reviewed for possible subtraction from the sample spectrum because of background contamination or coeluting peaks. Data system library reduction programs can sometimes create these discrepancies.

14.4.6 Determine the concentration of each analyte in the sample according to Sections 17.1 and 17.2.2.

14.5 GC/MS Performance Tests

14.5.1 Daily DFTPP Tuning - At the beginning of each day that analyses are to be performed, the GC/MS system must be checked to see that acceptable performance criteria are achieved when challenged with a 1 uL injection volume containing 50 ng of decafluorotriphenylphosphine (DFTPP). The DFTPP key ions and ion abundance criteria that must be met are illustrated in Table 3.0. Analysis should not begin until all those criteria are met. Background subtraction should be staightforward and designed only to eliminate column bleed or instrument background ions. The GC/MS tuning standard should also be used to assess GC column performance and injection port inertness. Obtain a background correction mass spectra of DFTPP and check that all key ions criteria are met. If the criteria are not achieved, the analyst must retune the mass spectrometer and repeat the test until all criteria are achieved. The

performance criteria must be achieved before any samples, blanks on standards are analyzed. If any key ion abundance observed for the daily DFTPP mass tuning check differs by more than 10% absolute abundance from that observed during the previous daily tuning, the instrument must be retuned or the sample and/or calibration solution reanalyzed until the above condition is met.

14.5.2 Daily 1-point Initial Calibration Check - At the beginning of each work day, a daily 1-point calibration check is performed by re-evaluating the midscale calibration standard. This is the same check that is applied during the initial calibration, but one instead of five working standards are evaluated. Analyze the one working standards under the same conditions the initial calibration curve was evaluated. Analyze 1 uL of each of the mid-scale calibration standard and tabulate the area response of the primary characteristic ion against mass injected. Calculate the percent difference using the following equation:

$$\% \text{ Difference} = \frac{RF_c - \overline{RF_I}}{\overline{RF_I}} \times 100$$

Where:

$\overline{RF_I}$ = average response factor from initial calibration using mid-scale standard.

RF_c = response factor from current verification check using mid-scale standard.

If the percent difference for the mid-scale level is greater than 10%, the laboratory should consider this a warning limit. If the percent difference for the mid-scale standard is less than 20%, the initial calibration is assumed to be valid. If the criterion is not met (<20% difference), then corrective action MUST be taken. [Note: Some possible problems are standard mixture degradation, injection port inlet contamination, contamination at the front end of the analytical column, and active sites in the column or chromatographic system.] This check must be met

before analysis begins. If no source of the problem can be determined after corrective action has been taken, a new five-point calibration MUST be generated. This criterion MUST be met before sample analysis begins.

14.5.3 12-hour Calibration Verification - A calibration standard at mid-level concentration containing B[a]P or other PAHs must be performed every twelve continuous hours of analysis. Compare the standard every 12-hours with the average response factor from the initial calibration. If the % difference for the response factor (see Section 14.5.2) is less than 20%, then the GC/MS system is operative within initial calibration values. If the criteria is not met (>20% difference), then the source of the problem must be determined and a new five-point curve MUST be generated.

14.5.4 Surrogate Recovery - Additional validation of the GC system performance is determined by the surrogate standard recovery. If the recovery of the surrogate standard deviates from 100% by not more than 20%, then the sample extraction, concentration, clean-up and analysis is certified. If it exceeds this value, then determine the cause of the problem and correct.

15. High Performance Liquid Chromatography (HPLC) Detection

15.1 Introduction

15.1.1 Detection of B[a]P by HPLC has also been a viable tool in recent years. The procedure outlined below has been written specifically for analysis of B[a]P by HPLC. However, by optimizing chromatographic conditions [(multiple detector fluorescence - excitation at 240 nm, emission at 425 nm; ultraviolet at 254 nm)] and varying the mobile phase composition through a gradient program, the following PAHs may also be quantitatified:

COMPOUND	DETECTOR[1]	COMPOUND	DETECTOR[1]
Acenaphthene	UV	Benzo(k)fluoranthene	FL
Acenaphthylene	UV	Dibenzo(a,h)anthracene	FL
Anthracene	UV	Fluoranthene	FL
Benzo(a)anthracene	FL	Fluorene	UV
Benzo(a)pyrene	FL	Indeno(1,2,3-cd)pyrene	FL
Benzo(b)fluoranthene	FL	Naphthalene	UV
Benzo[e]pyrene	FL	Phenanthrene	UV
Benzo(ghi)perylene	FL	Pyrene	FL

[1]UV= Ultraviolet
FL= Fluorescences

15.1.2 This method provides quantitative identification of the selected PAH's compounds listed above by high performance liquid chromatography. It is based on separating of compounds of a liquid mixture through a liquid chromatographic column and measuring the separated components with suitable detectors.

15.1.3 The method involves solvent exchange, with subsequent HPLC detection involving ultraviolet (UV) and fluoresence (FL) detection.

15.2 Solvent Exchange To Acetonitrile

15.2.1 To the extract in the concentrator tube, add 4 mL of acetonitrile and a new boiling chip; attach a micro-snyder column to the apparatus.

15.2.2 Increase temperature of the hot water bath to 95 to 100°C.

15.2.3 Concentrate the solvent as in Section 12.3.

15.2.4 After cooling, remove the micro-Snyder column and rinse its lower sections into the concentration tube with approximately 0.2 mL acetonitrile.

15.2.5 Adjust its volume to 1.0 mL.

15.3 HPLC Assembly

15.3.1 The HPLC system is assembled, as illustrated in Figure 10.

15.3.2 The HPLC system is operated according to the following parameters:

HPLC Operating Parameters

Guard Column:	VYDAC 201 GCCIOYT	
Analytical Column:	VYDAC 201 TP5415 C-18 RP (0.46 x 25 cm)	
Column Temperature:	27.0 ± 2°C	
Mobile Phase:	Solvent Composition	Time (Minutes)
	40% Acetonitrile/60% water	0
	100% Acetonitrile	25
	100% Acetonitrile	35
	40% Acetonitrile/60% water	45
	Linear gradient elution at 1.0 mL/min	
Detector:	Variable wavelength ultraviolet and fluorescence.	
Flow Rate:	1.0 mL/minute	

[Note: To prevent irreversible absorption due to "dirty" injections and premature loss of column efficiency, a guard column is installed between the injector and the analytical column. The guard column is generally packed with identical material as is found in the analytical column. The guard column is generally replaced with a fresh guard column after several injections (50) or when separation between compounds becomes difficult. The analytical column specified in this procedure has been laboratory evaluated. Other analytical columns may be used as long as they meet procedure and separation requirements. Table 7.0 outlines other columns uses to determine PAHs by HPLC.]

15.3.3 The mobile phases are placed in separate HPLC solvent reservoirs and the pumps are set to yield a total of 1.0 mL/minute and allowed to pump for 20-30 minutes before the first analysis. The detectors are switched on at least 30 minutes before the first analysis. UV detection at 254 nm is generally preferred. The fluorescence spectrometer excitation wavelengths range from 250 to 800 nanometers. The excitation and emission slits are both set at 10 nanometers nominal bandpass.

15.3.4 Before each analysis, the detector baseline is checked to ensure stable operation.

15.4 HPLC Calibration

15.4 1 Prepare stock standard solutions at PAH concentrations of 1.00 ug/uL by dissolving 0.0100 grams of assayed material in acetonitrile and diluting to volume in a 10 mL volumetric flask. [Note: Larger volumes can be used at the convenience of the analyst. When compound purity is assayed to be 98% or greater, the weight can be used without correction to calculate the concentration of the stock standard.] Commercially prepared stock standards can be used at any concentration if they are certified by the manufacturer or by an independent source.

15.4.2 Transfer the stock standard solutions into Teflon®-sealed screw-cap bottles. Store at 4°C and protect from light. Stock standards should be checked frequently for signs of degradation or evaporation, especially just prior to preparing calibration standards from them.

15.4.3 Stock standard solutions must be replaced after one year, or sooner, if comparision with check standards indicates a problem.

15.4.4 Prepare calibration standards at a minimum of five concentration levels ranging from 1 ng/uL to 10 ng/uL by first diluting the stock standard 10:1 with acetonitrile, giving a daughter solution of 0.1 ug/uL. Accurately pipette 100 uL, 300 uL, 500 uL, 700 uL and 1000 uL of the daughter solution (0.1 ug/uL) into each 10 mL volumetric flask, respectively. Dilute to mark with acetonitrile. One of the concentration levels should be at a concentration near, but above, the method detection limit (MDL). The remaining concentration levels should correspond to the expected range of concentrations found in real samples or should define the working range of the HPLC. [Note: Calibration standards must be replaced after six months, or sooner, if comparison with check standards indicates a problem.]

15.4.5 Analyze each calibration standard (at lease five levels) three times. Tabulate area response vs. mass injected. All calibration runs are performed as described for sample analysis in Section 15.5.1. Typical retetion times for specific PAHs are illustrated in Table 8.0. Linear response is indicated where a correlation coefficient of at least 0.999 for a linear least-squares fit of the data (concentration versus area response) is obtained. The retention times for each analyte should agree within $\pm$ 2%.

15.4.6 Once linear response has been documented, an intermediate concentration standard near the anticipated levels for each component, but at least 10 times the detection limit, should be chosen for a daily calibration check. The response for the various components should be within 15% day to day. If greater variability is observed, recalibration may be required or a new calibration curve must be developed from fresh standards.

15.4.7 The response for each component in the daily calibration standard is used to calculate a response factor according to the following equation:

$$RF_C = \frac{C_C \times V_I}{R_C}$$

Where

RF_C = response factor (usually area counts) for the component of interest in nanograms injected/ response unit.

C_C = concentration (mg/L) of analyte in the daily calibration standard.

V_I = volume (uL) of calibration standard injected.

R_C = response (area counts) for analyte in the calibration standard.

15.5 Sample Analysis

15.5.1 A 100 uL aliquot of the sample is drawn into a clean HPLC injection syringe. The sample injection loop (10 uL) is loaded and an injection is made. The data system, if avaible, is activated simultaneously with the injection and the point of injection is marked on the strip-chart recorded.

15.5.2 After approximately one minute, the injection valve is returned to the "load" position and the syringe and valve are flushed with water in preparation for the next sample analysis.

15.5.3 After elution of the last component of interest, concentrations are calculated as described in Section 16.2.3. [Note: Table 8.0 illustrates typical retention times associates with individual PAHs, while Figure 17 represent a typical chromatogram associates with fluorescence detection.]

15.5.4 After the last compound of interest has eluted, establish a stable baseline; the system can be now used for further sample analyses as described above.

15.5.5 If the concentration of analyte exceeds the linear range of the instrument, the sample should be diluted with mobile phase, or a smaller volume can be injected into the HPLC.

15.5.6 Calculate surrogate standard recovery on all samples, blanks and spikes. Calculate the percent difference by the following equation:

$$\% \text{ difference} = \frac{S_R - S_I}{S_I} \times 100$$

Where

S_I = surrogate injected, ng.
S_R = surrogate recovered, ng.

15.5.7 Once a minimum of thirty samples of the same matrix have been analyzed, calculte the averge percent recovery (%R) and standard deviation of the percent recovery (SD) for the surrogate.

15.5.8 For a given matrix, calculate the upper and lower control limit for method performance for the surrogate standard. This should be done as follows:

Upper Control Limit (UCL) = (%R) + 3(SD)

Lower Control Limit (LCL) = (%R) - 3(SD)

The surrogate recovery must fall within the control limits. If recovery is not within limits, the following is required.

- o Check to be sure there are no errors in calculations surrogate solutions and internal standards. Also, check instrument performance.
- o Recalculate the data and/or reanalyze the extract if any of the above checks reveal a problem.
- o Reextract and reanalyze the sample if none of the above are a problem or flag the data as "estimated concentration."

15.5.9 Determine the concentration of each analyte in the sample according to Sections 17.1 and 17.2.3.

15.6 HPLC System Performance

15.6.1 The general appearance of the HPLC system should be similar to that illustrated in Figure 10.

15.6.2 HPLC system efficiency is calculated according to the following equation:

$$N = 5.54 \quad \frac{t^2}{W_{1/2}}$$

where:

N = column efficiency (theoretical plates).

t_r = retention time (seconds) of analyte.

$W_{1/2}$ = width of component peak at half height (seconds).

A column efficiency of >5,000 theoretical plates should be obtained.

15.6.3 Precision of response for replicate HPLC injections should be ±10% or less, day to day, for analyte calibration standards at 1 ug/mL or greater levels. At 0.5 ug/mL level and below, precision of replicate analyses could vary up to 25%. Precision of retention times should be ±2% on a given day.

15.6.4 From the calibration standards, area responses for each PAH compound can be used against the concentrations to establish working calibration curves. The calibration curve must be linear and have a correlation coefficient greater than 0.98 to be acceptable.

15.6.5 The working calibration curve should be checked daily with an analysis of one or more calibration standards. If the observed response (r_p) for any PAH varies by more than 15% from the predicted response (r_p), the test method must be repeated with new calibration standards. Alternately a new calibration curve must be prepared. [Note: If $\frac{r_o - r_p}{r_p}$ >15%, recalibration is necessary.]

15.7 HPLC Method Modification

15.7.1 The HPLC procedure has been automated by Acurex Corporation as part of their "Standard Operating Procedure for Polynuclear Aromatic Hydrocarbon Analysis by High Performance Liquid Chromatography Methods," as reported in Reference 9 of Section 18.

15.7.2 The system consists of a Spectra Physics 8100 Liquid Chromatograph, a micro-processor-controlled HPLC, a ternary gradient generator, and an autosampler (10 uL injection loop).

15.7.3 The chromatographic analysis involves an automated solvent program allowing unattended instrument operation. The

solvent program consists of four timed segments using varying concentrations of acetonitrile in water with a constant flow rate, a constant column temperature, and a 10-minute equilibration time, as outlined below.

AUTOMATED HPLC WORKING PARAMETERS

Time	Solvent Composition	Temperature	Rate
10 minutes equilibration	40% Acetonitrile 60% Water	27.0 ± 2°C	1 mL/min
T=0	40% Acetonitrile 60% Water		
T=25	100% Acetonitrile		
T=35	100% Acetonitrile		
T=45	40% Acetonitrile 60% Water		

Table 9.0 outlines the associated PAHs with their minimum detection limits (MDL) which can be detected employing the automated HPLC methodology.

15.7.4 A Vydac or equivalent analytical column packed with a C_{18} bonded phase is used for PAH separation with a reverse phase guard column. The optical detection system consists of a Spectra Physics 8440 variable Ultraviolet (UV)/Visible (VIS) wavelength detector and a Perkin Elmer LS-4 Fluorescence Spectrometer. The UV/VIS detector, controlled by remote programmed commands, contains a Deuterium lamp with wavelength selection between 150 and 600 nanometers. It is set at 254 nanometers with the time constant (detector response) at 1.0 seconds.

15.7.5 The LS-4 Fluorescence Spectrometer contains separate excitation and emission monochromators which are positioned by separate microprocessor-controlled stepper motors. It contains a Xenon discharge lamp, side-on photomultiplier and a 3-microliter illuminated volume flow cell. It is equipped with a wavelength programming facility to set the monochromators automatically to a given wavelength position. This greatly enhances selectivity by changing

the fluorescence excitation and emission detection wavelengths during the chromatographic separation in order to optimize the detection of each PAH. The excitation wavelengths range from 230 to 720 nanometers; the emission wavelengths range from 250 to 800 nanometes. The excitation and emission slits are both set at 10 nanometers nominal bandpass.

15.7.6 The UV detector is used for determining naphthalene, acenapthylene and acenapthene, and the fluorescence detector is used for the remaining PAHs. Table 9 outlines the detection techniques and minimum detection limit (MDL) employing this HPLC system. A Dual Channel Spectra Physics (SP) 4200 computing integrator, with a Labnet power supply, provides data analysis and a chromatogram. An IBM PC XT with a 10-megabyte hard disk provides data storage and reporting. Both the SP4200 and the IBM PC XT can control all functions of the instruments in the series through the Labnet system except for the LS-4, whose wavelength program is started with a signal from the High Performance Liquid Chromatograph autosampler when it injects. All data are transmitted to the XT and stored on the hard disk. Data files can later be transmitted to floppy disk storage.

16.0 Quality Assurance/Quality Control

16.1 General System QA/QC

16.1.1 Each laboratory that uses these methods is required to operate a formal quality control program. The minimum requirements of this program consist of an initial demonstration of laboratory capability and an ongoing analysis of spiked samples to evaluate and document quality data. The laboratory must maintain records to document the quality of the data generated. Ongoing data quality checks are compared with established performance criteria to determine if the results of analyses meet the performance characteristics of the method. When results of sample spikes indicate a typical method performance, a quality control check standard must be analyzed to confirm that the measurements were performed in an in-control mode of operation.

16.1.2 Before processing any samples, the analyst should demonstrate, through the analysis of a reagent solvent blank, that interferences from the analytical system, glassware, and reagents are under control. Each time a set of samples is extracted or there is a change in reagents, a reagent solvent blank should be processed as a safeguard against chronic laboratory contamination. The blank samples should be carried through all stages of the sample preparation and measurement steps.

16.1.3 For each analytical batch (up to 20 samples), a reagent blank, matrix spike and deuterated/surrogate samples must be analyzed (the frequency of the spikes may be different for different monitoring programs). The blank and spiked samples must be carried through all stages of the sample preparation and measurement steps.

16.1.4 The experience of the analyst performing gas chromatography and high performance liquid chromatography is invaluable to the success of the methods. Each day that analysis is performed, the daily calibration sample should be evaluated to determine if the chromatographic system is operating properly. Questions that should be asked are: Do the peaks look normal?; Is the response windows obtained comparable to the response from previous calibrations? Careful examination of the standard chromatogram can indicate whether the column is still good, the injector is leaking, the injector septum needs replacing, etc. If any changes are made to the system (e.g., column changed), recalibration of the system must take place.

16.2 Process, Field, and Solvent Blanks

16.2.1 One cartridge (XAD-2 or PUF) and filter from each batch of approximately twenty should be analyzed, without shipment to the field, for the compounds of interest per to serve as a process blank. A blank level of less than 10 ng per cartridge/filter assembly for single PAH component is considered to be acceptable.

16.2.2 During each sampling episode, at least one cartridge and filter should be shipped to the field and returned, without drawing air through the sampler, to serve as a field blank.

16.2.3 During the analysis of each batch of samples at least one solvent process blank (all steps conducted but no cartridge or filter included) should be carried through the procedure and analyzed. Blank levels should be less than 10 ng/sample for single components to be acceptable.

16.2.4 Because the sampling configuration (filter and backup adsorbent) has been tested for targeted PAHs in the laboratory in relationship to collection efficiency and has been demonstrated to be greater than 95% for targeted PAHs, no field recovery evaluation will occur as part of the QA/QC program outlined in this section.

16.3 Gas Chromatography with Flame Ionization Detection

16.3.1 Under the calibration procedures (internal and external), the % RSD of the calibration factor should be <20% over the linear working range of a five point calibration curve (Sections 13.4.1.6 and 13.4.2.6).

16.3.2 Under the calibration procedures (internal and external), the daily working calibration curve for each analyte should not vary from the predicted response by more than $\pm$20% (Sections 13.4.1.7 and 13.4.2.8).

16.3.3 For each analyte, the retention time window must be established (Section 13.5.1), verified on a daily basis (Section 13.6.3.2) and established for each analyte throughout the course of a 72-hour period (Section 13.5.3).

16.3.4 For each analyte, the mid-level standard must fall within the retention time window on a daily basis as a qualitative performance evaluation of the GC system (Section 13.6.3.4).

16.3.5 The surrogate standard recovery must not deviate from 100% by no more than 20% (Section 13.6.3.5).

16.4 Gas Chromatography with Mass Spectroscopy Detection

16.4.1 Section 14.5.1 requires the mass spectrometer be tuned daily with DFTPP and meet relative ion abundance requirements outlined in Table 3.

16.4.2 Section 14.3.1.1 requires a minimum of five concentration levels of each analyte (plus deuterated internal standards) be prepared to establish a calibration factor to illustrate <20% variance over the linear working range of the calibration curve.

16.4.3 Section 14.3.1.13 requires the verification of the working curve each working day (if using the external standard technique) by the measurement of one or more calibration standards. The predicted response must not vary by more than ±20%.

16.4.4 Section 14.3.2.6 requires the initial calibration curve be verified each working day (if using the internal standard technique) by the measurement of one or more calibration standards. If the response varies by more than ±20% of predicted response, a fresh calibration curve (five point) must be established.

16.4.5 Section 14.4.5 requires that for sample analysis, the comparison between the sample and reference spectrum illustrate:

(1) Relative intensities of major ions in the reference spectrum (ions >10% of the most abundant ion) should be present in the sample spectrum.

(2) The relative intensities of the major ions should agree within ±20%. (Example: For an ion with an abundance of 50% in the standard spectrum, the corresponding sample ion abundance must be between 30 and 70%).

(3) Molecular ions present in the reference spectrum should be present in sample the spectrum.

(4) Ions present in the sample spectrum but not in the reference spectrum should be reviewed for possible background contaminatiuon or presence of coeluting compounds.

(5) Ions present in the reference spectrum but not in the sample spectrum should be reviewed for possible suotraction from the sample spectrum because of background contamination or coeluting peaks. Data system library reduction programs can sometimes create these discrepancies.

16.4.6 Section 14.5.3 requires that initial calibration curve be verified every twelve continuous hour of analysis by a mid-level calibration standard. The response must be less than 20% difference from the initial response.

16.4.7 The surrogate standard recovery must not deviate from 100% by no more than 20% (Section 14.5.4).

16.5 High Performance Liquid Chromatography

16.5.1 Section 15.4.4 requires the preparation of calibration standards at a minimum of five concentration levels to establish correlation coefficient of at least 0.999 for a linear least-squares fit of the data.

16.5.2 Section 15.4.5 requires that the retention time for each analyte should agree within $\pm$2%.

16.5.3 A daily calibration check involving an intermediate standard of the initial five point calibration curve should be within $\pm$15% from day to day.

16.5.4 Section 15.5.6 requires the calculation of percent difference of surrogate standard recovery in order to establish control limits:

Upper Control Limit (UCL) = (%R) + 3 (SD)
Lower Control Limit (LCL) = (%R) - 3 (SD)

The surrogate recovery must fall within the control limits.

17. Calculations

17.1 Sample Volume

17.1.1 The total sample volume should be corrected to standard temperature and pressure.

17.1.2 The total sample volume (V_m) is calculated from the periodic flow readings (Magnehelic readings taken in Section 11.3.13) using the following equation.

$$V_m = \frac{Q_1 + Q_2 \ldots Q_n}{N} \times \frac{T}{1000}$$

Where

V_m = total sample volume (m^3) at ambient conditions .

$Q_1, Q_2 \ldots Q_n$ = flow rates determined at the beginning, end, and intermediate points during sampling (m3/minute).

N = number of data points.

T = elapsed sampling time (minutes).

17.1.3 The volume of air sampled can be converted to standard conditions (760 mm Hg pressure and 25°C) using the following equation:

$$V_s = V_m \times \frac{p_A}{760} \times \frac{298}{273 + t_A}$$

Where

V_s = total sample volume (m^3) at standard temperature and pressure (25°C and 760 mm Hg pressure).

V_m = total sample flow under ambient conditions (m^3).

p_A = ambient pressure (mm Hg).

t_A = ambient temperature (°C).

17.2 Sample Concentration

17.2.1 GC/FI Detection

17.2.1.1 The concentration of each analyte in the sample may be determined from the external standard technique by calculating the amount of standard injected, from the peak response, using the calibration curve or the calibration factor determined in Section 13.4.1.6.

17.2.1.2 The concentration of a specific analyte is calculated as follows:

$$\text{Concentration, ng/m}^3 = \frac{[(A_x)(V_t)(D)]}{[(CF)(V_i)(V_s)]}$$

Where:

CF = calibration factor for chromatographic system, peak height or area response per mass injected, Section 13.4.1.6.

A_x = Response for the analyte in the sample, area counts or peak height.

V_t = volume of total sample, uL.

D = Dilution factor, if dilution was made on the sample prior to analysis. If no dilution was made, D=1, dimensionless.

V_i = volume of sample injected, uL

V_s = total sample volume (m^3) at standard temperature and pressure (25°C and 760 mm Hg), Section 17.1.3.

17.2.2 GC/MS Detection

17.2.2.1 When an analyte has been identified, the quantification of that analyte will be based on the integrated abundance from the monitoring of the primary characteristic ion. Quantification will take place using the internal standard technique. The internal standard used shall be the one nearest the retention time of that of a given analyte (see Section 14.3.2.1).

17.2.2.2 Calculate the concentration of each identified analyte in the sample as follows:

$$\text{Concentration, ng/m}^3 = \frac{[(A_x)(I_s)(V_t)(D)]}{[(A_{is})(RF)(V_i)(V_s)]}$$

Where

A_x = area of characteristic ion(s) for analyte being measured.

I_s = amount of internal standard injected, ng.

V_t = volume of total sample, uL.

D = dilution factor, if dilution was made on the sample prior to analysis. If no dilution was made, D = 1, dimensionless.

A_{is} = area of characteristic ion(s) for internal standard.

RF = Response factor for analyte being measured, Section 14.3.2.5.

V_i = volume of analyte injected, uL.

V_s = total sample volume (m^3) at standard temperature and pressure (25°C and 760 mm Hg), Section 17.1.3.

17.2.3 HPLC Detection

17.2.3.1 The concentration of each analyte in the sample may be determined from the external standard technique by calculating response factor and peak response using the calibration curve.

17.2.3.2 The concentration of a specific analyte is calculated as follows:

$$\text{Concentration, ng/m}^3 = \frac{[(RF_c)(A_x)(V_t)(D)]}{[(V_i)(V_s)]}$$

Where

RF_c = response factor (nanograms injected per area counts) calculated in Section 15.4.7.

A_x = response for the analyte in the sample, area counts or peak height.

V_t = volume of total sample, uL.

D = dilution factor, if dilution was made on the sample prior to analysis. If no dilution was made, D = 1, dimensionless.

V_i = volume of sample injected, uL.

V_s = total sample volume (m^3) at standard temperature and pressure (25°C and 760 mm Hg), Section 17.1.3.

17.3 Sample Concentration Conversion From ng/m^3 to ppbv

17.3.1 The concentrations calculated in Section 17.2 can be converted to ppbv for general reference.

17.3.2 The analyte concentration can be converted to ppbv using the following equation:

$$C_A \text{ (ppbv)} = C_A \text{ (ng/m}^3\text{)} \times \frac{24.4}{MW_A}$$

Where

C_A = concentration of analyte, ng/m^3, calculated according to Sections 17.2.1 through 17.2.3.

MW_A = molecular weight of analyte, g/g-mole

24.4 = molar volume occupied by ideal gas at standard temperature and pressure (25°C and 760 mm Hg), l/mole.

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36. "OSHA Safety and Health Standards, General Industry," (29CFR1910), Occupational Safety and Health Administration, OSHA 2206, Revised, January, 1976.

37. "Safety in Academic Chemistry Laboratories," American Chemical Society Publication, Committee on Chemical Safety, 3rd Edition, 1979.

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TABLE 1.0 FORMULAE AND PHYSICAL PROPERTIES OF SELECTIVE PAHs

	FORMULA	MOLECULAR WEIGHT	MELTING POINT °C	BOILING POINT °C	CASE #
Acenaphthene	$C_{12}H_{10}$	154.21	96.2°	279	83-32-9
Acenaphthylene	$C_{12}H_{8}$	152.20	92-93	265-275	208-96-8
Anthracene	$C_{14}H_{10}$	178.22	218°	342	120-12-7
Benzo(a)anthracene	$C_{18}H_{12}$	228.29	158-159	-	56-55-3
Benzo(a)pyrene	$C_{20}H_{12}$	252.32	177°	310-312	50-32-8
Benzo(b)fluoranthene	$C_{20}H_{12}$	252.32	168	-	205-99-2
Benzo(e)pyrene	$C_{20}H_{12}$	252.32	178-179	-	192-92-2
Benzo(g,h,i)perlene	$C_{22}H_{12}$	276.34	273	-	191-24-2
Benzo(k)fluoranthene	$C_{20}H_{12}$	252.32	217	480	207-08-9
Chrysene	$C_{18}H_{12}$	228.29	255-256	-	218-01-9
Dibenzo(a,h)anthracene	$C_{22}H_{14}$	278.35	262	-	53-70-3
Fluoranthene	$C_{16}H_{10}$	202.26	110	-	206-44-0
Fluorene	$C_{13}H_{10}$	166.22	116-117	293-295	86-73-7
Indeno(1,2,3-cd)pyrene	$C_{22}H_{12}$	276.34	161.5-163	-	193-39-5
Naphthalene	$C_{10}H_{8}$	128.16	80.2	217.9	91-20-3
Phenanthrene	$C_{14}H_{10}$	178.22	100°	340	85-01-8
Pyrene	$C_{16}H_{10}$	202.26	156	399	129-00-0

*Many of these compounds sublime.

TABLE 2.0 RETENTION TIMES FOR SELECTIVE PAHs FOR PACKED AND CAPILLARY COLUMNS

Compound	Packed[1]	Capillary[2]
Acenaphthene	10.8	16.8
Acenaphthylene	10.4	15.9
Anthracene	15.9	20.7
Benzo(a)anthracene	20.6	29.1
Benzo(a)pyrene	29.4	36.2
Benzo(b)fluoranthene	28.0	34.2
Benzo(ghi)perylene	38.6	48.4
Benzo(k)fluoranthene	28.0	34.4
Chrysene	24.7	29.3
Dibenzo(a,h)anthracene	36.2	46.1
Fluoranthene	19.8	24.3
Fluorene	12.6	18.1
Indeno(1,2,3-cd)pyrene	36.2	45.6
Naphthalene	4.5	11.0
Phenanthrene	15.9	20.6
Pyrene	20.6	25.0

[1]GC conditions: Chromosorb W-AW-DMCS (100/120 mesh) coated with 3% OV-17, packed in a 1.8-m long x 2 mm ID glass column, with nitrogen carrier gas at a flow rate of 40 mL/min. Column temperature was held at 100°C for 4 min. then programmed at 8°/minute to a final hold at 280°C.

[2]Capillary GC conditions: 30 meter fused silica SPB-5 capillary column; flame ionization detector, splitless injection; oven temperature held at 80 degrees C for 2 minutes, increased at 8 degrees/min. to 280 degrees C.

TABLE 3.0 DFTPP KEY IONS AND ION ABUNDANCE CRITERIA

Mass	Ion Abundance Criteria
51	30-60% of mass 198
68	Less than 2% of mass 69
70	Less than 2% of mass 69
127	40-60% of mass 198
197	Less than 1% of mass 198
198	Base peak, 100% relative abundance
199	5-9% of mass 198
275	10-30% of mass 198
365	Greater than 1% of mass 198
441	Present but less than mass 443
442	Greater than 40% of mass 198
443	17-23% of mass 442

TABLE 4.0 GC AND MS OPERATING CONDITIONS

Chromatography	
Column	Hewlett-Packard Ultra #2 crosslinked 5% phenyl methyl silicone (50 m x 0.25 mm, 0.25 um film thickness) or equivalent
Carrier Gas	Helium velocity 20 cm^3/sec at 250°C
Injection Volume	Constant (1-3 uL)
Injection Mode	Splitless
Temperature Program	
Initial Column Temperature	45°C
Initial Hold Time	1 min
Program	45°C to 100°C in 5 min, then 100°C to 320°C at 8°C/min
Final Hold Time	15 min
Mass Spectrometer	
Detection Mode	Multiple ion detection, SIM mode

TABLE 5.0 CHARACTERISTIC IONS FROM GC/MS DETECTION FOR DEUTERATED INTERNAL STANDARDS AND SELECTED PAHs

Compound	M/Z
D_8-naphthalene	136
D_{10}-phenanthrene	188
Phenathrene	178
Anthracene	178
Fluoranthene	202
D_{10}-pyrene	212
Pyrene	202
Cyclopenta[c,d]pyrene	226
Benz[a]anthracene	228
D_{12}-chrysene	240
Benzo[e]pyrene	252
D_{12}-benzo[a]pyrene	264
Benzo[a]pyrene	252

TABLE 6.0 CHARACTERISTIC IONS FROM GC/MS DETECTION FOR SELECTED PAHs

Compound	Primary		Secondary
Acenaphthene	154	153	152
Acenaphthylene	152	151	153
Anthracene	178	179	176
Benzo(a)anthracene	228	229	226
Benzo(a)pyrene	252	253	125
Benzo(b)fluoranthene	252	253	125
Benzo(ghi)perylene	276	138	277
Benzo(k)fluoranthene	252	253	125
Chrysene	228	226	229
Dibenzo(a,h)anthracene	278	139	279
Fluoranthene	202	101	203
Fluorene	166	165	167
Indeno(1,2,3-cd)pyrene	276	138	227
Naphthalene	128	129	127
Phenanthrene	178	179	176
Pyrene	202	200	203

TABLE 7.0. COMMERCIAL AVAILABLE COLUMNS FOR PAH ANALYSIS USING HPLC

Company	Column Identification	Column Name
The Separation Group P.O. Box 867 Hesperia, California 92345	201-TP	VYDAC
Rainin Instrument Company Mack Road Wasurn, MA 01801-4626	Ultrasphere - ODS	ALEX
Supelco, Inc. Supelco Park Bellefonte, PA 16823-0048	LC-PAH	Supelcosil
DuPont Company Biotechnology Systems Barley Mill Plaza, P24 Wilmington, DE 19898	ODS	Zorbax
Perkin-Elmer Corp. Corporate Office Main Avenue Norwalk, CT 06856	HC-ODS	Sil-X
Waters Associates 34-T Maple St. Milford, MA 01757	u-Bondapak	NH_3 u-Bondapak

TABLE 8.0. TYPICAL RETENTION TIME FOR SELECTIVE PAHs BY HPLC SEPARATION AND DETECTION

Compound	Retention Times (minutes) HPLC Conditions			
	Condition A		Condition B	
	Fluorescence	UV	Fluorescence	UV
Acenaphthene		20.5		18.0
Acenaphthylene		18.5		15.8
Anthracene	23.4		21.0	21.0
Benzo(a)anthracene	28.5		26.3	26.3
Benzo(a)pyrene	33.9		31.1	31.1
Benzo(b)fluoranthene	31.6		29.3	29.3
Benzo(e)pyrene			31.1	
Benzo(ghi)perylene	36.3		33.9	33.9
Benzo(k)fluoranthene	32.9		30.2	30.2
Chrysene	29.3		26.7	
Dibenzo(a,h)anthracene	35.7		32.7	32.7
Fluoranthene	24.5		22.5	22.5
Fluorene		21.2	18.5	18.5
Indeno(1,2,3-cd)pyrene	37.4		34.6	34.6
Naphthalene		16.6		14.0
Phenanthrene	22.1		19.9	19.9
Pyrene	25.4		23.4	23.4

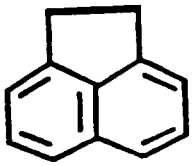
Condition A HPLC parameters: Reverse phase HC-ODS Sil-X, 5 micron particle size, in a 250-mm x 2.6-mm I.D. stainless steel column. Isocratic elution for 5 min using acetonitrile/water (4:6)(v/v), then linear gradient elution to 100% acetonitrile over 25 min at 0.5 mL/min flow rate. If columns having other internal diameters are used, the flow rate should be adjusted to maintain a linear velocity of 2 mm/sec.

Condition B HPLC parameters: Reverse phase VYDAC 201 TP 5415, 5 micron particle size, in a .46 x 25 cm stainless steel column. Isocratic elution for 10 min using acetonitrile/water (4:6)(v/v), then linear gradient elution to 100% acetonitrile for 10 minutes then linear gradient to 40/60 acetonitrile for 10 minutes at 15 mL/min.

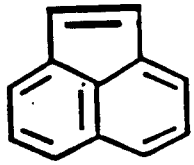
TABLE 9.0. RETENTION TIMES (RT) AND MINIMUM DETECTION LIMITS (MDLs) FOR SELECTED PAHs USING ULTRAVIOLET AND FLOURESCENCE DETECTION

	Ultraviolet Detector		Flourescence Detector	
PAH	RT	MDL	RT	MDL
Naphthalene	14.0	250pg/uL		
Acenaphthylene	15.85	250pg/uL		
Acenaphthene	18.0	250pg/uL		
Fluorene	18.5	50pg/uL	18.5	5pg/uL
Phenanthrene	19.9	50pg/uL	19.9	10pg/uL
Anthracene	21.0	50pg/uL	21.0	50pg/uL
Fluoranthene	22.5	50pg/uL	22.5	10pg/uL
Pyrene	23.4	50pg/uL	23.4	5pg/uL
Benzo(a)anthracene	26.3	50pg/uL	26.3	5pg/uL
Chrysene	26.7	50pg/uL	26.7	5pg/uL
Benzo(b)fluoranthene	29.3	50pg/uL	29.3	10pg/uL
Benzo(k)fluoranthene	30.2	50pg/uL	30.2	5pg/uL
Benzo(a)pyrene	31.1	50pg/uL	31.1	5pg/uL
Dibenzo(a,h)anthracene	32.7	50pg/uL	32.7	5pg/uL
Benzo(ghi)perylene	33.9	50pg/uL	33.9	5pg/uL
Indeno(1,2,3-cd)pyrene	34.6	50pg/uL	34.6	50pg/uL

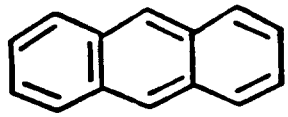
RT = Retention time in minutes
MDL = Minimum detection limit



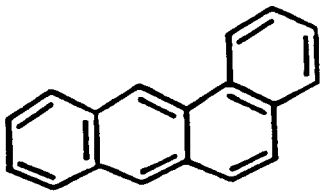
Acenaphthene



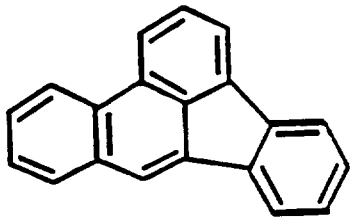
Acenaphthylene



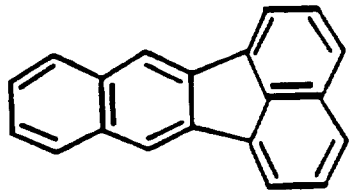
Anthracene



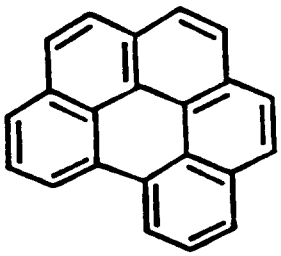
Benzo(a)anthracene



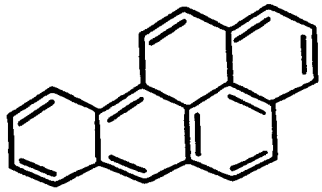
Benzo(b)fluoranthene



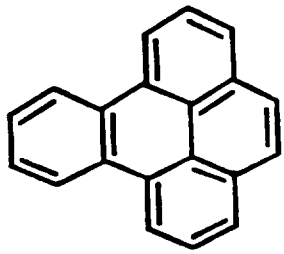
Benzo(k)fluoranthene



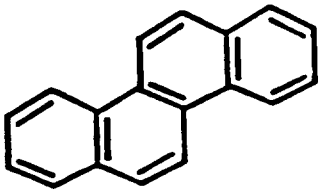
Benzo(g,h,i)perylene



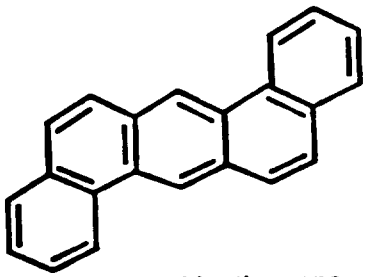
Benzo(a)pyrene



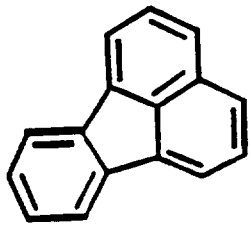
Benzo(e)pyrene



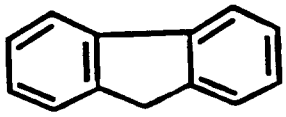
Chrysene



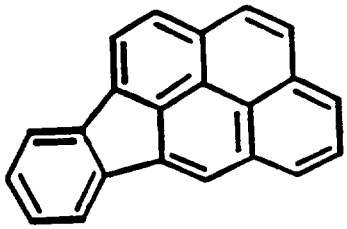
Dibenz(a,h)anthracene



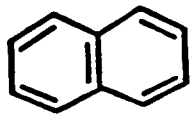
Fluoranthene



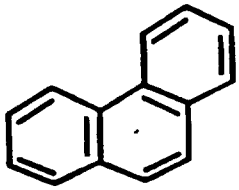
Fluorene



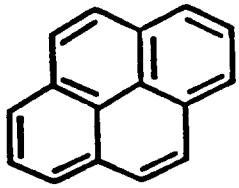
Indeno(1,2,3-c,d)pyrene



Naphthalene



Phenanthrene



Pyrene

FIGURE 1.0 RING STRUCTURE OF SELECTIVE PAHs.

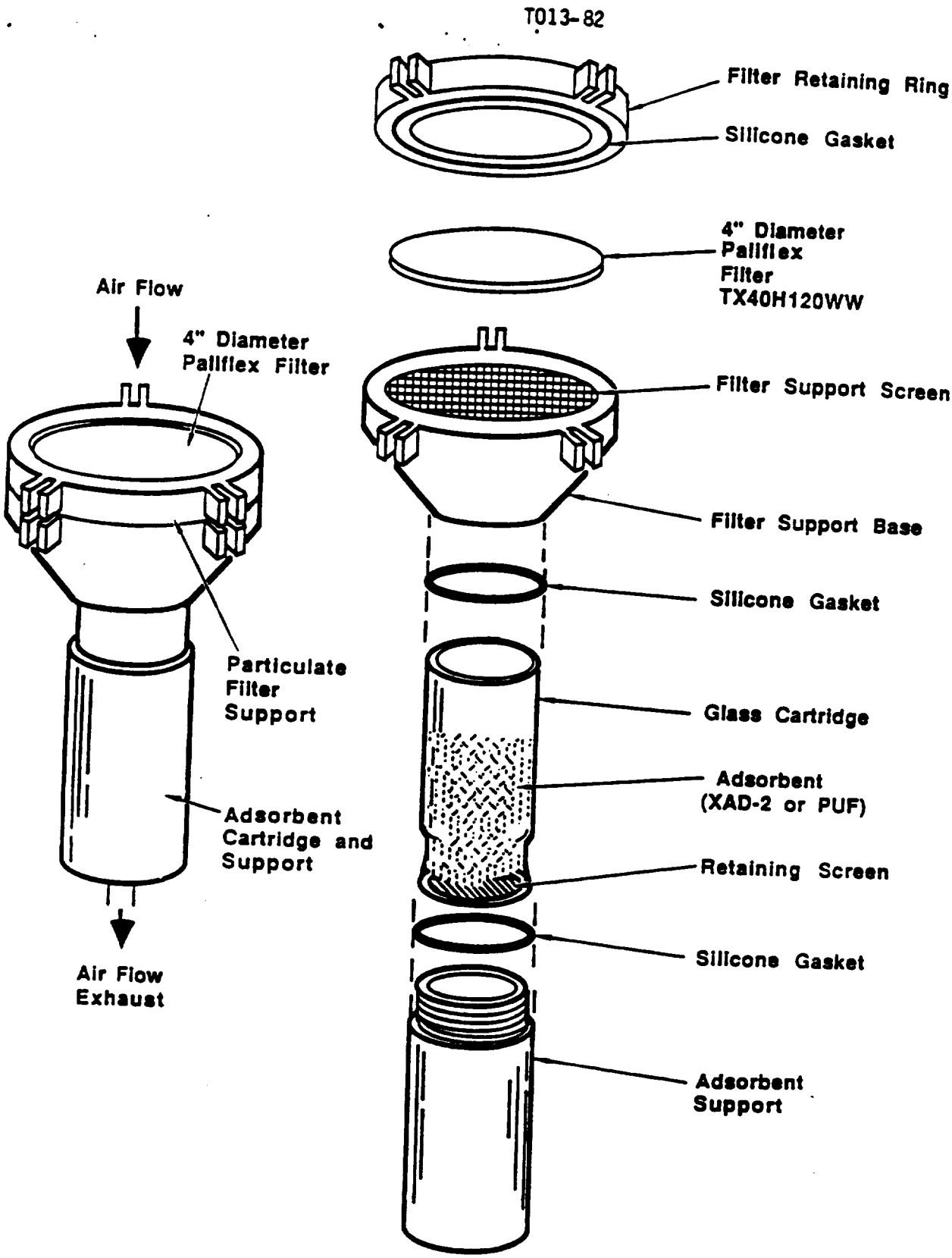


FIGURE 2.0 GENERAL METAL WORKS SAMPLING HEAD

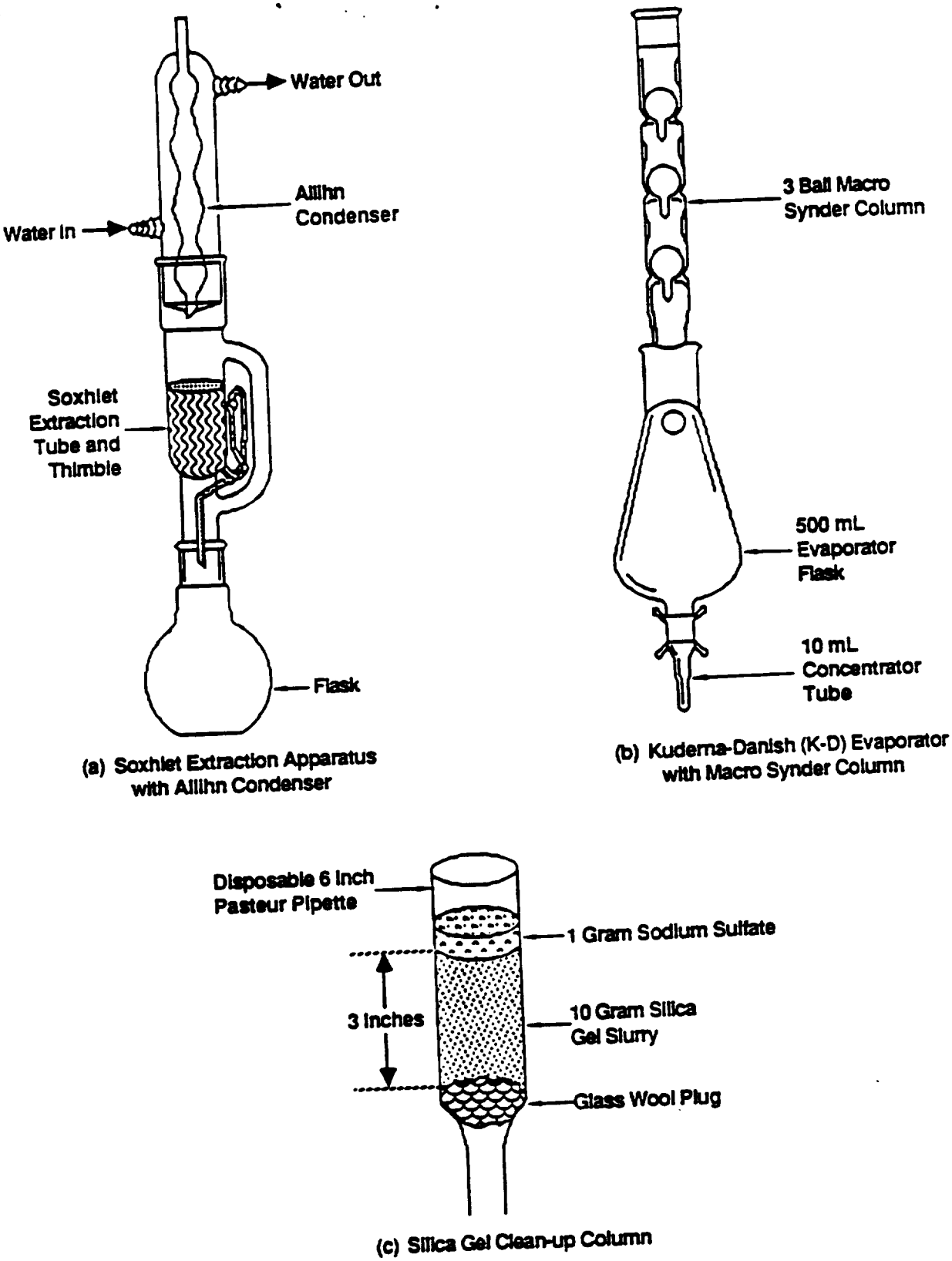


FIGURE 3. APPARATUS USES IN SAMPLING ANALYSIS.

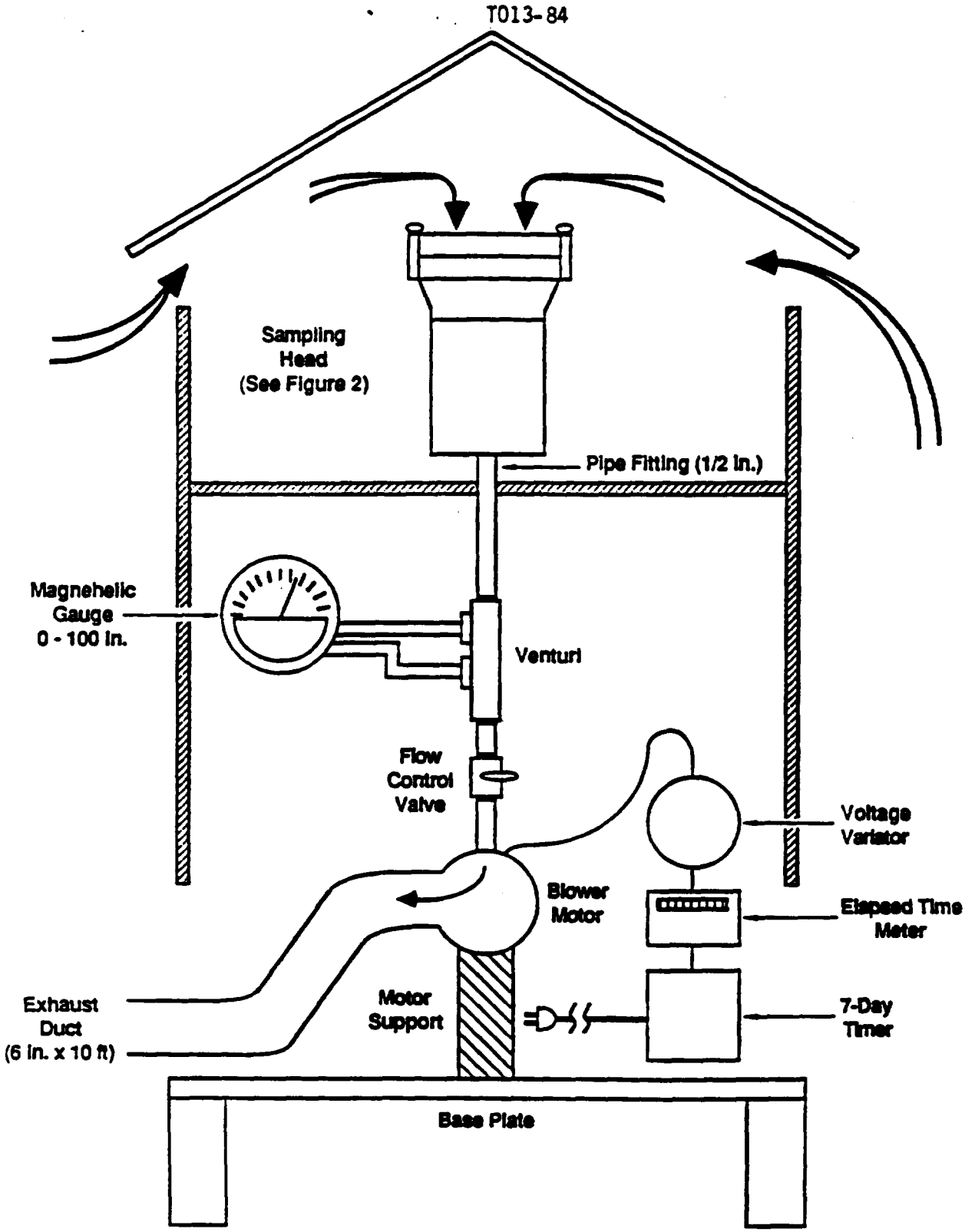


FIGURE 4. MODIFIED HIGH VOLUME AIR SAMPLER

GENERAL METAL WORKS MODEL PS-1 SAMPLER

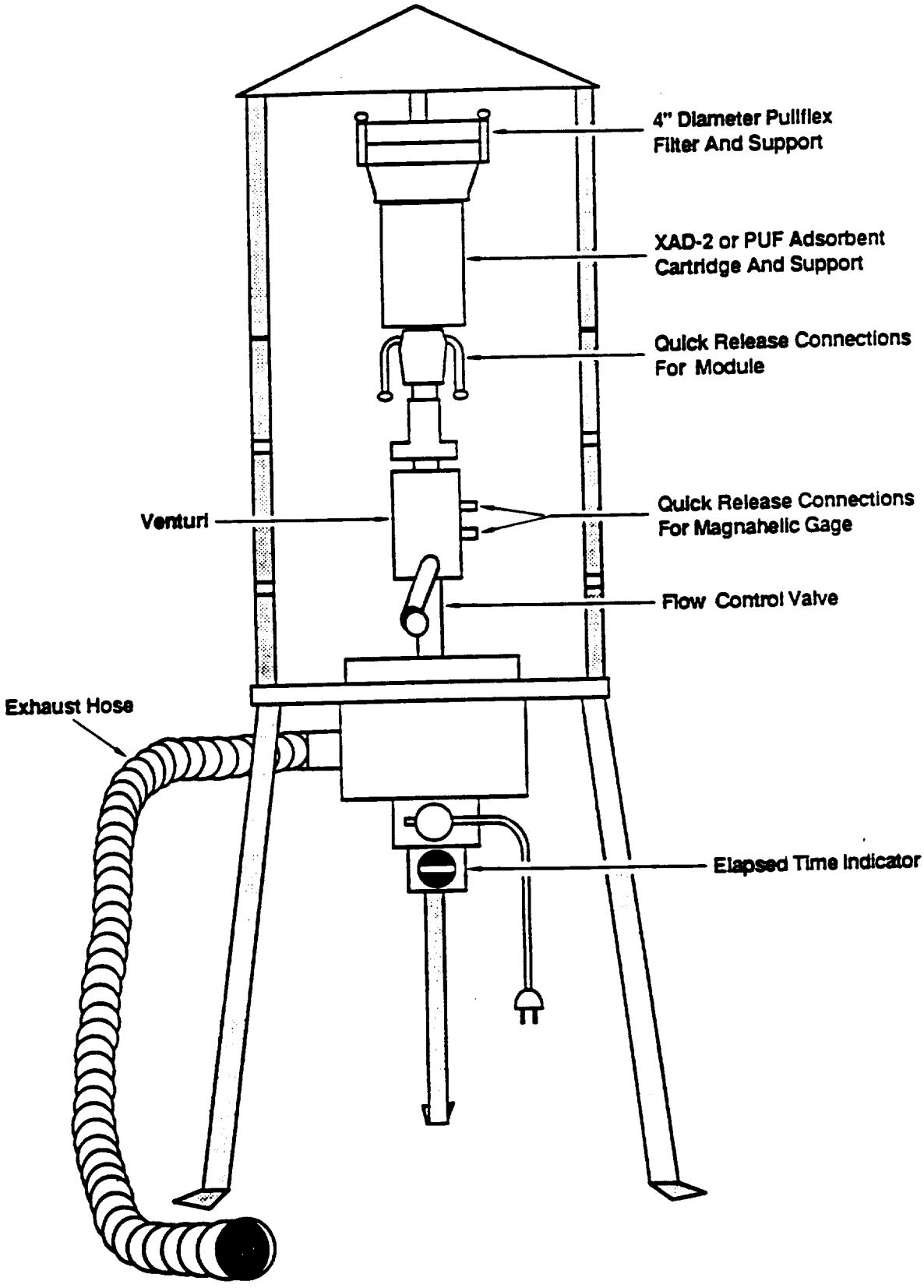


FIGURE 5. PORTABLE HIGH VOLUME AIR SAMPLER

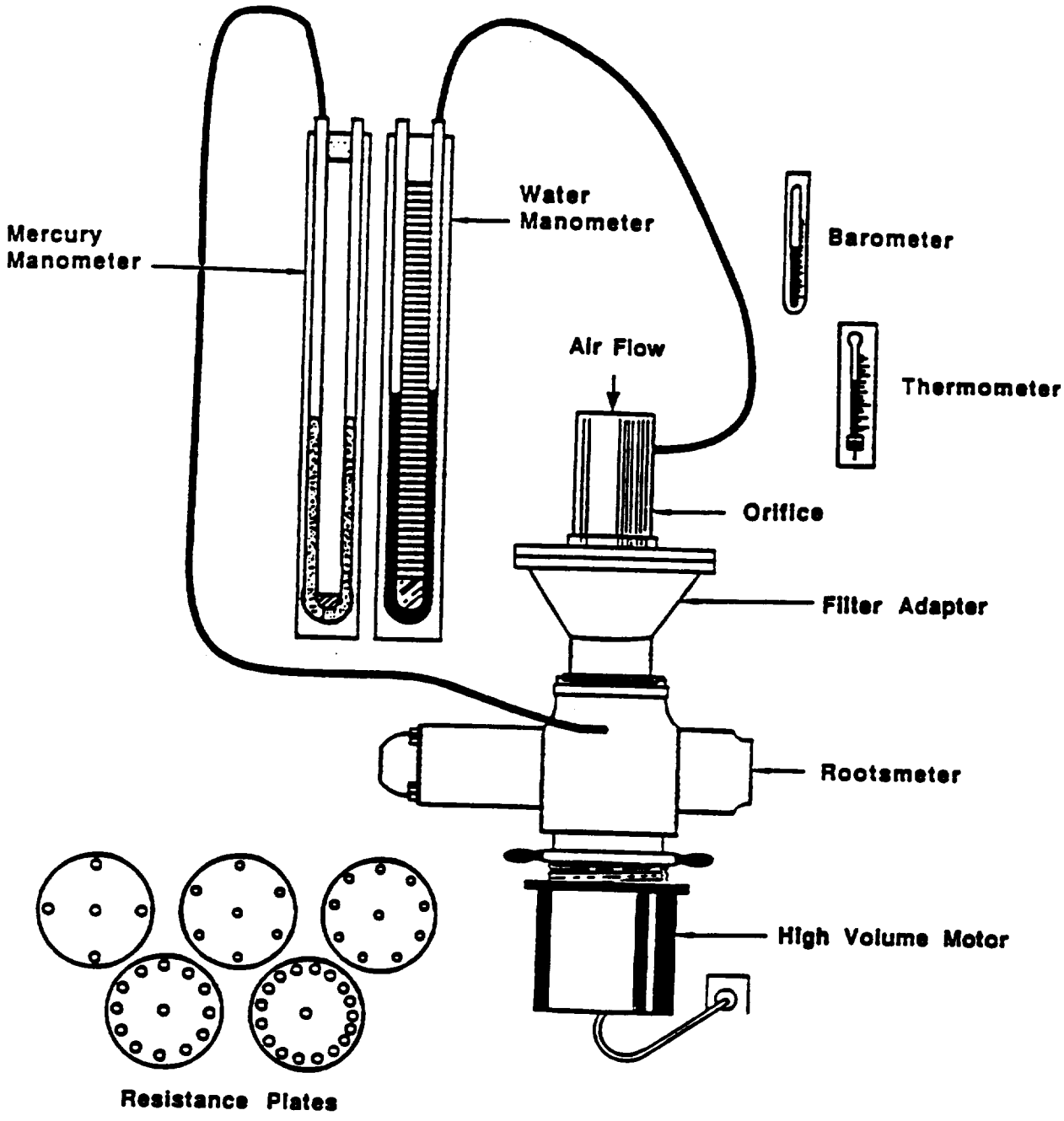


FIGURE 6. LABORATORY ORIFICE CALIBRATION SETUP

T_1 _____ °C _____ K

P_1 _____ mmHg

Orifice No. _____

Roots Meter No. _____

Name _____

Date _____

Resistance Plates (No. of Holes)	Air Volume Measured By Rootsmeter V_m		Standard Volume V_{std} (std m^3)	Time For Air Volume To Pass Through Rootsmeter Θ (min)	Roots Meter Pressure Differential ΔP (mm Hg)	Pressure Drop Across Orifice ΔH (in. H_2O)	x-Axis Standard Flow Rate Q_{std} (std m^3/min)	y-Axis $\sqrt{\Delta H(P_1 / P_{std})(298 / T_1)}$ Value
	(ft^3)	(m^3)						
5	200	5.66						
7	200	5.66						
10	300	8.50						
13	300	8.50						
18	300	8.50						

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Factors: $(ft^3)\left(0.02832 \frac{m^3}{ft^3}\right) = m^3$ and (In. Hg) $25.4\left(\frac{\text{mm Hg}}{\text{In. Hg}}\right)$ = mm Hg.

Calculation Equations: 1. $V_{std} = V_m \left(\frac{P_1 - \Delta P}{P_{std}}\right)\left(\frac{T_{std}}{T_1}\right)$ Where: T_{std} = 298 K, P_{std} = 760.0 mm Hg 2. $Q_{std} = \frac{V_{std}}{\Theta}$

FIGURE 7. ORIFICE CALIBRATION DATA SHEET.

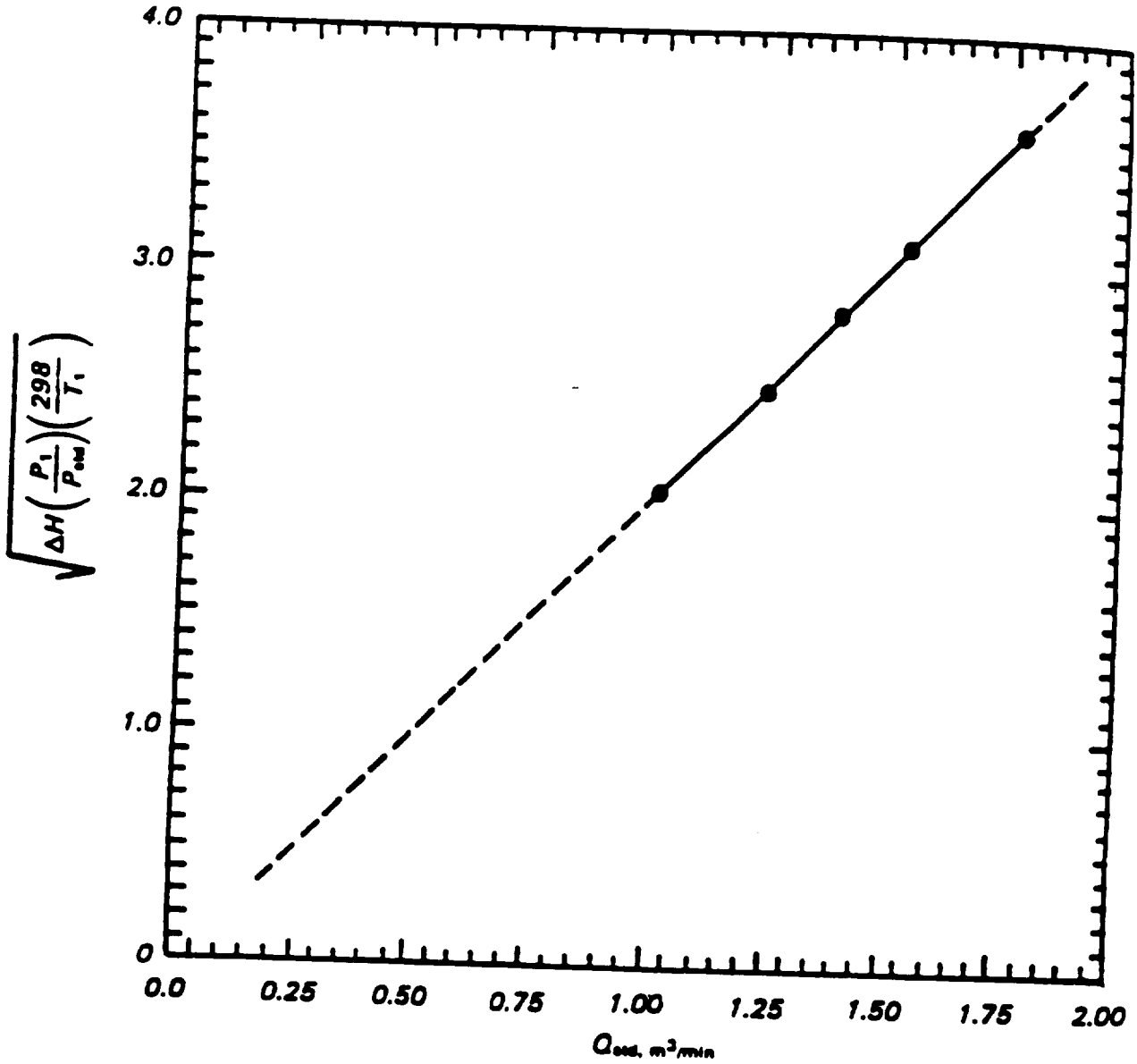

FIGURE 8. ORIFICE METER CALIBRATION CURVE

Performed by _____ Calibration Orifice _____ S/N _____ Ambient Temperature _____ ° C

Date/Time _____ Manometer S/N _____ Bar. Press. _____ mm Hg

Sampler S/N	Variac Setting V	Timer OK? Yes/No	Flow Rate Transfer Standard		Sampler Venturi Date		Comments
			Manometer in. H_2O	Q_{std} [a]	Magnehelic, in. H_2O	Q_{ms} [b]	

[a] From Calibration Curve For Flow Rate Transfer Standard (Section 11.2.1).

[b] From Calibration Curve for Venturi Tube Using Flow Rate Transfer Standard (Section 11.2.2.9).

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FIGURE 9. FIELD CALIBRATION DATA SHEET

Sampler Site _____

Sampler Location _____

Date _____

	Before	After
Barometric Pressure		
Ambient Temperature		

Site _____ Date _____ Performed By _____

Sampler S/N	Sampling Location I.D.	Height Above Ground	Identification No.		Sampling Period		Totaling Sampling Time, min.	Pump Timer Hr. Min.	Sampler Flow Check[1]				
			Filter	XAD-2 or PUF	Start	Stop			Manometer Δ H, Inches of Water	Q_{xs}	M	Q_{ms}	Within ± 10%

[1] Must Be Performed Before and After Each Sampling Period

Checked By _____

Date _____

T013-90

FIGURE 10. FIELD TEST DATA SHEET.

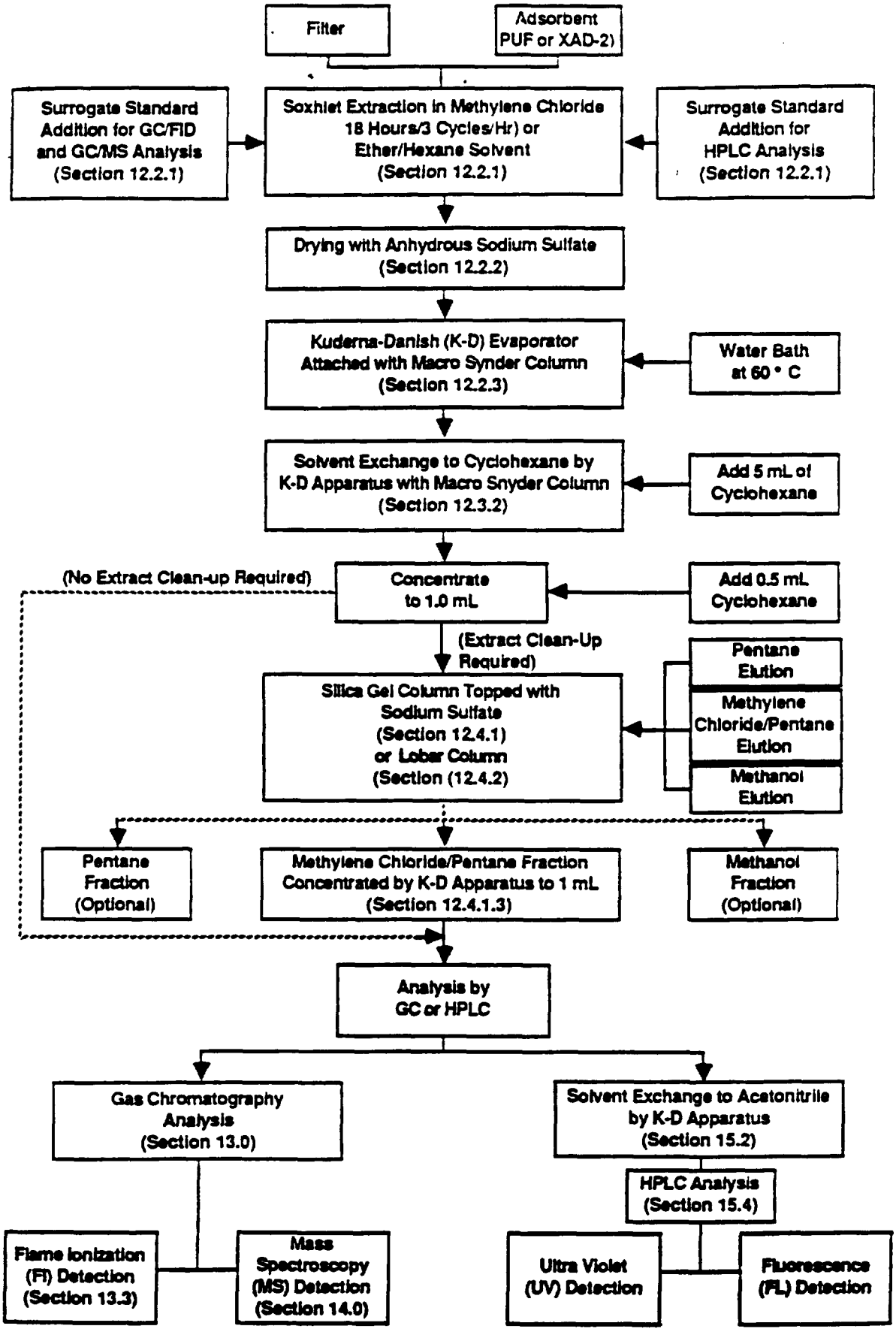


FIGURE 11.0. SAMPLE CLEAN-UP, CONCENTRATION, SEPARATION AND ANALYSIS SEQUENCE.

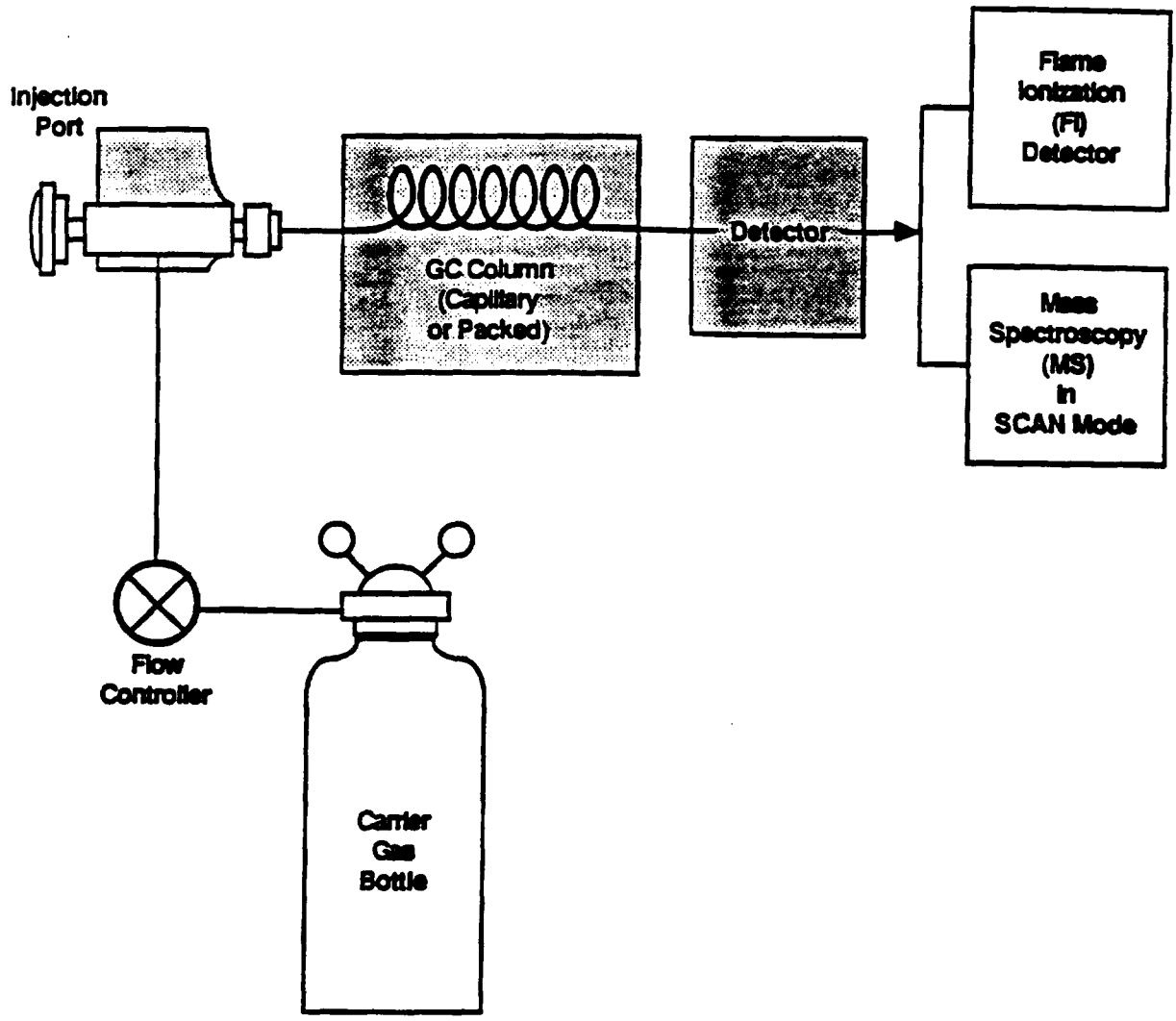


FIGURE 12.0 GC SEPARATION WITH SUBSEQUENT FLAME IONIZATION (FI) OR MASS SPECTROSCOPY (MS) DETECTION.

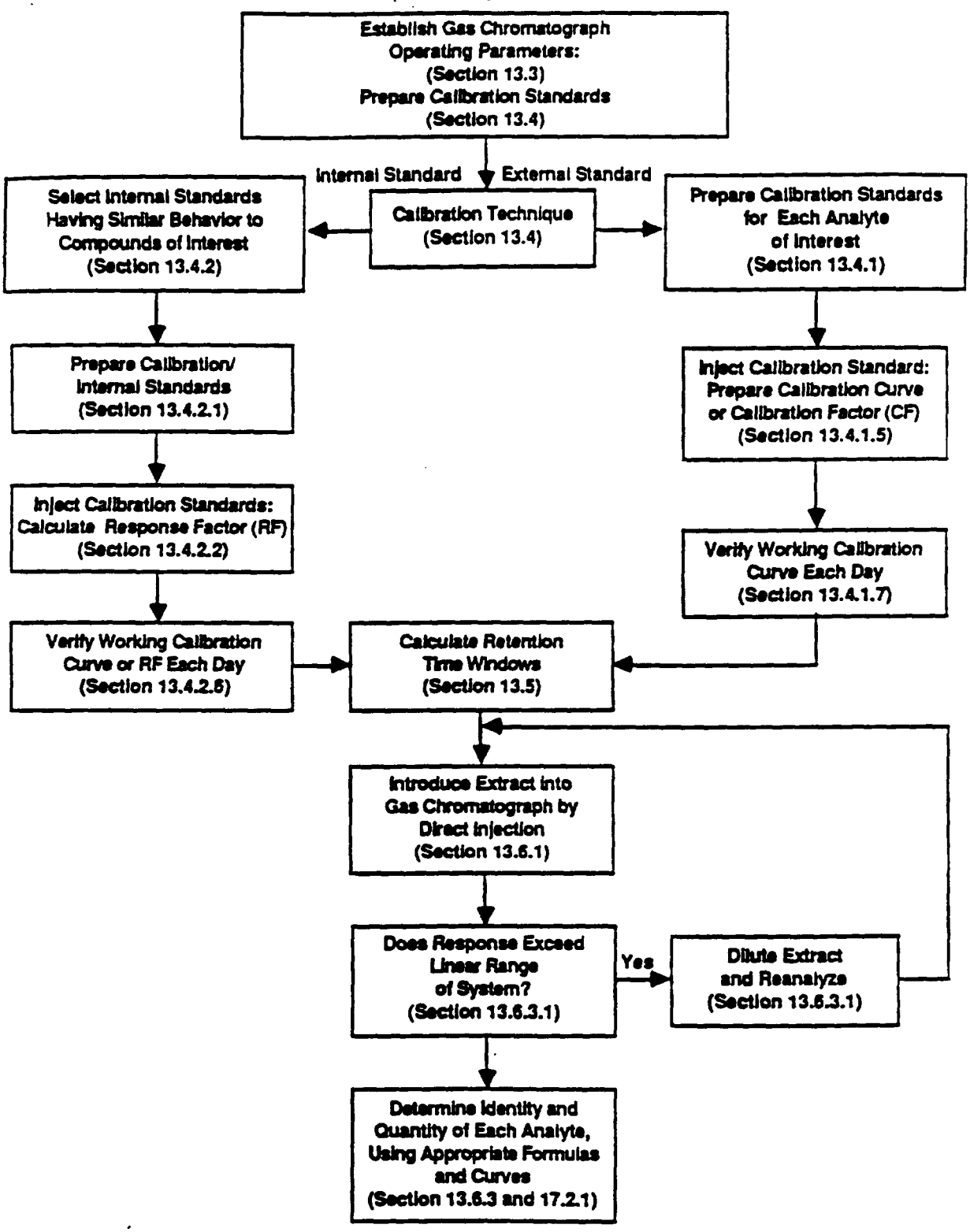
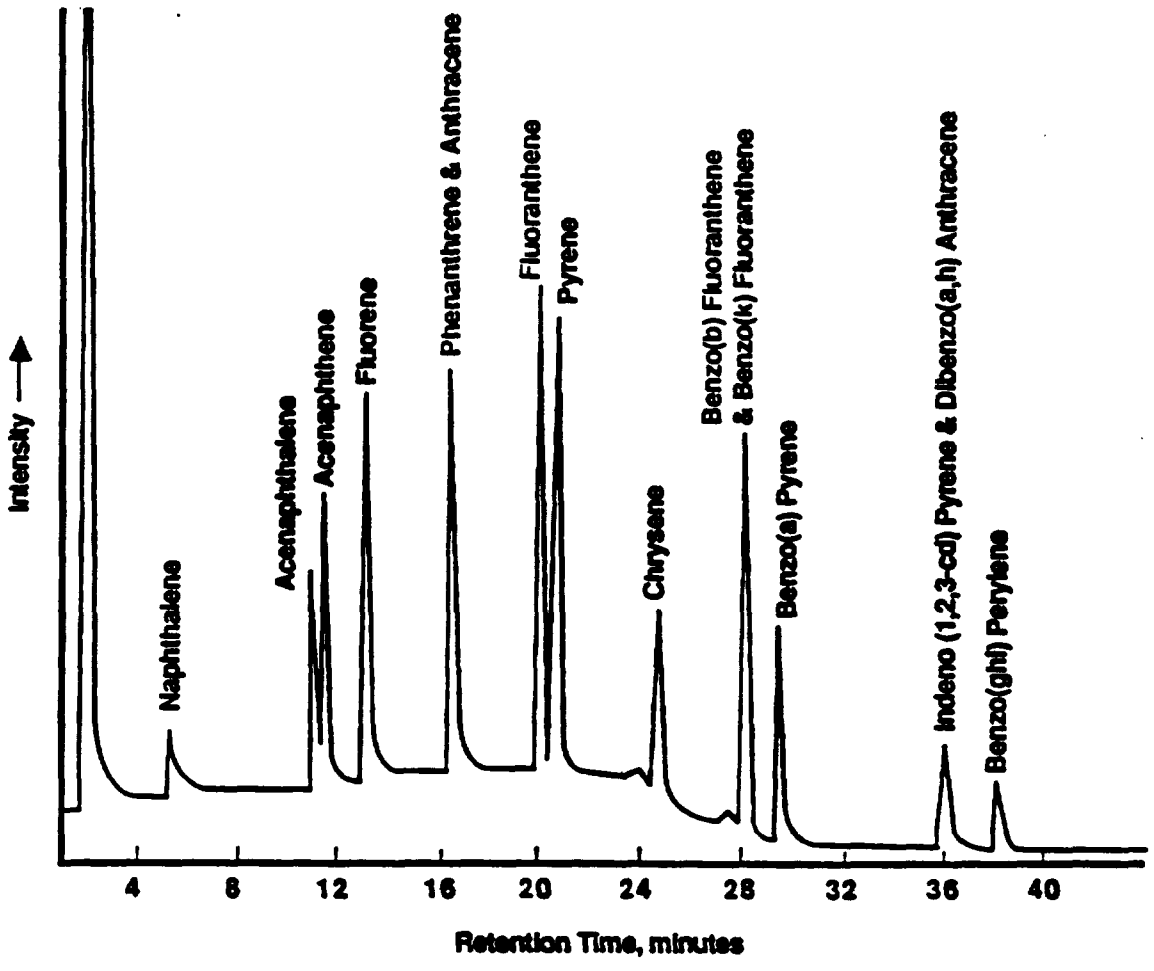


FIGURE 13.0 GC CALIBRATION AND RETENTION TIME WINDOW DETERMINATION.



Column: 3% OV-17 on Chromosorb W-AW-DCMS
Program: 100 °C. 4 min., 8 ° per min. to 280 °C.
Detector: Flame ionization

FIGURE 14.0 TYPICAL CHROMATOGRAM OF SELECTIVE PNAs BY GC EQUIPPED WITH FI DETECTOR.

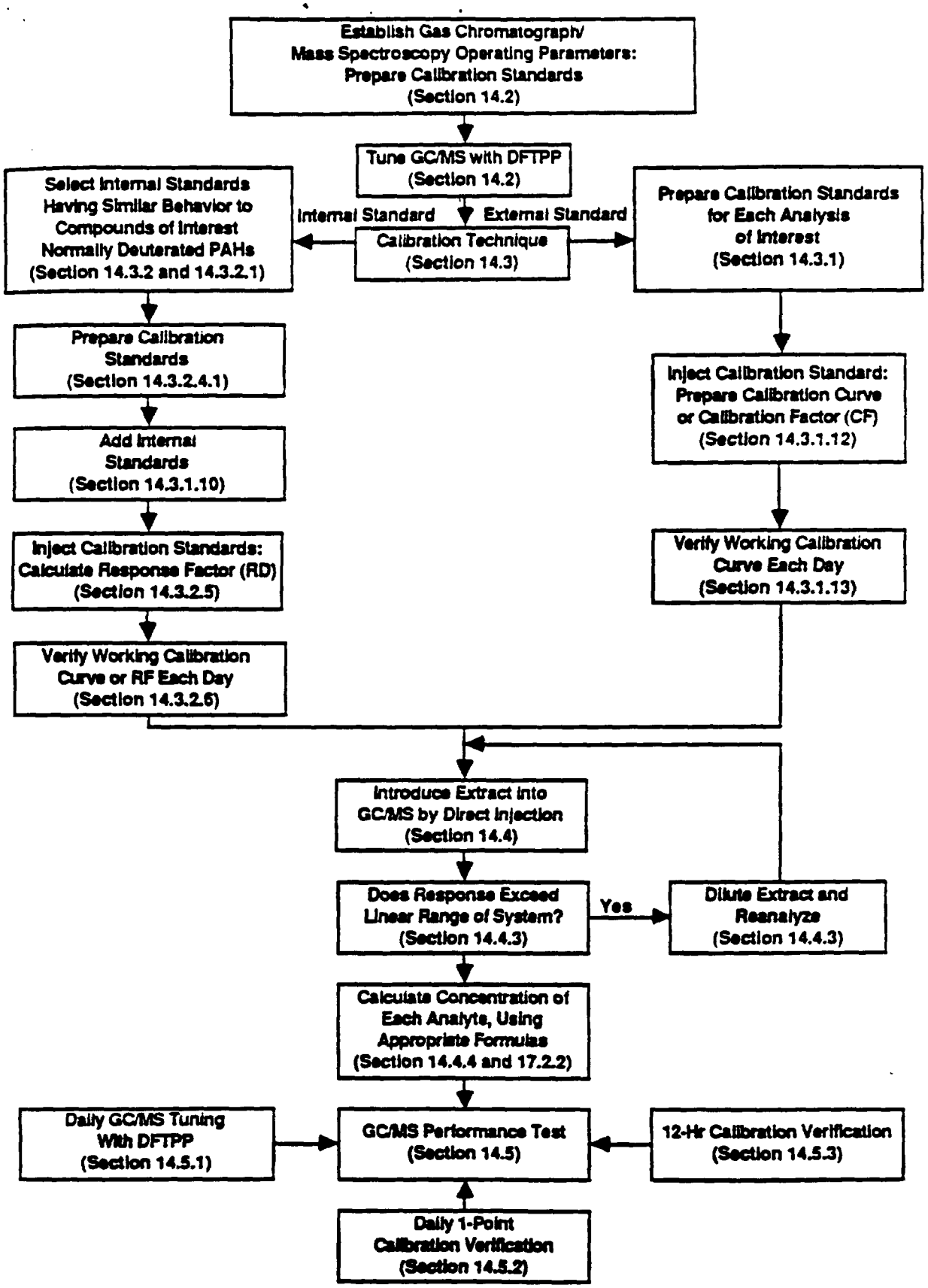


FIGURE 15.0 GC/MS CALIBRATION AND ANALYSIS.

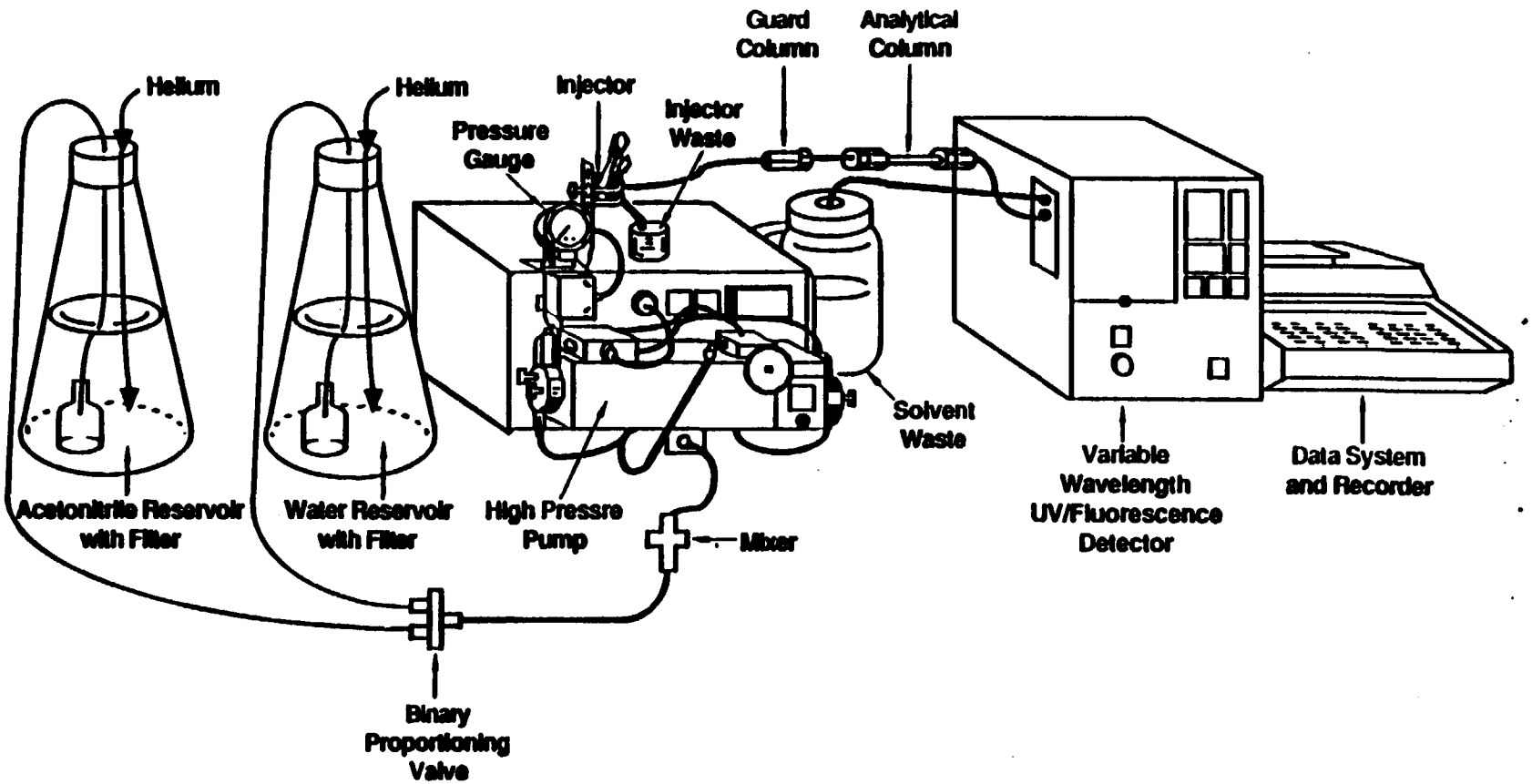


FIGURE 16. IMPORTANT COMPONENTS OF AN HPLC SYSTEM.

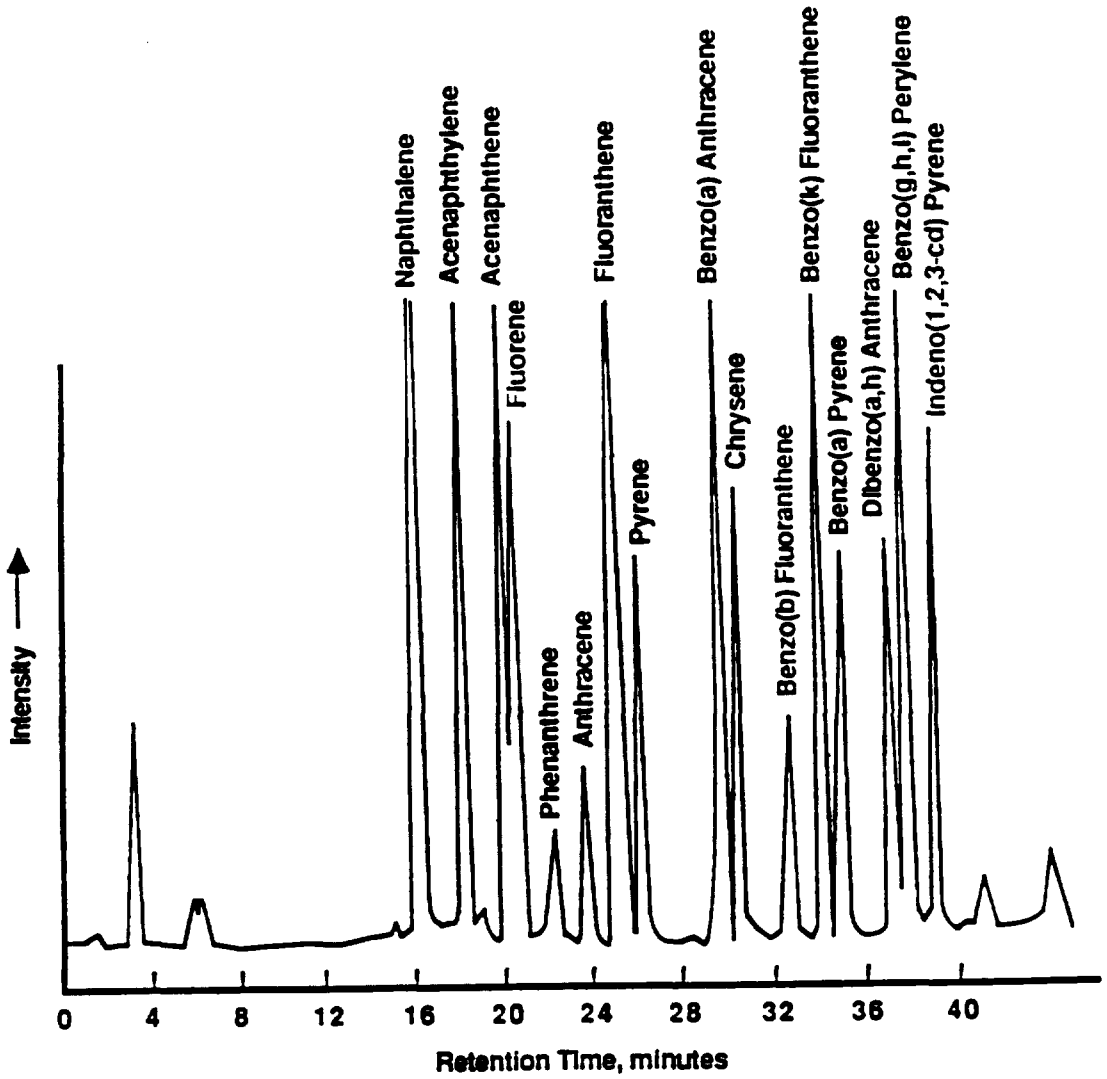


FIGURE 17.0 TYPICAL CHROMATOGRAM OF SELECTIVE PAHs ASSOCIATES WITH HPLC ANALYSIS WITH FLUORESCENCE DETECTION.

methods remove greater than 99.99 percent of the mercury.

13.1 *Disposal of Mercury-Containing Solutions.*

13.2 *Method for Forming an Amalgam.*

1. Place the waste solution in an uncapped vessel in a hood.

2. For each liter of waste solution, add approximately 10 g of sodium carbonate until neutralization has occurred (NaOH may have to be used).

3. Following neutralization, add 10 g of granular zinc or magnesium.

4. Stir the solution in a hood for 24 hours. Caution must be exercised as hydrogen gas is evolved by this treatment process.

5. After 24 hours, allow the solution to stand without stirring to allow the mercury amalgam (solid black material) to settle to the bottom of the waste receptacle.

6. Upon settling, decant and discard the supernatant liquid.

7. Quantitatively transfer the solid material to a container and allow to dry.

8. The solid material can be sent to a mercury reclaiming plant. It must not be discarded.

13.3 *Method Using Aluminum Foil Strips.*

1. Place the waste solution in an uncapped vessel in a hood.

2. For each liter of waste solution, add approximately 10 g of aluminum foil strips. If all the aluminum is consumed and no gas is evolved, add an additional 10 g of foil. Repeat until the foil is no longer consumed and allow the gas to evolve for 24 hours.

3. Decant the supernatant liquid and discard.

4. Transfer the elemental mercury that has settled to the bottom of the vessel to a storage container.

5. The mercury can be sent to a mercury reclaiming plant. It must not be discarded.

14.0 *References for SO_2 Method.*

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[Appendix A added at 47 FR 54899, Dec. 6, 1982; amended at 48 FR 17355, April 22, 1983]

APPENDIX B—REFERENCE METHOD FOR THE DETERMINATION OF SUSPENDED PARTICULATE MATTER IN THE ATMOSPHERE (HIGH-VOLUME METHOD)

1.0 *Applicability.*

1.1 This method provides a measurement of the mass concentration of total

suspended particulate matter (TSP) in ambient air for determining compliance with the primary and secondary national ambient air quality standards for particulate matter as specified in §50.6 and §50.7 of this chapter. The measurement process is nondestructive, and the size of the sample collected is usually adequate for subsequent chemical analysis. Quality assurance procedures and guidance are provided in Part 58, Appendixes A and B, of this chapter and in References 1 and 2.

2.0 *Principle.*

2.1 An air sampler, properly located at the measurement site, draws a measured quantity of ambient air into a covered housing and through a filter during a 24-hr (nominal) sampling period. The sampler flow rate and the geometry of the shelter favor the collection of particles up to 25-50 μm (aerodynamic diameter), depending on wind speed and direction.(*3*) The filters used are specified to have a minimum collection efficiency of 99 percent for 0.3 μm (DOP) particles (see Section 7.1.4).

2.2 The filter is weighed (after moisture equilibration) before and after use to determine the net weight (mass) gain. The total volume of air sampled, corrected to EPA standard conditions (25°C, 760 mm Hg [101 kPa]), is determined from the measured flow rate and the sampling time. The concentration of total suspended particulate matter in the ambient air is computed as the mass of collected particles divided by the volume of air sampled, corrected to standard conditions, and is expressed in micrograms per standard cubic meter (μg/std m^3). For samples collected at temperatures and pressures significantly different than standard conditions, these corrected concentrations may differ substantially from actual concentrations (micrograms per actual cubic meter), particularly at high elevations. The actual particulate matter concentration can be calculated from the corrected concentration using the actual temperature and pressure during the sampling period.

3.0 *Range.*

3.1 The approximate concentration range of the method is 2 to 750 μg/std m^3. The upper limit is determined by the point at which the sampler can no longer maintain the specified flow rate due to the increased pressure drop of the loaded filter. This point is affected by particle size distribution, moisture content of the collected particles, and variability from filter to filter, among other things. The lower limit is determined by the sensitivity of the balance (see Section 7.10) and by inherent sources of error (see Section 6).

3.2 At wind speeds between 1.3 and 4.5 m/sec (3 and 10 mph), the high-volume air sampler has been found to collect particles up to 25 to 50 μm, depending on wind speed and direction.(*3*) For the filter specified in Section 7.1, there is effectively no lower limit on the particle size collected.

4.0 *Precision.*

4.1 Based upon collaborative testing, the relative standard deviation (coefficient of variation) for single analyst precision (repeatability) of the method is 3.0 percent. The corresponding value for interlaboratory precision (reproducibility) is 3.7 percent.(*4*)

5.0 *Accuracy.*

5.1 The absolute accuracy of the method is undefined because of the complex nature of atmospheric particulate matter and the difficulty in determining the "true" particulate matter concentration. This method provides a measure of particulate matter concentration suitable for the purpose specified under Section 1.0, Applicability.

6.0 *Inherent Sources of Error.*

6.1 *Airflow variation.* The weight of material collected on the filter represents the (integrated) sum of the product of the instantaneous flow rate times the instantaneous particle concentration. Therefore, dividing this weight by the average flow rate over the sampling period yields the true particulate matter concentration only when the flow rate is constant over the period. The error resulting from a nonconstant flow rate depends on the magnitude of the instantaneous changes in the flow rate and in the particulate matter concentration. Normally, such errors are not large, but they can be greatly reduced by equipping the sampler with an automatic flow controlling mechanism that maintains constant flow during the sampling period. Use of a contant flow controller is recommended.*

6.2 *Air volume measurement.* If the flow rate changes substantially or nonuniformly during the sampling period, appreciable error in the estimated air volume may result from using the average of the presampling and postsampling flow rates. Greater air volume measurement accuracy may be achieved by (1) equipping the sampler with a flow controlling mechanism that maintains constant air flow during the sampling period,* (2) using a calibrated, continuous flow rate recording device to record the actual flow rate during the samping period and integrating the flow rate over the period, or (3) any other means that will accurately measure the total air volume sampled during the sampling period. Use of a continuous flow recorder is recommended, particularly if the sampler is not equipped with a constant flow controller.

6.3 *Loss of volatiles.* Volatile particles collected on the filter may be lost during subsequent sampling or during shipment and/or storage of the filter prior to the postsampling weighing.(*5*) Although such losses are largely unavoidable, the filter should be reweighed as soon after sampling as practical.

6.4 *Artifact particulate matter.* Artifact particulate matter can be formed on the surface of alkaline glass fiber filters by oxidation of acid gases in the sample air, resulting in a higher than true TSP determination.(*6 7*) This effect usually occurs early in the sample period and is a function of the filter pH and the presence of acid gases. It is generally believed to account for only a small percentage of the filter weight gain, but the effect may become more significant where relatively small particulate weights are collected.

6.5 *Humidity.* Glass fiber filters are comparatively insensitive to changes in relative humidity, but collected particulate matter can be hygroscopic.(*8*) The moisture conditioning procedure minimizes but may not completely eliminate error due to moisture.

6.6 *Filter handling.* Careful handling of the filter between the presampling and postsampling weighings is necessary to avoid errors due to loss of fibers or particles from the filter. A filter paper cartridge or cassette used to protect the filter can minimize handling errors. (See Reference 2, Section 2).

6.7 *Nonsampled particulate matter.* Particulate matter may be deposited on the filter by wind during periods when the sampler is inoperative. (*9*) It is recommended that errors from this source be minimized by an automatic mechanical device that keeps the filter covered during nonsampling periods, or by timely installa-

*At elevated altitudes, the effectiveness of automatic flow controllers may be reduced because of a reduction in the maximum sampler flow.

tion and retrieval of filters to minimize the nonsampling periods prior to and following operation.

6.8 *Timing errors.* Samplers are normally controlled by clock timers set to start and stop the sampler at midnight. Errors in the nominal 1,440-min sampling period may result from a power interruption during the sampling period or from a discrepancy between the start or stop time recorded on the filter information record and the actual start or stop time of the sampler. Such discrepancies may be caused by (1) poor resolution of the timer set-points, (2) timer error due to power interruption, (3) missetting of the timer, or (4) timer malfunction. In general, digital electronic timers have much better set-point resolution than mechanical timers, but require a battery backup system to maintain continuity of operation after a power interruption. A continuous flow recorder or elapsed time meter provides an indication of the sampler run-time, as well as indication of any power interruption during the sampling period and is therefore recommended.

6.9 *Recirculation of sampler exhaust.* Under stagnant wind conditions, sampler exhaust air can be resampled. This effect does not appear to affect the TSP measurement substantially, but may result in increased carbon and copper in the collected sample. (*10*) This problem can be reduced by ducting the exhaust air well away, preferably downwind, from the sampler.

7.0 *Apparatus.*

(See References 1 and 2 for quality assurance information.)

NOTE: Samplers purchased prior to the effective date of this amendment are not subject to specifications preceded by (†).

7.1 *Filter.* (Filters supplied by the Environmental Protection Agency can be assumed to meet the following criteria. Additional specifications are required if the sample is to be analyzed chemically.)

7.1.1 *Size:* 20.3±0.2×25.4 ± 0.2 cm (nominal 8×10 in).

7.1.2 *Nominal exposed area:* 406.5 cm^2 (63 in^2).

7.1.3. *Material:* Glass fiber or other relatively inert, nonhygroscopic material. (*8*)

7.1.4 *Collection efficiency:* 99 percent minimum as measured by the DOP test (ASTM-2986) for particles of 0.3 μm diameter.

7.1.5 *Recommended pressure drop range:* 42-54 mm Hg (5.6-7.2 kPa) at a flow rate of 1.5 std m^3/min through the nominal exposed area.

7.1.6 *pH:* 6 to 10. (*11*)

7.1.7 *Integrity:* 2.4 mg maximum weight loss. (*11*)

7.1.8 *Pinholes:* None.

7.1.9 *Tear strength:* 500 g minimum for 20 mm wide strip cut from filter in weakest dimension. (See ASTM Test D828-60).

7.1.10 *Brittleness:* No cracks or material separations after single lengthwise crease.

7.2 *Sampler.* The air sampler shall provide means for drawing the air sample, via reduced pressure, through the filter at a uniform face velocity.

7.2.1 The sampler shall have suitable means to:

a. Hold and seal the filter to the sampler housing.

b. Allow the filter to be changed conveniently.

c. Preclude leaks that would cause error in the measurement of the air volume passing through the filter.

d. † Manually adjust the flow rate to accommodate variations in filter pressure drop and site line voltage and altitude. The adjustment may be accomplished by an automatic flow controller or by a manual flow adjustment device. Any manual adjustment device must be designed with positive detents or other means to avoid unintentional changes in the setting.

7.2.2 *Minimum sample flow rate, heavily loaded filter:* 1.1 m^3/min (39 ft^3/min).††

7.2.3 *Maximum sample flow rate, clean filter:* 1.7 m^3/min (60 ft^3/min).††

7.2.4 *Blower Motor:* The motor must be capable of continuous operation for 24-hr periods.

7.3 *Sampler shelter.*

7.3.1 The sampler shelter shall:

a. Maintain the filter in a horizontal position at least 1 m above the sampler supporting surface so that sample air is drawn downward through the filter.

†See note at beginning of Section 7 of this appendix.

††These specifications are in actual air volume units; to convert to EPA standard air volume units, multiply the specifications by $(P_b/P_{std})(298/T)$ where P_b and T are the barometric pressure in mm Hg (or kPa) and the temperature in K at the sampler, and P_{std} is 760 mm Hg (or 101 kPa).

b. Be rectangular in shape with a gabled roof, similar to the design shown in Figure 1.

c. Cover and protect the filter and sampler from precipitation and other weather.

d. Discharge exhaust air at least 40 cm from the sample air inlet.

e. Be designed to minimize the collection of dust from the supporting surface by incorporating a baffle between the exhaust outlet and the supporting surface.

7.3.2 The sampler cover or roof shall overhang the sampler housing somewhat, as shown in Figure 1, and shall be mounted so as to form an air inlet gap between the cover and the sampler housing walls. †This sample air inlet should be approximately uniform on all sides of the sampler. †The area of the sample air inlet must be sized to provide an effective particle capture air velocity of between 20 and 35 cm/sec at the recommended operational flow rate. The capture velocity is the sample air flow rate divided by the inlet area measured in a horizontal plane at the lower edge of the cover. †Ideally, the inlet area and operational flow rate should be selected to obtain a capture air velocity of 25 ± cm/sec.

7.4 *Flow rate measurement devices.*

7.4.1 The sampler shall incorporate a flow rate measurement device capable of indicating the total sampler flow rate. Two common types of flow indicators covered in the calibration procedure are (1) an electronic mass flowmeter and (2) an orifice or orifices located in the sample air stream together with a suitable pressure indicator such as a manometer, or aneroid pressure gauge. A pressure recorder may be used with an orifice to provide a continuous record of the flow. Other types of flow indicators (including rotameters) having comparable precision and accuracy are also acceptable.

7.4.2 † The flow rate measurement device must be capable of being calibrated and read in units corresponding to a flow rate which is readable to the nearest 0.02 std m^3/min over the range 1.0 to 1.8 std m^3/min.

7.5 *Thermometer,* to indicate the approximate air temperature at the flow rate measurement orifice, when temperature corrections are used.

7.5.1 *Range:* -40° to +50°C (223-323 K).

†See note at beginning of Section 7 of this appendix.

7.5.2 *Resolution:* 2°C (2 K).

7.6 *Barometer,* to indicate barometric pressure at the flow rate measurement orifice, when pressure corrections are used.

7.6.1 *Range:* 500 to 800 mm Hg (66-106 kPa).

7.6.2 *Resolution:* ± *mm Hg (0.67 kPa).*

7.7 *Timing/control device.*

7.7.1 The timing device must be capable of starting and stopping the sampler to obtain an elapsed run-time of 24 hr ±1 hr (1,440 ±60 min).

7.7.2 *Accuracy of time setting:* ±30 min, or better. (See Section 6.8).

7.8 *Flow rate transfer standard,* traceable to a primary standard. (See Section 9.2.)

7.8.1 *Approximate range:* 1.0 to 1.8 m^3/min.

7.8.2 *Resolution:* 0.02 m^3/min.

7.8.3 *Reproducibility:* ±2 percent (2 times coefficient of variation) over normal ranges of ambient temperature and pressure for the stated flow rate range. (See Reference 2, Section 2.)

7.8.4 *Maximum pressure drop at 1.7 std* m^3/min: 50 cm H_2O (5 kPa).

7.8.5 The flow rate transfer standard must connect without leaks to the inlet of the sampler and measure the flow rate of the total air sample.

7.8.6 The flow rate transfer standard must include a means to vary the sampler flow rate over the range of 1.0 to 1.8 m^3/min (35-64 ft^3/min) by introducing various levels of flow resistance between the sampler and the transfer standard inlet.

7.8.7 The conventional type of flow transfer standard consists of: An orifice unit with adapter that connects to the inlet of the sampler, a manometer or other device to measure orifice pressure drop, a means to vary the flow through the sampler unit, a thermometer to measure the ambient temperature, and a barometer to measure ambient pressure. Two such devices are shown in Figures 2a and 2b. Figure 2a shows multiple fixed resistance plates, which necessitate disassembly of the unit each time the flow resistance is changed. A preferable design, illustrated in Figure 2b, has a variable flow restriction that can be adjusted externally without disassembly of the unit. Use of a conventional, orifice-type transfer standard is assumed in the calibration procedure (Section 9). However, the use of other types of transfer standards meeting the above specifications, such as the one shown in Figure 2c, may be approved; see the note following Section 9.1.

7.9 *Filter conditioning environment*

7.9.1 *Controlled temperature:* between 15° and 30°C with less than ±°C variation during equilibration period.

7.9.2 *Controlled humidity:* Less than 50 percent relative humidity, constant within ±5 percent.

7.10 *Analytical balance.*

7.10.1 *Sensitivity:* 0.1 mg.

7.10.2 Weighing chamber designed to accept an unfolded 20.3 x 25.4 cm (8 x 10 in) filter.

7.11 *Area light source,* similar to X-ray film viewer, to backlight filters for visual inspection.

7.12 *Numbering device,* capable of printing identification numbers on the filters before they are placed in the filter conditioning environment, if not numbered by the supplier.

8.0 *Procedure.*

(See References 1 and 2 for quality assurance information.)

8.1 Number each filter, if not already numbered, near its edge with a unique identification number.

8.2 Backlight each filter and inspect for pinholes, particles, and other imperfections; filters with visible imperfections must not be used.

8.3 Equilibrate each filter in the conditioning environment for at least 24-hr.

8.4 Following equilibration, weigh each filter to the nearest milligram and record this tare weight (W_i) with the filter identification number.

8.5 Do not bend or fold the filter before collection of the sample.

8.6 Open the shelter and install a numbered, preweighed filter in the sampler, following the sampler manufacturer's instructions. During inclement weather, precautions must be taken while changing filters to prevent damage to the clean filter and loss of sample from or damage to the exposed filter. Filter cassettes that can be loaded and unloaded in the laboratory may be used to minimize this problem (See Section 6.6).

8.7 Close the shelter and run the sampler for at least 5 min to establish run-temperature conditions.

8.8 Record the flow indicator reading and, if needed, the barometric pressure (P_3) and the ambient temperature (T_3) see NOTE following step 8.12). Stop the sampler. Determine the sampler flow rate (see Section 10.1); if it is outside the acceptable range (1.1 to 1.7 m^3/min [39-60 ft^3/min]), use a different filter, or adjust the sampler flow rate. Warning: Substantial flow adjustments may affect the calibration of the orifice-type flow indicators and may necessitate recalibration.

8.9 Record the sampler identification information (filter number, site location or identification number, sample date, and starting time).

8.10 Set the timer to start and stop the sampler such that the sampler runs 24-hrs, from midnight to midnight (local time).

8.11 As soon as practical following the sampling period, run the sampler for at least 5 min to again establish run-temperature conditions.

8.12 Record the flow indicator reading and, if needed, the barometric pressure (P_3) and the ambient temperature (T_3).

NOTE: No onsite pressure or temperature measurements are necessary if the sampler flow indicator does not require pressure or temperature corrections (e.g., a mass flowmeter) or if average barometric pressure and seasonal average temperature for the site are incorporated into the sampler calibration (see step 9.3.9). For individual pressure and temperature corrections, the ambient pressure and temperature can be obtained by onsite measurements or from a nearby weather station. Barometric pressure readings obtained from airports must be station pressure, not corrected to sea level, and may need to be corrected for differences in elevation between the sampler site and the airport. For samplers having flow recorders but not constant flow controllers, the average temperature and pressure at the site *during the sampling period* should be estimated from weather bureau or other available data.

8.13 Stop the sampler and carefully remove the filter, following the sampler manufacturer's instructions. Touch only the outer edges of the filter. See the precautions in step 8.6.

8.14 Fold the filter in half lengthwise so that only surfaces with collected particulate matter are in contact and place it in the filter holder (glassine envelope or manila folder).

8.15 Record the ending time or elapsed time on the filter information record, either from the stop set-point time, from an elapsed time indicator, or from a continuous flow record. The sample period must be 1,440 ± 60 min. for a valid sample.

8.16 Record on the filter information record any other factors, such as meteorological conditions, construction activity, fires or dust storms, etc., that might be pertinent to the measurement. If the sam-

ple is known to be defective, void it at this time.

8.17 Equilibrate the exposed filter in the conditioning environment for at least 24-hrs.

8.18 Immediately after equilibration, reweigh the filter to the nearest milligram and record the gross weight with the filter identification number. See Section 10 for TSP concentration calculations.

9.0 *Calibration.*

9.1 Calibration of the high volume sampler's flow indicating or control device is necessary to establish traceability of the field measurement to a primary standard via a flow rate transfer standard. Figure 3a illustrates the certification of the flow rate transfer standard and Figure 3b illustrates its use in calibrating a sampler flow indicator. Determination of the corrected flow rate from the sampler flow indicator, illustrated in Figure 3c, is addressed in Section 10.1

NOTE: The following calibration procedure applies to a conventional orifice-type flow transfer standard and an orifice-type flow indicator in the sampler (the most common types). For samplers using a pressure recorder having a square-root scale, 3 other acceptable calibration procedures are provided in Reference 12. Other types of transfer standards may be used if the manufacturer or user provides an appropriately modified calibration procedure that has been approved by EPA under Section 2.8 of Appendix C to Part 58 of this chapter.

9.2 *Certification of the flow rate transfer standard.*

9.2.1 *Equipment required:* Positive displacement standard volume meter traceable to the National Bureau of Standards (such as a Roots meter or equivalent), stop-watch, manometer, thermometer, and barometer.

9.2.2 Connect the flow rate transfer standard to the inlet of the standard volume meter. Connect the manometer to measure the pressure at the inlet of the standard volume meter. Connect the orifice manometer to the pressure tap on the transfer standard. Connect a high-volume air pump (such as a high-volume sampler blower) to the outlet side of the standard volume meter. See Figure 3a.

9.2.3 Check for leaks by temporarily clamping both manometer lines (to avoid fluid loss) and blocking the orifice with a large-diameter rubber stopper, wide cellophane tape, or other suitable means. Start the high-volume air pump and note any change in the standard volume meter reading. The reading should remain constant. If the reading changes, locate any leaks by listening for a whistling sound and/or retightening all connections, making sure that all gaskets are properly installed.

9.2.4 After satisfactorily completing the leak check as described above, unclamp both manometer lines and zero both manometers.

9.2.5 Achieve the appropriate flow rate through the system, either by means of the variable flow resistance in the transfer standard or by varying the voltage to the air pump. (Use of resistance plates as shown in Figure 1a is discouraged because the above leak check must be repeated each time a new resistance plate is installed.) At least five different but constant flow rates, evenly distributed, with at least three in the specified flow rate interval (1.1 to 1.7 m^3/min [39-60 ft^3/min]), are required.

9.2.6 Measure and record the certification data on a form similar to the one illustrated in Figure 4 according to the following steps.

9.2.7 Observe the barometric pressure and record as P_1 (item 8 in Figure 4).

9.2.8 Read the ambient temperature in the vicinity of the standard volume meter and record it as T_1 (item 9 in Figure 4).

9.2.9 Start the blower motor, adjust the flow, and allow the system to run for at least 1 min for a constant motor speed to be attained.

9.2.10 Observe the standard volume meter reading and simultaneously start a stopwatch. Record the initial meter reading (V_i) in column 1 of Figure 4.

9.2.11 Maintain this constant flow rate until at least 3 m^3 of air have passed through the standard volume meter. Record the standard volume meter inlet pressure manometer reading as ΔP (column 5 in Figure 4), and the orifice manometer reading as ΔH (column 7 in Figure 4). Be sure to indicate the correct units of measurement.

9.2.12 After at least 3 m^3 of air have passed through the system, observe the standard volume meter reading while simultaneously stopping the stopwatch. Record the final meter reading (V_f) in column 2 and the elapsed time (t) in column 3 of Figure 4.

9.2.13 Calculate the volume measured by the standard volume meter at meter conditions of temperature and pressures as $V_m = V_f - V_i$. Record in column 4 of Figure 4.

9.2.14 Correct this volume to standard volume (std m_3) as follows:

$$V_{std} = V_m \frac{P_1 - \Delta P}{P_{std}} \frac{T_{std}}{T_1}$$

where:

V_{std}=standard volume, std m^3;

V_m=actual volume measured by the standard volume meter;

P_1=barometric pressure during calibration, mm Hg or kPa;

ΔP=differential pressure at inlet to volume meter, mm Hg or kPa;

P_{std}=760 mm Hg or 101 kPa;

T_{std}=298 K;

T_1=ambient temperature during calibration, K.

Calculate the standard flow rate (std m^3/min) as follows:

$$Q_{std} = \frac{V_{std}}{t}$$

where:

Q_{std}=standard volumetric flow rate, std m^3/min

t=elapsed time, minutes.

Record Q_{std} to the nearest 0.01 std m^3/min in column 6 of Figure 4.

9.2.15 Repeat steps 9.2.9 through 9.2.14 for at least four additional constant flow rates, evenly spaced over the approximate range of 1.0 to 1.8 std m^3/min (35-64 ft^3/min).

9.2.16 For each flow, compute

$\sqrt{\Delta H}\ (P_1/P_{std})(298/T_1)$

(column 7a of Figure 4) and plot these value against Q_{std} as shown in Figure 3a. Be sure to use consistent units (mm Hg or kPa) for barometric pressure. Draw the orifice transfer standard certification curve or calculate the linear least squares slope (m) and intercept (b) of the certification curve:

$\sqrt{\Delta H}\ (P_1/P_{std})(298/T_1)$

$=mQ_{std}+b$. See Figures 3 and 4. A certification graph should be readable to 0.02 std m^3/min.

9.2.17 Recalibrate the transfer standard annually or as required by applicable quality control procedures. (See Reference 2.)

9.3 *Calibration of sampler flow indicator.*

NOTE: For samplers equipped with a flow controlling device, the flow controller must be disabled to allow flow changes during calibration of the sampler's flow indicator, or the alternate calibration of the flow controller given in 9.4 may be used. For samplers using an orifice-type flow indicator downstream of the motor, do not vary the flow rate by adjusting the voltage or power supplied to the sampler.

9.3.1 A form similar to the one illustrated in Figure 5 should be used to record the calibration data.

9.3.2 Connect the transfer standard to the inlet of the sampler. Connect the orifice manometer to the orifice pressure tap, as illustrated in Figure 3b. Make sure there are no leaks between the orifice unit and the sampler.

9.3.3 Operate the sampler for at least 5 minutes to establish thermal equilibrium prior to the calibration.

9.3.4 Measure and record the ambient temperature, T_2, and the barometric pressure, P_2, during calibration.

9.3.5 Adjust the variable resistance or, if applicable, insert the appropriate resistance plate (or no plate) to achieve the desired flow rate.

9.3.6 Let the sampler run for at least 2 min to re-establish the run-temperature conditions. Read and record the pressure drop across the orifice (ΔH) and the sampler flow rate indication (I) in the appropriate columns of Figure 5.

9.3.7 Calculate $\sqrt{\Delta H}\ (P_2/P_{std})(298/T_2)$ and determine the flow rate at standard conditions (Q_{std}) either graphically from the certification curve or by calculating Q_{std} from the least square slope and intercept of the transfer standard's transposed certification curve:

$Q_{std}=1/m\ \sqrt{\Delta H}\ (P_2/P_{std})(298/T_2)$-b

Record the value of Q_{std} on Figure 5.

9.3.8 Repeat steps 9.3.5, 9.3.6, and 9.3.7 for several additional flow rates distributed over a range that includes 1.1 to 1.7 std m^3/min.

9.3.9 Determine the calibration curve by plotting values of the appropriate expression involving I, selected from Table 1, against Q_{std}. The choice of expression from Table 1 depends on the flow rate measurement device used (see Section 7.4.1) and also on whether the calibration curve is to incorporate geographic average barometric pressure (P_a) and seasonal average temperature (T_a) for the site to approximate actual pressure and temperature. Where P_a and T_a can be determined for a site for a seasonal period such that the actual barometric pressure and temperature at the site do not vary by more than ±60 mm Hg (8 kPa) from P_a or ±15°C from T_a, respectively, then using P_a and T_a avoids the need for subsequent pressure and temperature calculation when the sampler is used. The geographic average barometric pressure (P_a) may be estimated from an altitude-pressure table or by making an (approximate) elevation correction of -26 mm Hg (-3.46 kPa) for each 305 m (1,000 ft) above sea level (760 mm Hg or 101 kPa). The seasonal average temperature (T_a) may be estimated from weather station or other records. Be sure to use consistent units (mm Hg or kPa) for barometric pressure.

9.3.10 Draw the sampler calibration curve or calculate the linear least squares slope (m), intercept (b), and correlation coefficient of the calibration curve: [Expression from Table 1]= $mQ_{std}+b$. See Figures 3 and 5. Calibration curves should be readable to 0.02 std m^3/min.

9.3.11 For a sampler equipped with a flow controller, the flow controlling mechanism should be re-enabled and set to a flow near the lower flow limit to allow maximum control range. The sample flow rate should be verified at this time with a clean filter installed. Then add two or more filters to the sampler to see if the flow controller maintains a constant flow; this is particularly important at high altitudes where the range of the flow controller may be reduced.

9.4 Alternate calibration of flow-controlled samplers. A flow-controlled sampler may be calibrated solely at its controlled flow rate, provided that previous operating history of the sampler demonstrates that the flow rate is stable and reliable. In this case, the flow indicator may remain uncalibrated but should be used to indicate any relative change between initial and final flows, and the sampler should be recalibrated more often to minimize potential loss of samples because of controller malfunction.

9.4.1 Set the flow controller for a flow near the lower limit of the flow range to allow maximum control range.

9.4.2 Install a clean filter in the sampler and carry out steps 9.3.2, 9.3.3, 9.3.4, 9.3.6, and 9.3.7.

9.4.3 Following calibration, add one or two additional clean filters to the sampler, reconnect the transfer standard, and operate the sampler to verify that the controller maintains the same calibrated flow rate; this is particularly important at high altitudes where the flow control range may be reduced.

[Part 50, Appendix B]

TABLE 1. EXPRESSIONS FOR PLOTTING SAMPLER CALIBRATION CURVES

Type of sampler flow rate measuring device	Expression	
	For actual pressure and temperature corrections	For incorporation of geographic average pressure and seasonal average temperature
Mass flowmeter	I	I
Orifice and pressure indicator	$\sqrt{I\left(\frac{P_2}{P_{std}}\right)\left(\frac{298}{T_2}\right)}$	$\sqrt{I\left(\frac{P_2}{P_a}\right)\left(\frac{T_a}{T_2}\right)}$
Rotameter, or orifice and pressure recorder having square root scale*	$I\sqrt{\left(\frac{P_2}{P_{std}}\right)\left(\frac{298}{T_2}\right)}$	$I\sqrt{\left(\frac{P_2}{P_a}\right)\left(\frac{T_a}{T_2}\right)}$

*This scale is recognizable by its nonuniform divisions and is the most commonly available for high-volume samplers.

[Part 50, Appendix B]

TABLE 2. EXPRESSIONS FOR DETERMINING FLOW RATE DURING SAMPLER OPERATION

Type of sampler flow rate measuring device	Expression: For actual pressure and temperature corrections	Expression: For use when geographic average pressure and seasonal average temperature have been incorporated into the sampler calibration
Mass flowmeter	I	I
Orifice and pressure indicator	$\sqrt{I\left(\frac{P_3}{P_{std}}\right)\left(\frac{298}{T_3}\right)}$	$\sqrt{I}$
Rotameter, or orifice and pressure recorder having square root scale*	$I\sqrt{\left(\frac{P_3}{P_{std}}\right)\left(\frac{298}{T_3}\right)}$	I

*This scale is recognizable by its nonuniform divisions and is the most commonly available for high-volume samplers.

10.0 *Calculations of TSP Concentration.*

10.1 Determine the average sampler flow rate during the sampling period according to either 10.1.1 or 10.1.2 below.

10.1.1 For a sampler without a continuous flow recorder, determine the appropriate expression to be used from Table 2 corresponding to the one from Table 1 used in step 9.3.9. Using this appropriate expression, determine Q_{std} for the initial flow rate from the sampler calibration curve, either graphically or from the transposed regression equation:

$Q_{std}=$
1/m ([Appropriate expression from Table 2] - b)

Similarly, determine Q_{std} from the final flow reading, and calculate the average flow Q_{std} as one-half the sum of the initial and final flow rates.

10.1.2 For a sampler with a continuous flow recorder, determine the average flow rate device reading, I, for the period. Determine the appropriate expression from Table 2 corresponding to the one from Table 1 used in step 9.3.9. Then using this expression and the average flow rate reading, determine Q_{std} from the sampler calibration curve, either graphically or from the transposed regression equation:

$Q_{std}=$
1/m ([Appropriate expression from Table 2] - b)

If the trace shows substantial flow change during the sampling period, greater accuracy may be achieved by dividing the sampling period into intervals and calculating an average reading before determining Q_{std}.

10.2 Calculate the total air volume sampled as:

$V=Q_{std}\times t$

where:

V = total air volume sampled, in standard volume units, std m^3/;

Q_{std}=average standard flow rate, std m^3/min;

t = sampling time, min.

10.3 Calculate and report the particulate matter concentration as:

$$TSP = \frac{(W_f-W_i)\times 10^6}{V}$$

where:

TSP=mass concentration of total suspended particulate matter, μg/std m^3;

W_i=initial weight of clean filter, g;

W_f=final weight of exposed filter, g;

V=air volume sampled, converted to standard conditions, std m^3,

10^6=conversion of g to μg.

10.4 If desired, the actual particulate matter concentration (see Section 2.2) can be calculated as follows:

$(TSP)_a=TSP\ (P_3/P_{std})(298/T_3)$

where:

$(TSP)_a$=actual concentration at field conditions, $\mu g/m^3$;

TSP=concentration at standard conditions, μg/std m^3;

P_3=average barometric pressure during sampling period, mm Hg;

P_{std}=760 mn Hg (or 101 kPa);

T_3=average ambient temperature during sampling period, K.

11.0 *References.*

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[Part 50, Appendix B]

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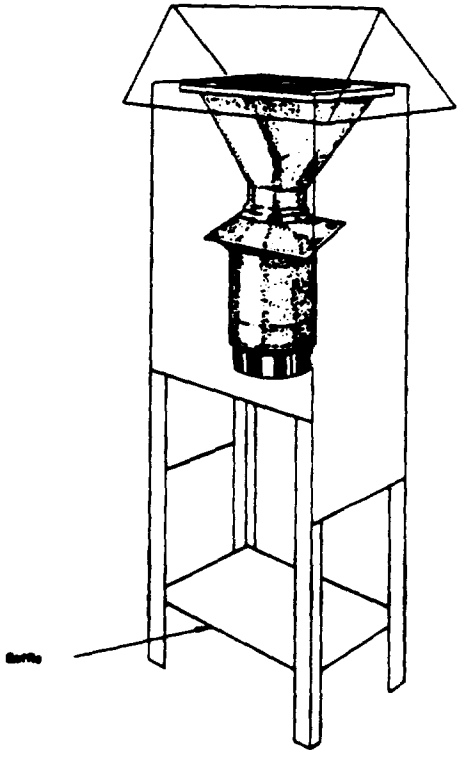


Figure 1. High-volume sampler in shelter.

[Part 50, Appendix B]

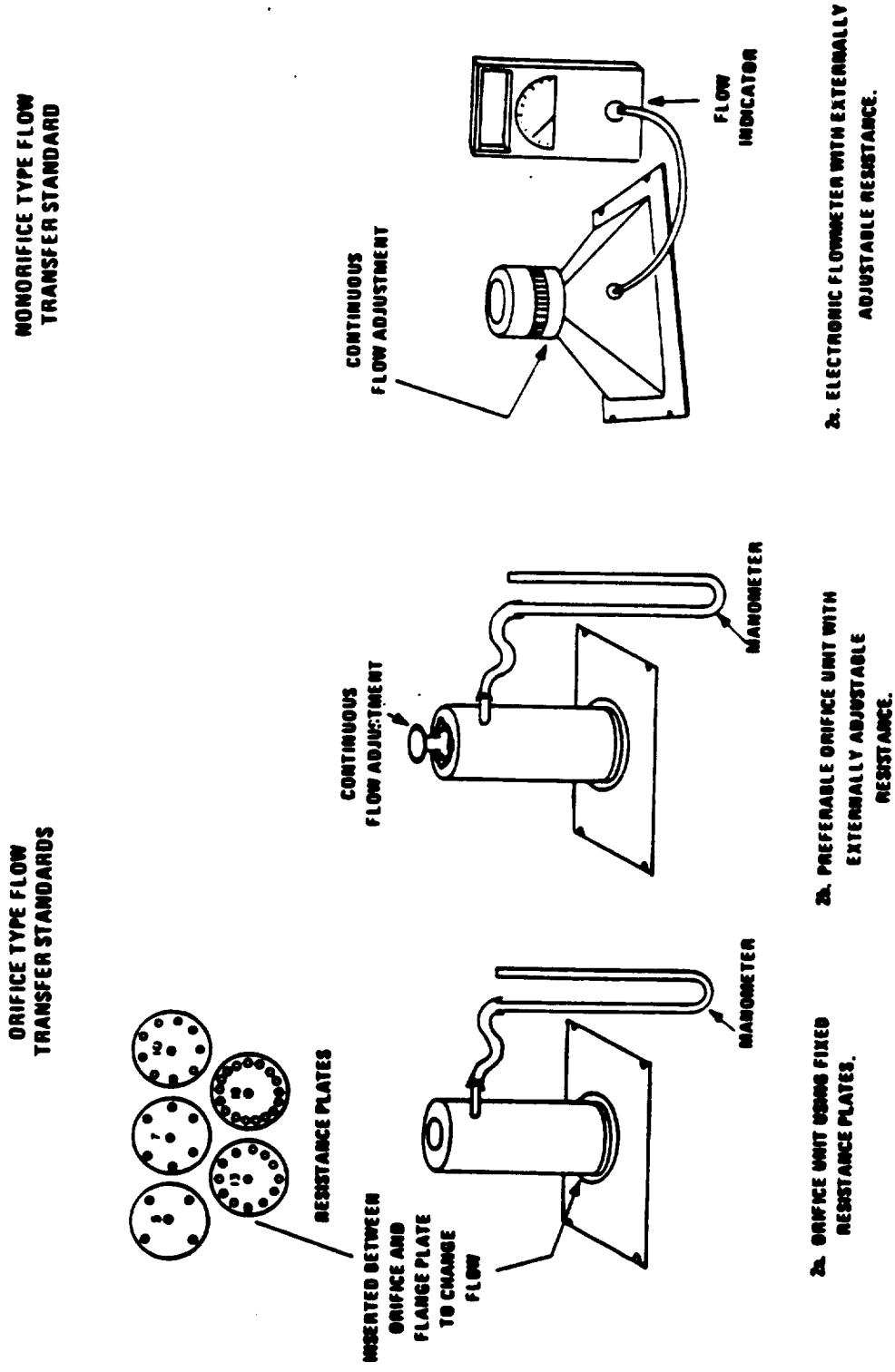


Figure 2. Various types of flow transfer standards. Note that all devices are designed to mount to the filter inlet area of the sampler.

[Part 50, Appendix B]

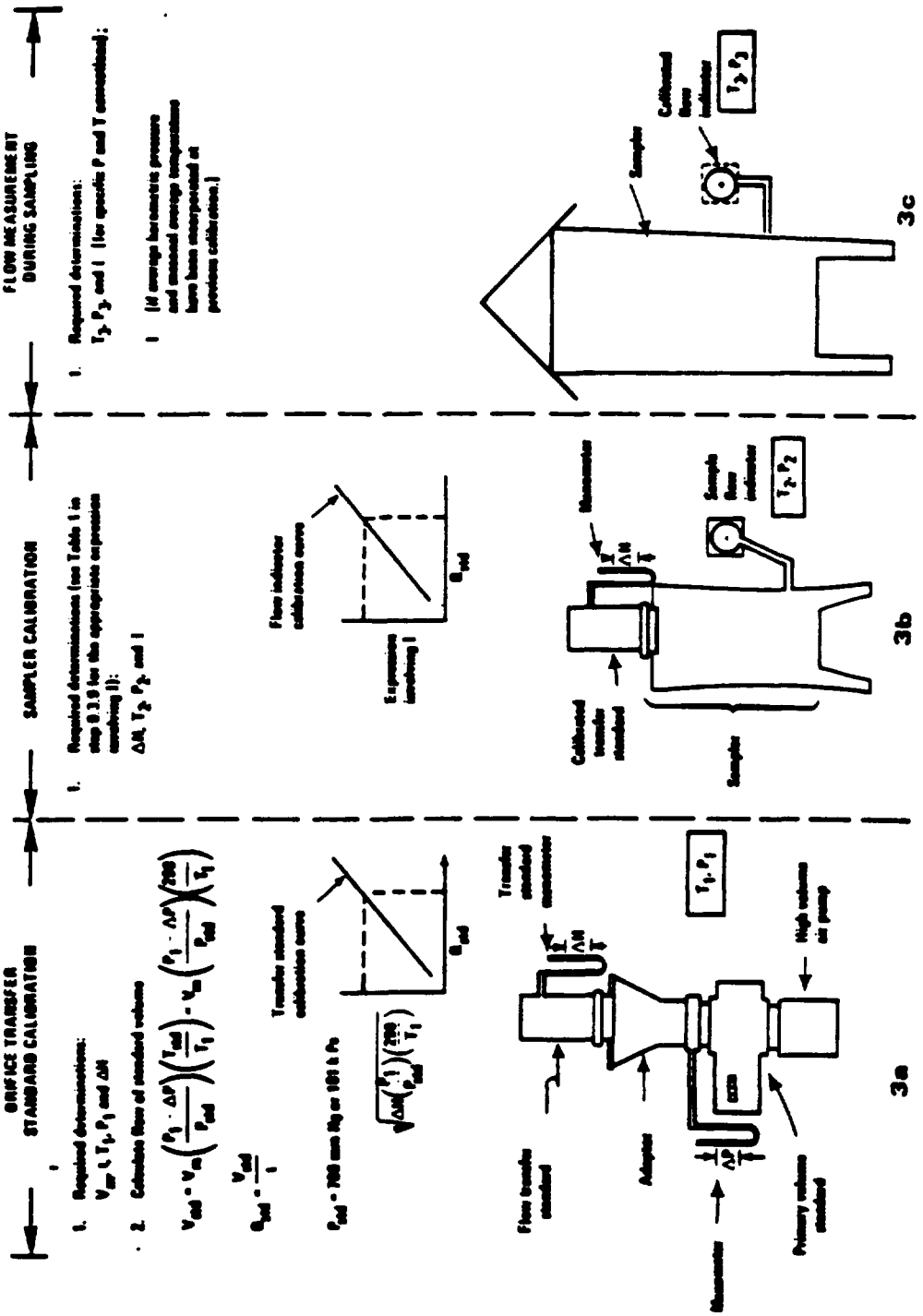


Figure 3. Illustration of the 3 steps in the flow measurement process.

[Part 50, Appendix B]

ORIFICE TRANSFER STANDARD CERTIFICATION WORKSHEET

Run No.	(1) Meter reading start V_i (m^3)	(2) Meter reading stop V_f (m^3)	(3) Sampling time t (min)	(4) Volume measured V_m (m^3)	(5) Differential pressure (at inlet to volume meter) ΔP (mm Hg or kPa)	(6) (X) Flow rate Q_{std} (std m^3/min)	(7) Pressure drop across orifice ΔH ☐ (in) or ☐ (cm) of water	(7a) $(\dot{Y})$ $\sqrt{\Delta H\left(\frac{P_i}{P_{std}}\right)\left(\frac{298}{T_i}\right)}$
1								
2								
3								
4								
5								
6								

RECORDED CALIBRATION DATA

Standard volume meter no. _____

Transfer standard type: ☐ orifice ☐ other

Model No. _____ Serial No. _____

(8) P_i: _____ mm Hg (or kPa) (10) P_{std}: 760 mm Hg (or 101 kPa)

(9) T_i: _____ K (11) T_{std}: 298 K

Calibration performed by: _____

Date: _____

CALCULATION EQUATIONS

(1) $V_m = V_f - V_i$

(2) $V_{std} = V_m\left(\frac{P_i - \Delta P}{P_{std}}\right)\left(\frac{T_{std}}{T_i}\right)$

(3) $Q_{std} = \frac{V_{std}}{t}$

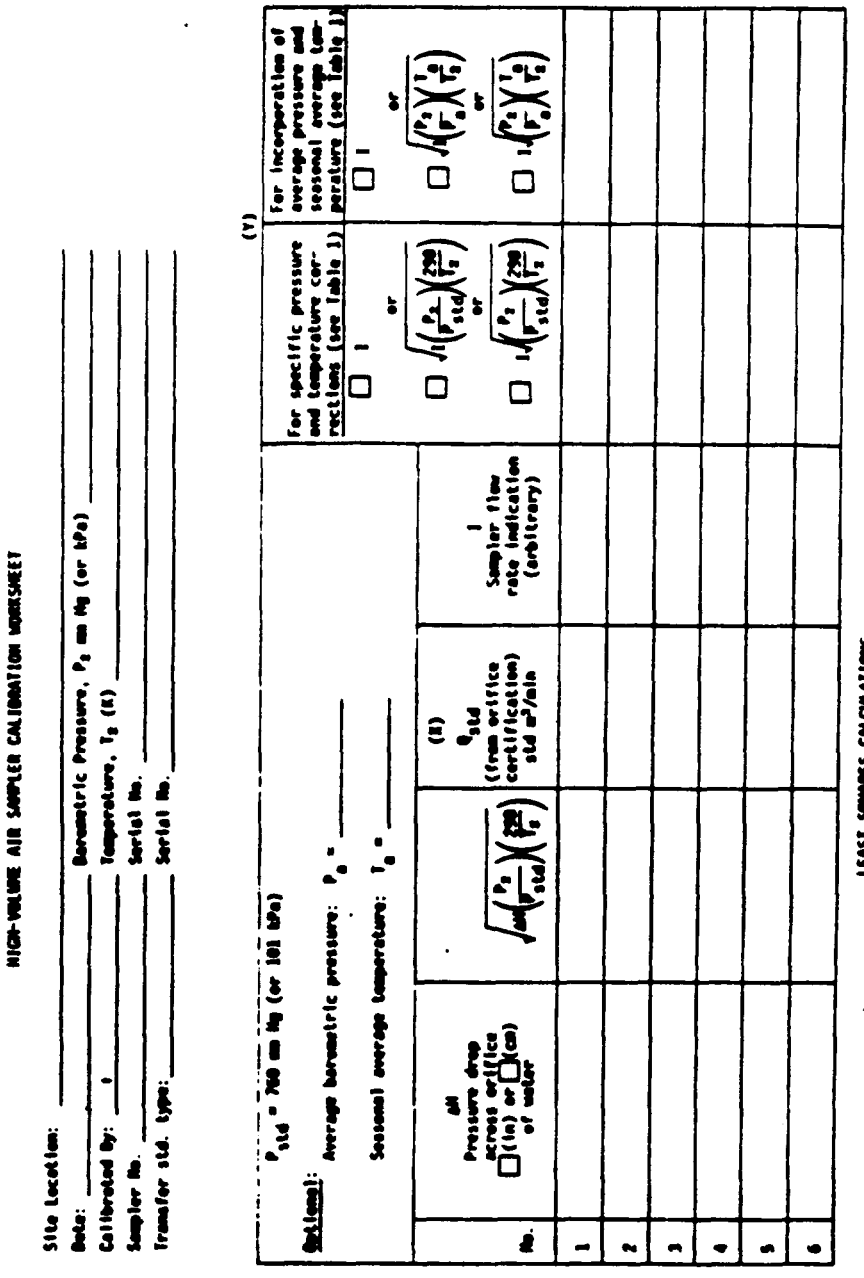
LEAST SQUARES CALCULATIONS

Linear ($Y = mX + b$) regression equation of $Y = \sqrt{\Delta H(P_i/P_{std})(298/T_i)}$ on $X = Q_{std}$ for Orifice Calibration Unit (i.e., $\sqrt{\Delta H(P_i/P_{std})(298/T_i)} = mQ_{std} + b$)

Slope (m) = _____ Intercept (b) = _____ Correlation coefficient (r) = _____

To use for subsequent calibration: $X = \frac{1}{m}(Y-b)$; $\boxed{Q_{std} = \frac{1}{m}\left(\sqrt{\Delta H\left(\frac{P_i}{P_{std}}\right)\left(\frac{298}{T_i}\right)} - b\right)}$

Figure 4. Example of orifice transfer standard certification worksheet.



HIGH-VOLUME AIR SAMPLER CALIBRATION WORKSHEET

Site Location: _____ Barometric Pressure, P_a = _____ mm Hg (or kPa) _____

Date: _____ Temperature, T_a (K) _____

Calibrated By: _____ Serial No. _____

Sampler No. _____ Serial No. _____

Transfer std. type: _____

(Y)

P_{std} = 760 mm Hg (or 101 kPa)

Optional: Average barometric pressure: P_a = _____

Seasonal average temperature: T_a = _____

No.	(H) Pressure drop across orifice ☐(in) or ☐(cm) of water	$\sqrt{H\left(\frac{P_a}{P_{std}}\right)\left(\frac{298}{T_a}\right)}$	(I) Q_{std} (from orifice certification) std m^3/min	I Sampler flow rate indication (arbitrary)	For specific pressure and temperature corrections (see Table 1) ☐ I or $\sqrt{I\left(\frac{P_a}{P_{std}}\right)\left(\frac{298}{T_a}\right)}$ or $I\sqrt{\left(\frac{P_a}{P_{std}}\right)\left(\frac{298}{T_a}\right)}$	For incorporation of average pressure and seasonal average temperature (see Table 1) ☐ I or $\sqrt{I\left(\frac{P_a}{P_a}\right)\left(\frac{T_a}{T_a}\right)}$ or $I\sqrt{\left(\frac{P_a}{P_a}\right)\left(\frac{T_a}{T_a}\right)}$
1						
2						
3						
4						
5						
6						

LEAST SQUARES CALCULATIONS

Linear regression of Y on X: Y = aX + b; Y = appropriate expression from Table 1; X = Q_{std}

Slope (a) = ____ Intercept (b) = ____ Correlation Coeff. (r) = ____

To determine subsequent flow rate during use: $X = \frac{1}{a}(Y-b)$; $Q_{std} = \frac{1}{a}$ ((appropriate expression from Table 2) - b)

Figure 8. Example of high-volume air sampler calibration worksheet.

[47 FR 54912, Dec. 6, 1982; 48 FR 17355, Apr. 22, 1983]

[Appendix B added at 47 FR 54912, Dec. 6, 1982; 48 FR 17355, April 22, 1983]

[Part 50, Appendix B]

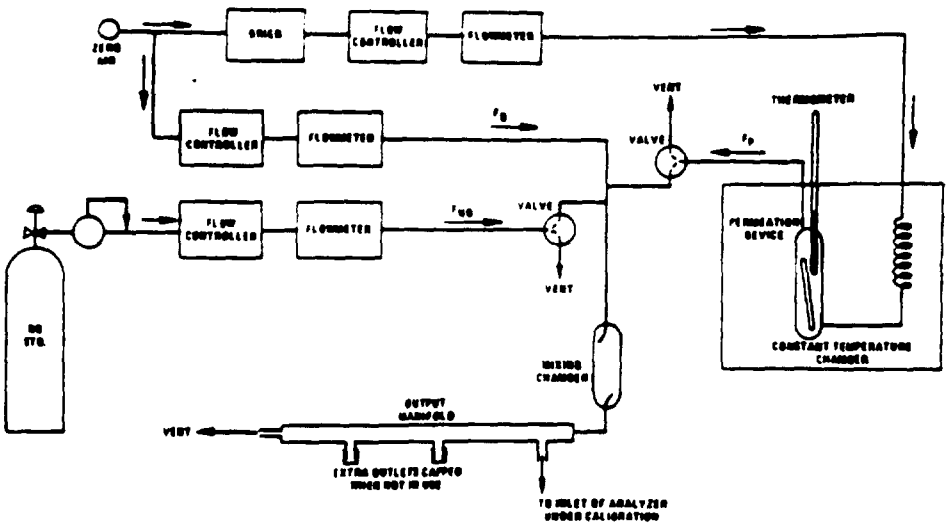


Figure 2. Schematic diagram of a typical calibration apparatus using an NO_2 permeation device.

[Appendix F added at 41 FR 52686, Dec. 1, 1976; amended at 48 FR 2529, Jan 20, 1983]

APPENDIX G TO PART 50—REFERENCE METHOD FOR THE DETERMINATION OF LEAD IN SUSPENDED PARTICULATE MATTER COLLECTED FROM AMBIENT AIR

1. *Principle and applicability.*

1.1 Ambient air suspended particulate matter is collected on a glass-fiber filter for 24 hours using a high volume air sampler. The analysis of the 24-hour samples may be performed for either individual samples or composites of the samples collected over a calendar month or quarter, provided that the compositing procedure has been approved in accordance with section 2.8 of Appendix C to Part 58 of this chapter—*Modifications of methods by users.* (Guidance or assistance in requesting approval under Section 2.8 can be obtained from the address given in section 2.7 of Appendix C to Part 58 of this chapter.)

1.2 Lead in the particulate matter is solubilized by extraction with nitric acid (HNO_3), facilitated by heat or by a mixture of HNO_3 and hydrochloric acid (HCl) facilitated by ultrasonication.

1.3 The lead content of the sample is analyzed by atomic absorption spectrometry using an air-acetylene flame, the 283.3 or 217.0 nm lead absorption line, and the optimum instrumental conditions recommended by the manufacturer.

1.4 The ultrasonication extraction with HNO_3/HCl will extract metals other than lead from ambient particulate matter.

2. *Range, sensitivity, and lower detectable limit.* The values given below are typical of the methods capabilities. Absolute values will vary for individual situations depending on the type of instrument used, the lead line, and operating conditions.

2.1 *Range.* The typical range of the method is 0.07 to 7.5 μg Pb/m^3assuming an upper linear range of analysis of 15 μg/ml and an air volume of 2,400 m^3.

2.2 *Sensitivity.* Typical sensitivities for a 1 percent change in absorption (0.0044 absorbance units) are 0.2 and 0.5 μg Pb/ml for the 217.0 and 283.3 nm lines, respectively.

2.3 *Lower detectable limit (LDL).* A typical LDL is 0.07 μg Pb/m^3. The above value was calculated by doubling the between-laboratory standard deviation obtained for the lowest measurable lead concentration in a collaborative test of the method.(*15*) An air volume of 2,400 $m^3$was assumed.

3. *Interferences.* Two types of interferences are possible: chemical and light scattering.

3.1 *Chemical.* Reports on the absence (*1, 2, 3, 4, 5*) of chemical interferences far outweigh those reporting their presence, (*6*) therefore, no correction for chemical interferences is given here. If the analyst suspects that the sample matrix is causing a chemical interference, the interference can be verified and corrected for by carrying out the analysis with and without the method of standard additions.(*7*)

3.2 *Light scattering.* Nonatomic absorption or light scattering, produced by high concentrations of dissolved solids in the sample, can produce a significant interference, especially at low lead concentrations. (*2*) The interference is greater at the 217.0 nm line than at the 283.3 nm line. No interference was observed using the 283.3 nm line with a similar method.(*1*)

Light scattering interferences can, however, be corrected for instrumentally. Since the dissolved solids can vary depending on the origin of the sample, the correction may be necessary, especially when using the 217.0 nm line. Dual beam instruments with a continuum source give the most accurate correction. A less accurate correction can be obtained by using a nonabsorbing lead line that is near the

lead analytical line. Information on use of these correction techniques can be obtained from instrument manufacturers' manuals.

If instrumental correction is not feasible, the interference can be eliminated by use of the ammonium pyrrolidine-carbodithioate-methylisobutyl ketone, chelation-solvent extraction technique of sample preparation.(*8*)

4. *Precision and bias.*

4.1 The high-volume sampling procedure used to collect ambient air particulate matter has a between-laboratory relative standard deviation of 3.7 percent over the range 80 to 125 $\mu g/m^3$.(*9*) The combined extraction-analysis procedure has an average within-laboratory relative standard deviation of 5 to 6 percent over the range 1.5 to 15 μg Pb/ml, and an average between laboratory relative standard deviation of 7 to 9 percent over the same range. These values include use of either extraction procedure.

4.2 Single laboratory experiments and collaborative testing indicate that there is no significant difference in lead recovery between the hot and ultrasonic extraction procedures.(*15*)

5. *Apparatus.*

5.1 *Sampling.*

5.1.1 *High-Volume Sampler.* Use and calibrate the sampler as described in Appendix B to this part.

5.2 *Analysis.*

5.2.1 *Atomic absorption spectrophotometer.* Equipped with lead hollow cathode or electrodeless discharge lamp.

5.2.1.1 *Acetylene.* The grade recommended by the instrument manufacturer should be used. Change cylinder when pressure drops below 50-100 psig.

5.2.1.2 *Air.* Filtered to remove particulate, oil, and water.

5.2.2 *Glassware.* Class A borosilicate glassware should be used throughout the analysis.

5.2.2.1 *Beakers.* 30 and 150 ml. graduated, Pyrex.

5.2.2.2 *Volumetric flasks.* 100-ml.

5.2.2.3 *Pipettes.* To deliver 50, 30, 15, 8, 4, 2, 1 ml.

5.2.2.4 *Cleaning.* All glassware should be scrupulously cleaned. The following procedure is suggested. Wash with laboratory detergent, rinse, soak for 4 hours in 20 percent (w/w) HNO_3 rinse 3 times with distilled-deionized water, and dry in a dust free manner.

5.2.3 *Hot plate.*

5.2.4. *Ultrasonication water bath, unheated.* Commercially available laboratory ultrasonic cleaning baths of 450 watts or higher "cleaning power," i.e., actual ultrasonic power output to the bath have been found satisfactory.

5.2.5 *Template.* To aid in sectioning the glass-fiber filter. See figure 1 for dimensions.

5.2.6 *Pizza cutter.* Thin wheel. Thickness 1mm.

5.2.7 *Watch glass.*

5.2.8 *Polyethylene bottles.* For storage of samples. Linear polyethylene gives better storage stability than other polyethylenes and is preferred.

5.2.9 Parafilm "M".[1] American Can Co., Marathon Products, Neenah, Wis., or equivalent.

6. *Reagents.*

6.1 *Sampling.*

6.1.1 *Glass fiber filters.* The specifications given below are intended to aid the user in obtaining high quality filters with reproducible properties. These specifications have been met by EPA contractors.

6.1.1.1 *Lead content.* The absolute lead content of filters is not critical, but low values are, of course, desirable. EPA typically obtains filters with a lead content of 75 μg/filter.

It is important that the variation in lead content from filter to filter, within a given batch, be small.

6.1.1.2 *Testing.*

6.1.1.2.1 For large batches of filters (>500 filters) select at random 20 to 30 filters from a given batch. For small batches (>500 filters) a lesser number of filters may be taken. Cut one 3/4"x8" strip from each filter anywhere in the filter. Analyze all strips, separately, according to the directions in sections 7 and 8.

6.1.1.2.2 Calculate the total lead in each filter as

$$F_b = \mu g\ Pb/ml \times \frac{100\ ml}{strip} \times \frac{12\ strips}{filter}$$

where:

F_b=Amount of lead per 72 square inches of filter, μg.

6.1.1.2.3 Calculate the mean, F_b, of the values and the relative standard deviation (standard deviation/mean 100). If the relative standard deviation is high enough so that, in the analysts opinion, subtraction of F_b, (section 10.3) may result in a significant error in the μg Pb/m^3, the batch should be rejected.

6.1.1.2.4 For acceptable batches, use the value of F_b to correct all lead analyses (section 10.3) of particulate matter collected using that batch of filters. If the analyses are below the LDL (section 2.3) no correction is necessary.

6.2 *Analysis.*

6.2.1 Concentrated (15.6 *M*) HNO_3. ACS reagent grade HNO_3 and commercially available redistilled HNO_3 has found to have sufficiently low lead concentrations.

6.2.2 Concentrated (11.7 *M*) HCl. ACS reagent grade.

6.2.3 *Distilled-deionized water.* (D.I. water).

6.2.4 3 *M* HNO_3. This solution is used in the hot extraction procedure. To prepare, add 192 ml of concentrated HNO_3 to D.I. water in a 1 *l* volumetric flask. Shake well, cool, and dilute to volume with D.I. water. *Caution:* Nitric acid fumes are toxic. Prepare in a well ventilated fume hood.

6.2.5 0.45 *M* HNO_3This solution is used as the matrix for calibration standards when using the hot extraction procedure. To prepare, add 29 ml of concentrated HNO_3 to D.I. water in a 1 *l* volumetric flask. Shake well, cool, and dilute to volume with D.I. water.

6.2.6 2.6 *M* HNO_3+0 to 0.9 *M* HCl. This solution is used in the ultrasonic extraction procedure. The concentration of HCl can be varied from 0 to 0.9 *M*. Directions are given for preparation of a 2.6 *M* HNO_3+0.9 *M* HCl solution. Place 167 ml of concentrated HNO_3 into a 1 *l* volumetric flask and add 77 ml of concentrated HCl. Stir 4 to 6 hours, dilute to nearly 1 *l* with D.I. water, cool to room temperature, and dilute to 1 *l*.

6.2.7 0.40 *M* HNO_3+ X *M* HCl. This solution is used as the matrix for calibration standards when using the ultrasonic extraction procedure. To prepare, add 26 ml of concentrated HNO_3, plus the ml of HCl required, to a 1 *l* volumetric flask. Dilute to nearly 1 *l* with D.I. water, cool to room temperature, and dilute to 1 *l*. The amount of HCl required can be determined from the following equation:

[1] Mention of commercial products does not imply endorsement by the U.S. Environmental Protection Agency.

0013-9211/92/$0+.50

$$y = \frac{77ml \times 0.15 \times}{0.9M}$$

where:

y = ml of concentrated HCl required.

x = molarity of HCl in 6.2.6.

0.15 = dilution factor in 7.2.2.

6.2.8 Lead nitrate, $Pb(NO_3)_2$. ACS reagent grade, purity 99.0 percent. Heat for 4 hours at 120°C and cool in a desiccator.

6.3 *Calibration standards.*

6.3.1 Master standard, 1000 μg Pb/ml in HNO_3. Dissolve 1.598 g of $Pb(NO_3)_2$ in 0.45 *M* HNO_3 contained in a 1 *l* volumetric flask and dilute to volume with 0.45 *M* HNO_3.

6.3.2 Master standard, 1000 μg Pb/ml in HNO_3/HCl. Prepare as in section 6.3.1 except use the HNO_3/HCl solution in section 6.2.7.

Store standards in a polyethylene bottle. Commercially available certified lead standard solutions may also be used.

7. *Procedure.*

7.1 *Sampling.* Collect samples for 24 hours using the procedure described in reference *10* with glass-fiber filters meeting the specifications in section 6.1.1. Transport collected samples to the laboratory taking care to minimize contamination and loss of sample.(*16*).

7.2 *Sample preparation.*

7.2.1 *Hot extraction procedure.*

7.2.1.1 Cut a 3/4"x8" strip from the exposed filter using a template and a pizza cutter as described in Figures 1 and 2. Other cutting procedures may be used.

Lead in ambient particulate matter collected on glass fiber filters has been shown to be uniformly distributed across the filter.[1,3,11] Another study[12] has shown that when sampling near a roadway, strip position contributes significantly to the overall variability associated with lead analyses. Therefore, when sampling near a roadway, additional strips should be analyzed to minimize this variability.

7.2.1.2 Fold the strip in half twice and place in a 150-ml beaker. Add 15 ml of 3 *M* HNO_3 to cover the sample. The acid should completely cover the sample. Cover the beaker with a watch glass.

7.2.1.3 Place beaker on the hot-plate, contained in a fume hood, and boil gently for 30 min. Do not let the sample evaporate to dryness. *Caution:* Nitric acid fumes are toxic.

7.2.1.4 Remove beaker from hot plate and cool to near room temperature.

7.2.1.5 Quantitatively transfer the sample as follows:

7.2.1.5.1 Rinse watch glass and sides of beaker with D.I. water.

7.2.1.5.2 Decant extract and rinsings into a 100-ml volumetric flask.

7.2.1.5.3 Add D.I. water to 40 ml mark on beaker, cover with watch glass, and set aside for a minimum of 30 minutes. This is a critical step and cannot be omitted since it allows the HNO_3 trapped in the filter to diffuse into the rinse water.

7.2.1.5.4 Decant the water from the filter into the volumetric flask.

7.2.1.5.5 Rinse filter and beaker twice with D.I. water and add rinsings to volumetric flask until total volume is 80 to 85 ml.

7.2.1.5.6 Stopper flask and shake vigorously. Set aside for approximately 5 minutes or until foam has dissipated.

7.2.1.5.7 Bring solution to volume with D.I. water. Mix thoroughly.

7.2.1.5.8 Allow solution to settle for one hour before proceeding with analysis.

7.2.1.5.9 If sample is to be stored for subsequent analysis, transfer to a linear polyethylene bottle.

7.2.2 *Ultrasonic extraction procedure.*

7.2.2.1 Cut a 3/4"x8" strip from the exposed filter as described in section 7.2.1.1.

7.2.2.2 Fold the strip in half twice and place in a 30 ml beaker. Add 15 ml of the HNO_3/HCl solution in section 6.2.6. The acid should completely cover the sample. Cover the beaker with parafilm.

The parafilm should be placed over the beaker such that none of the parafilm is in contact with water in the ultrasonic bath. Otherwise, rinsing of the parafilm (section 7.2.2.4.1) may contaminate the sample.

7.2.2.3 Place the beaker in the ultrasonication bath and operate for 30 minutes.

7.2.2.4 Quantitatively transfer the sample as follows:

7.2.2.4.1 Rinse parafilm and sides of beaker with D.I. water.

7.2.2.4.2 Decant extract and rinsings into a 100 ml volumetric flask.

7.2.2.4.3 Add 20 ml D.I. water to cover the filter strip, cover with parafilm, and set aside for a minimum of 30 minutes. This is a critical step and cannot be omitted. The sample is then processed as in sections 7.2.1.5.4 through 7.2.1.5.9.

NOTE: Samples prepared by the hot extraction procedure are now in 0.45 *M* HNO_3. Samples prepared by the ultrasonication procedure are in 0.40 *M* HNO_3+X *M* HCl.

8. *Analysis.*

8.1 Set the wavelength of the monochromator at 283.3 or 217.0 nm. Set or align other instrumental operating conditions as recommended by the manufacturer.

8.2 The sample can be analyzed directly from the volumetric flask, or an appropriate amount of sample decanted into a sample analysis tube. In either case, care should be taken not to disturb the settled solids.

8.3 Aspirate samples, calibration standards and blanks (section 9.2) into the flame and record the equilibrium absorbance.

8.4 Determine the lead concentration in μg Pb/ml, from the calibration curve, section 9.3.

8.5 Samples that exceed the linear calibration range should be diluted with acid of the same concentration as the calibration standards and reanalyzed.

9. *Calibration.*

9.1 Working standard, 20 μg Pb/ml. Prepared by diluting 2.0 ml of the master standard (section 6.3.1 if the hot acid extraction was used or section 6.3.2 if the ultrasonic extraction procedure was used) to 100 ml with acid of the same concentration as used in preparing the master standard.

9.2 *Calibration standards.* Prepare daily by diluting the working standard, with the same acid matrix, as indicated below. Other lead concentrations may be used.

Volume of 20 μg/ml working standard, ml	Final volume, ml	Concentration μg Pb/ml
0	100	0
1.0	200	0.1
2.0	200	0.2
2.0	100	0.4
4.0	100	0.8
8.0	100	1.6
15.0	100	3.0
30.0	100	6.0
50.0	100	10.0
100.0	100	20.0

9.3 *Preparation of calibration curve.* Since the working range of analysis will vary depending on which lead line is used and the type of instrument, no one set of instructions for preparation of a calibration curve can be given. Select standards (plus the reagent blank), in the same acid concentration as the samples, to cover the linear absorption range indicated by the

instrument manufacturer. Measure the absorbance of the blank and standards as in section 8.0. Repeat until good agreement is obtained between replicates. Plot absorbance (y-axis) versus concentration in μg Pb/ml (x-axis). Draw (or compute) a straight line through the linear portion of the curve. Do not force the calibration curve through zero. Other calibration procedures may be used.

To determine stability of the calibration curve, remeasure-alternately-one of the following calibration standards for every 10th sample analyzed: Concentration ≤ 1μg Pb/ml; concentration ≤ 10 μg Pb/ml. If either standard deviates by more than 5 percent from the value predicted by the calibration curve, recalibrate and repeat the previous 10 analyses.

10. *Calculation.*

10.1 *Measured air volume.* Calculate the measured air volume at Standard Temperature and Pressure as described in Reference 10.

10.2 *Lead concentration.* Calculate lead concentration in the air sample.

$$C = \frac{(\mu g\ Pb/ml \times 100\ ml/strip \times 12\ strips/filter) - F_b}{V_{STP}}$$

where:

C=Concentration, μg Pb/sm³.

μg Pb/ml=Lead concentration determined from section 8.

100 ml/strip=Total sample volume.

12 strips=Total useable filter area, 8" 9".

Exposed area of one strip, ¾" 7".

Filter=Total area of one strip, ¾" 8".

F_b=Lead concentration of blank filter, μg, from section 6.1.1.2.3.

V_{STP}=Air volume from section 10.2.

11. *Quality control.*

¾" 8" glass fiber filter strips containing 80 to 2000 μg Pb/strip (as lead salts) and blank strips with zero Pb content should be used to determine if the method-as being used-has any bias. Quality control charts should be established to monitor differences between measured and true values. The frequency of such checks will depend on the local quality control program.

To minimize the possibility of generating unreliable data, the user should follow practices established for assuring the quality of air pollution data, (*13*) and take part in EPA's semiannual audit program for lead analyses.

12. *Trouble shooting.*

1. During extraction of lead by the hot extraction procedure, it is important to keep the sample covered so that corrosion products-formed on fume hood surfaces which may contain lead-are not deposited in the extract.

2. The sample acid concentration should minimize corrosion of the nebulizer. However, different nebulizers may require lower acid concentrations. Lower concentrations can be used provided samples and standards have the same acid concentration.

3. Ashing of particulate samples has been found, by EPA and contractor laboratories, to be unnecessary in lead analyses by atomic absorption. Therefore, this step was omitted from the method.

4. Filtration of extracted samples, to remove particulate matter, was specifically excluded from sample preparation, because some analysts have observed losses of lead due to filtration.

5. If suspended solids should clog the nebulizer during analysis of samples, centrifuge the sample to remove the solids.

13. *Authority.*

(Secs. 109 and 301(a), Clean Air Act, as amended (42 U.S.C. 7409, 7601(a)))

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[Part 50, Appendix G]

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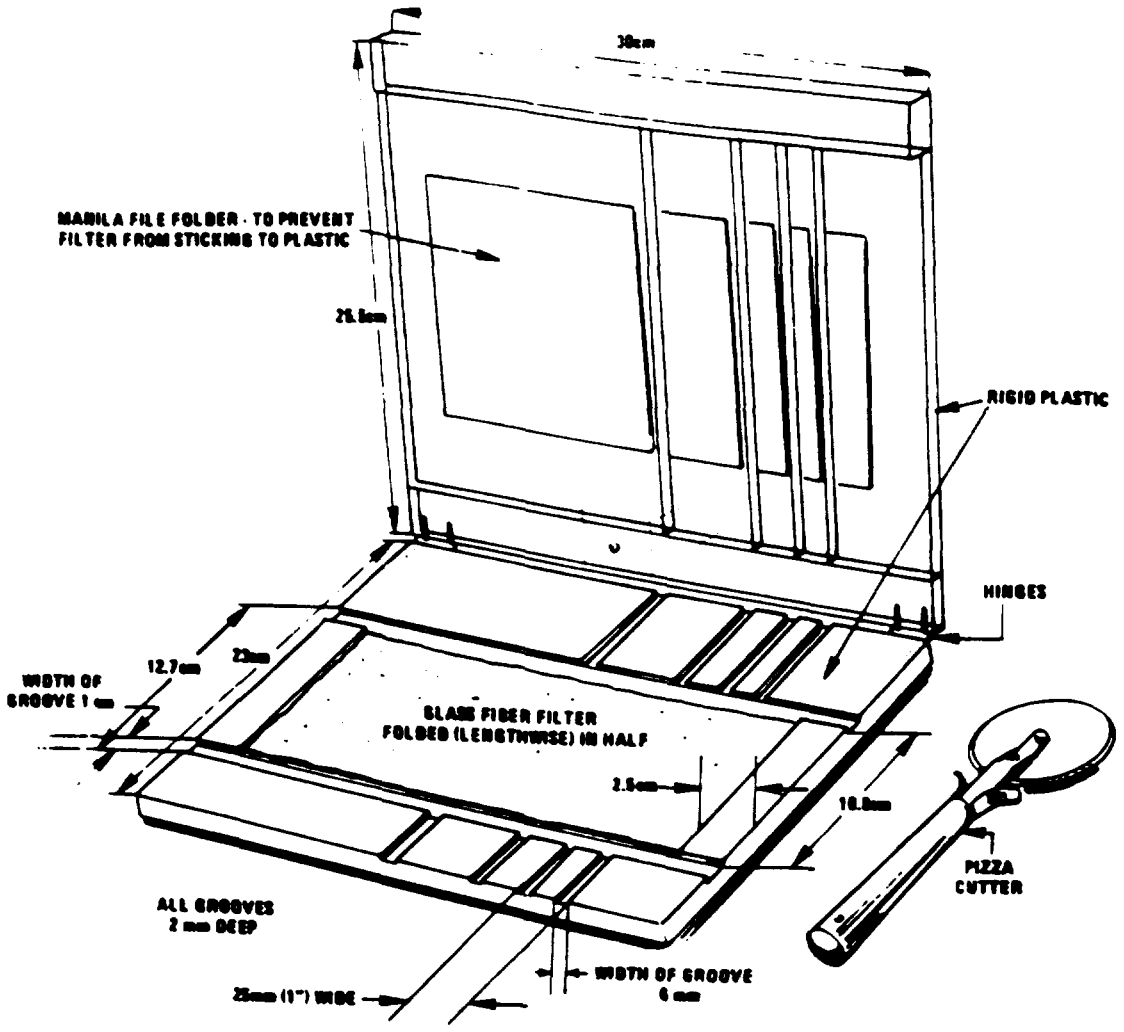

Figure 1

[Part 50, Appendix G]

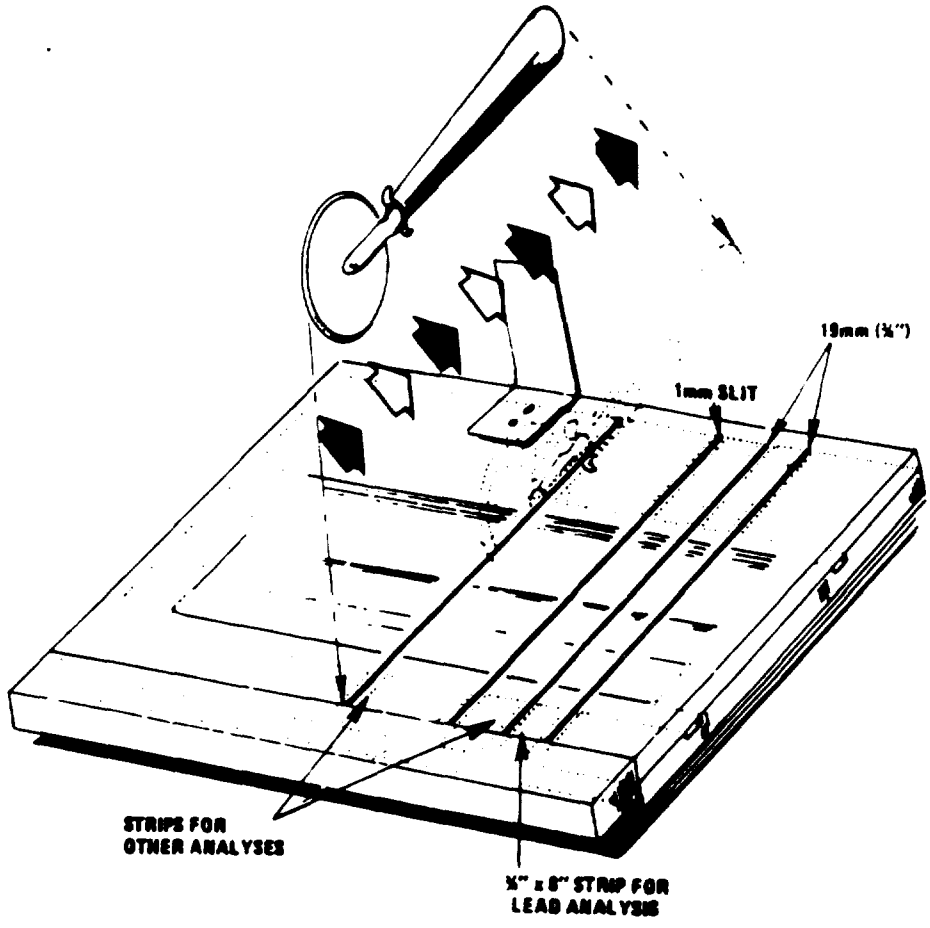

Figure 2

(Secs. 109, 301(a) of the Clean Air Act, as amended (42 U.S.C. 7409, 7601(a)); secs. 110, 301(a) and 319 of the Clean Air Act (42 U.S.C. 7410, 7601(a), 7619))

[Appendix G added at 43 FR 46258, Oct. 5, 1978; amended at 44 FR 37915, June 29, 1979; 46 FR 44163, Sept. 3, 1981; 52 FR 24663, July 1, 1987]

APPENDIX H TO PART 50—INTERPRETATION OF THE NATIONAL AMBIENT AIR QUALITY STANDARDS FOR OZONE

1. *General*

This appendix explains how to determine when the expected number of days per calendar year with maximum hourly average concentrations above 0.12 ppm (235 $\mu g/m^3$) is equal to or less than 1. An expanded discussion of these procedures and associated examples are contained in the "Guideline for Interpretation of Ozone Air Quality Standards." For purposes of clarity in the following discussion, it is convenient to use the term "exceedance" to describe a daily maximum hourly average ozone measurement that is greater than the level of the standard. Therefore, the phrase "expected number of days with maximum hourly average ozone concentrations above the level of the standard" may be simply stated as the "expected number of exceedances."

The basic principle in making this determination is relatively straightforward. Most of the complications that arise in determining the expected number of annual exceedances relate to accounting for incomplete sampling. In general, the average number of exceedances per calendar year must be less than or equal to 1. In its simplest form, the number of exceedances at a monitoring site would be recorded for each calendar year and then averaged over the past 3 calendar years to determine if this average is less than or equa' to 1.

2. *Interpretation of Expected Exceedances*

The ozone standard states that the expected number of exceedances per year must be less than or equal to 1. The statistical term "expected number" is basically an arithmetic average. The following example explains what it would mean for an area to be in compliance with this type of standard. Suppose a monitoring station records a valid daily maximum hourly average ozone value for every day of the year during the past 3 years. At the end of

each year, the number of days with maximum hourly concentrations above 0.12 ppm is determined and this number is averaged with the results of previous years. As long as this average remains "less than or equal to 1," the area is in compliance.

3. *Estimating the Number of Exceedances for a Year*

In general, a valid daily maximum hourly average value may not be available for each day of the year, and it will be necessary to account for these missing values when estimating the number of exceedances for a particular calendar year. The purpose of these computations is to determine if the expected number of exceedances per year is less than or equal to 1. Thus, if a site has two or more observed exceedances each year, the standard is not met and it is not necessary to use the procedures of this section to account for incomplete sampling.

The term "missing value" is used here in the general sense to describe all days that do not have an associated ozone measurement. In some cases, a measurement might actually have been missed but in other cases no measurement may have been scheduled for that day. A daily maximum ozone value is defined to be the highest hourly ozone value recorded for the day. This daily maximum value is considered to be valid if 75 percent of the hours from 9:01 a.m. to 9:00 p.m. (LST) were measured or if the highest hour is greater than the level of the standard.

In some areas, the seasonal pattern of ozone is so pronounced that entire months need not be sampled because it is extremely unlikely that the standard would be exceeded. Any such waiver of the ozone monitoring requirement would be handled under provisions of 40 CFR Part 58. Some allowance should also be made for days for which valid daily maximum hourly values were not obtained but which would quite likely have been below the standard. Such an allowance introduces a complication in that it becomes necessary to define under what conditions a missing value may be assumed to have been less than the level of the standard. The following criterion may be used for ozone:

A missing daily maximum ozone value may be assumed to be less than the level of the standard if the valid daily maxima on both the preceding day and the following day do not exceed 75 percent of the level of the standard.

Let z denote the number of missing daily maximum values that may be assumed to be less than the standard. Then the following formula shall be used to estimate the expected number of exceedances for the year:

$$e = v + [(v/n)8(N-n-z)] \quad (1)$$

(*Indicates multiplication.)

where:

e=the estimated number of exceedances for the year,

N=the number of required monitoring days in the year,

n=the number of valid daily maxima,

v=the number of daily values above the level of the standard, and

z=the number of days assumed to be less than the standard level.

This estimated number of exceedances shall be rounded to one decimal place (fractional parts equal to 0.05 round up).

It should be noted that N will be the total number of days in the year unless the appropriate Regional Administrator has granted a waiver under the provisions of 40 CFR Part 58.

The above equation may be interpreted intuitively in the following manner. The estimated number of exceedances is equal to the observed number of exceedances (v) plus an increment that accounts for incomplete sampling. There were (N-n) missing values for the year but a certain number of these, namely z, were assumed to be less than the standard. Therefore, (N-n-z) missing values are considered to include possible exceedances. The fraction of measured values that are above the level of the standard is v/n. It is assumed that this same fraction applies to the (N-n-z) missing values and that (v/n)*(N-n-z) of these values would also have exceeded the level of the standard.

[Appendix H added at 44 FR 8220, Feb. 8, 1979]

APPENDIX I—[Reserved]

APPENDIX J TO PART 50—REFERENCE METHOD FOR THE DETERMINATION OF PARTICULATE MATTER AS PM_{10} IN THE ATMOSPHERE

1.0 *Applicability.*

1.1 This method provides for the measurement of the mass concentration of particulate matter with an aerodynamic diameter less than or equal to a nominal 10 micrometers (PM_{10}) in ambient air over a 24-hour period for purposes of determining attainment and maintenance of the primary and secondary national ambient air quality standards for particulate matter specified in §50.6 of this chapter. The measurement process is nondestructive, and the PM_{10} sample can be subjected to subsequent physical or chemical analyses. Quality assurance procedures and guidance are provided in part 58, appendices A and B, of this chapter and in References 1 and 2.

2.0 *Principle.*

2.1 An air sampler draws ambient air at a constant flow rate into a specially shaped inlet where the suspended particulate matter is inertially separated into one or more size fractions within the PM_{10} size range. Each size fraction in the PM_{10} size range is then collected on a separate filter over the specified sampling period. The particle size discrimination characteristics (sampling effectiveness and 50 percent cutpoint) of the sampler inlet are prescribed as performance specifications in part 53 of this chapter.

2.2 Each filter is weighed (after moisture equilibration) before and after use to determine the net weight (mass) gain due to collected PM_{10}. The total volume of air sampled, corrected to EPA reference conditions (25°C, 101.3 kPa), is determined from the measured flow rate and the sampling time. The mass concentration of PM_{10} in the ambient air is computed as the total mass of collected particles in the PM_{10} size range divided by the volume of air sampled, and is expressed in micrograms per standard cubic meter ($\mu g/std\ m^3$). For PM_{10} samples collected at temperatures and pressures significantly different from EPA reference conditions, these corrected concentrations sometimes differ substantially from actual concentrations (in micrograms per actual cubic meter), particularly at high elevations. Although not required, the actual PM_{10} concentration can be calculated from the corrected concentration, using the average ambient temperature and barometric pressure during the sampling period.

2.3 A method based on this principle will be considered a reference method only if (a) the associated sampler meets the requirements specified in this appendix and the requirements in part 53 of this

chapter, and (b) the method has been designated as a reference method in accordance with part 53 of this chapter.

3.0 *Range.*

3.1 The lower limit of the mass concentration range is determined by the repeatability of filter tare weights, assuming the nominal air sample volume for the sampler. For samplers having an automatic filter-changing mechanism, there may be no upper limit. For samplers that do not have an automatic filter-changing mechanism, the upper limit is determined by the filter mass loading beyond which the sampler no longer maintains the operating flow rate within specified limits due to increased pressure drop across the loaded filter. This upper limit cannot be specified precisely because it is a complex function of the ambient particle size distribution and type, humidity, filter type, and perhaps other factors. Nevertheless, all samplers should be capable of measuring 24-hour PM_{10} mass concentrations of at least 300 $\mu g/std\ m^3$ while maintaining the operating flow rate within the specified limits.

4.0 *Precision.*

4.1 The precision of PM_{10} samplers must be 5 $\mu g/m^3$ for PM_{10} concentrations below 80 $\mu g/m^3$ and 7 percent for PM_{10}concentrations above 80 $\mu g/m^3$, as required by Part 53 of this chapter, which prescribes a test procedure that determines the variation in the PM_{10} concentration measurements of identical samplers under typical sampling conditions. Continual assessment of precision via collocated samplers is required by Part 58 of this chapter for PM_{10} samplers used in certain monitoring networks.

5.0 *Accuracy.*

5.1 Because the size of the particles making up ambient particulate matter varies over a wide range and the concentration of particles varies with particle size, it is difficult to define the absolute accuracy of PM_{10} samplers. Part 53 of this chapter provides a specification for the sampling effectiveness of PM_{10} samplers. This specification requires that the expected mass concentration calculated for a candidate PM_{10} sampler, when sampling a specified particle size distribution, be within ±10 percent of that calculated for an ideal sampler whose sampling effectiveness is explicitly specified. Also, the particle size for 50 percent sampling effectivensss is required to be 10 ± 0.5 micrometers. Other specifications related to accuracy apply to flow measurement and calibration, filter media, analytical (weighing) procedures, and artifact. The flow rate accuracy of PM_{10} samplers used in certain monitoring networks is required by Part 58 of this chapter to be assessed periodically via flow rate audits.

6.0 *Potential Sources of Error.*

6.1 *Volatile Particles.* Volatile particles collected on filters are often lost during shipment and/or storage of the filters prior to the post-sampling weighing[3]. Although shipment or storage of loaded filters is sometimes unavoidable, filters should be reweighed as soon as practical to minimize these losses.

6.2 *Artifacts.* Positive errors in PM_{10} concentration measurements may result from retention of gaseous species on filters[4, 5]. Such errors include the retention of sulfur dioxide and nitric acid. Retention of sulfur dioxide on filters, followed by oxidation to sulfate, is referred to as artifact sulfate formation, a phenomenon which increases with increasing filter alkalinity[6]. Little or no artifact sulfate formation should occur using filters that meet the alkalinity specification in section 7.2.4. Artifact nitrate formation, resulting primarily from retention of nitric acid, occurs to varying degrees on many filter types, including glass fiber, cellulose ester, and many quartz fiber filters[5, 7, 8, 9, 10]. Loss of true atmospheric particulate nitrate during or following sampling may also occur due to dissociation or chemical reaction. This phenomenon has been observed on Teflon® filters[8] and inferred for quartz fiber filters[11, 12]. The magnitude of nitrate artifact errors in PM_{10} mass concentration measurements will vary with location and ambient temperature; however, for most sampling locations, these errors are expected to be small.

6.3 *Humidity.* The effects of ambient humidity on the sample are unavoidable. The filter equilibration procedure in section 9.0 is designed to minimize the effects of moisture on the filter medium.

6.4 *Filter Handling.* Careful handling of filters between presampling and post-sampling weighings is necessary to avoid errors due to damaged filters or loss of collected particles from the filters. Use of a filter cartridge or cassette may reduce the magnitude of these errors. Filters must also meet the integrity specification in section 7.2.3.

6.5 *Flow Rate Variation.* Variations in the sampler's operating flow rate may alter the particle size discrimination characteristics of the sampler inlet. The magnitude of this error will depend on the sensitivity of the inlet to variations in flow rate and on the particle distribution in the atmosphere during the sampling period. The use of a flow control device (section 7.1.3) is required to minimize this error.

6.6 *Air Volume Determination.* Errors in the air volume determination may result from errors in the flow rate and/or sampling time measurements. The flow control device serves to minimize errors in the flow rate determination, and an elapsed time meter (section 7.1.5) is required to minimize the error in the sampling time measurement.

7.0 *Apparatus.*

7.1 *PM_{10} Sampler.*

7.1.1 The sampler shall be designed to:

a. Draw the air sample into the sampler inlet and through the particle collection filter at a uniform face velocity.

b. Hold and seal the filter in a horizontal position so that sample air is drawn downward through the filter.

c. Allow the filter to be installed and removed conveniently.

d. Protect the filter and sampler from precipitation and prevent insects and other debris from being sampled.

e. Minimize air leaks that would cause error in the measurement of the air volume passing through the filter.

f. Discharge exhaust air at a sufficient distance from the sampler inlet to minimize the sampling of exhaust air.

g. Minimize the collection of dust from the supporting surface.

7.1.2 The sampler shall have a sample air inlet system that, when operated within a specified flow rate range, provide particle size discrimination characteristics meeting all of the applicable performance specifications prescribed in part 53 of this chapter. The sampler inlet shall show no significant wind direction dependence. The latter requirement can generally be satisfied by an inlet shape that is circularly symmetrical about a vertical axis.

7.1.3 The sampler shall have a flow control device capable of maintaining the sampler's operating flow rate within the flow rate limits specified for the sampler inlet over normal variations in line voltage and filter pressure drop.

[Part 50, Appendix J]

7.1.4 The sampler shall provide a means to measure the total flow rate during the sampling period. A continuous flow recorder is recommended but not required. The flow measurement device shall be accurate to ±2 percent.

7.1.5 A timing/control device capable of starting and stopping the sampler shall be used to obtain a sample collection period of 24 ± 1 hr (1,440 ± 60 min). An elapsed time meter, accurate to within ± 15 minutes, shall be used to measure sampling time. This meter is optional for samplers with continuous flow recorders if the sampling time measurement obtained by means of the recorder meets the ± 15 minute accuracy specification.

7.1.6 The sampler shall have an associated operation or instruction manual as required by part 53 of this chapter which includes detailed instructions on the calibration, operation, and maintenance of the sampler.

7.2 *Filters.*

7.2.1 *Filter Medium.* No commercially available filter medium is ideal in all respects for all samplers. The user's goals in sampling determine the relative importance of various filter characteristics (e.g., cost, ease of handling, physical and chemical characteristics, etc.) and, consequently, determine the choice among acceptable filters. Furthermore, certain types of filters may not be suitable for use with some samplers, particularly under heavy loading conditions (high mass concentrations), because of high or rapid increase in the filter flow resistance that would exceed the capability of the sampler's flow control device. However, samplers equipped with automatic filter-changing mechanisms may allow use of these types of filters. The specifications given below are minimum requirements to ensure acceptability of the filter medium for measurement of PM_{10} mass concentrations. Other filter evaluation criteria should be considered to meet individual sampling and analysis objectives.

7.2.2 *Collection Efficiency.* ± 99 percent, as measured by the DOP test (ASTM-2986) with 0.3 μm particles at the sampler's operating face velocity.

7.2.3 *Integrity.* ±5 $\mu g/m^3$ (assuming sampler's nominal 24-hour air sample volume). Integrity is measured as the PM_{10} concentration equivalent corresponding to the average difference between the initial and the final weights of a random sample of test filters that are weighed and handled under actual or simulated sampling conditions, but have no air sample passed through them (i.e., filter blanks). As a minimum, the test procedure must include initial equilibration and weighing, installation on an inoperative sampler, removal from the sampler, and final equilibration and weighing.

7.2.4 *Alkalinity.* <25 microequivalents/gram of filter, as measured by the procedure given in Reference 13 following at least two months storage in a clean environment (free from contamination by acidic gases) at room temperature and humidity.

7.3 *Flow Rate Transfer Standard.* The flow rate transfer standard must be suitable for the sampler's operating flow rate and must be calibrated against a primary flow or volume standard that is traceable to the National Bureau of Standards (NBS). The flow rate transfer standard must be capable of measuring the sampler's operating flow rate with an accuracy of ± 2 percent.

7.4 *Filter Conditioning Environment.*

7.4.1 Temperature range: 15° to 30°C.

7.4.2 Temperature control: ±3°C.

7.4.3 Humidity range: 20% to 45% RH.

7.4.4 Humidity control: ± 5% RH.

7.5 *Analytical Balance.* The analytical balance must be suitable for weighing the type and size of filters required by the sampler. The range and sensitivity required will depend on the filter tare weights and mass loadings. Typically, an analytical balance with a sensitivity of 0.1 mg is required for high volume samplers (flow rates >0.5 m^3/min). Lower volume samplers (flow rates > 0.5 m^3/min) will require a more sensitive balance.

8.0 *Calibration.*

8.1 *General Requirements.*

8.1.1 Calibration of the sampler's flow measurement device is required to establish traceability of subsequent flow measurements to a primary standard. A flow rate transfer standard calibrated against a primary flow or volume standard shall be used to calibrate or verify the accuracy of the sampler's flow measurement device.

8.1.2 Particle size discrimination by inertial separation requires that specific air velocities be maintained in the sampler's air inlet system. Therefore, the flow rate through the sampler's inlet must be maintained throughout the sampling period within the design flow rate range specified by the manufacturer. Design flow rates are specified as actual volumetric flow rates, measured at existing conditions of temperature and pressure (Q_a). In contrast, mass concentrations of PM_{10} are computed using flow rates corrected to EPA reference conditions of temperature and pressure (Q_{std}).

8.2 *Flow Rate Calibration Procedure.*

8.2.1 PM_{10} samplers employ various types of flow control and flow measurement devices. The specific procedure used for flow rate calibration or verification will vary depending on the type of flow controller and flow indicator employed. Calibration in terms of actual volumetric flow rates (Q_a) is generally recommended, but other measures of flow rate (e.g., Q_{std}) may be used provided the requirements of section 8.1 are met. The general procedure given here is based on actual volumetric flow units (Q_a) and serves to illustrate the steps involved in the calibration of a PM_{10} sampler. Consult the sampler manufacturer's instruction manual and Reference 2 for specific guidance on calibration. Reference 14 provides additional information on the use of the commonly used measures of flow rate and their interrelationships.

8.2.2 Calibrate the flow rate transfer standard against a primary flow or volume standard traceable to NBS. Establish a calibration relationship (e.g., an equation or family of curves) such that traceability to the primary standard is accurate to within 2 percent over the expected range of ambient conditions (i.e., temperatures and pressures) under which the transfer standard will be used. Recalibrate the transfer standard periodically.

8.2.3 Following the sampler manufacturer's instruction manual, remove the sampler inlet and connect the flow rate transfer standard to the sampler such that the transfer standard accurately measures the sampler's flow rate. Make sure there are no leaks between the transfer standard and the sampler.

8.2.4 Choose a minimum of three flow rates (actual m^3/min), spaced over the acceptable flow rate range specified for the inlet (see 7.1.2) that can be obtained by suitable adjustment of the sampler flow rate. In accordance with the sampler manufacturer's instruction manual, obtain or verify the calibration relationship between the flow rate (actual m^3/min) as

indicated by the transfer standard and the sampler's flow indicator response. Record the ambient temperature and barometric pressure. Temperature and pressure corrections to subsequent flow indicator readings may be required for certain types of flow measurement devices. When such corrections are necessary, correction on an individual or daily basis is preferable. However, seasonal average temperature and average barometric pressure for the sampling site may be incorporated into the sampler calibration to avoid daily corrections. Consult the sampler manufacturer's instruction manual and Reference 2 for additional guidance.

8.2.5 Following calibration, verify that the sampler is operating at its design flow rate (actual m^3/min) with a clean filter in place.

8.2.6 Replace the sampler inlet.

9.0 *Procedure.*

9.1 The sampler shall be operated in accordance with the specific guidance provided in the sampler manufacturer's instruction manual and in Reference 2. The general procedure given here assumes that the sampler's flow rate calibration is based on flow rates at ambient conditions (Q_a) and serves to illustrate the steps involved in the operation of a PM_{10} sampler.

9.2 Inspect each filter for pinholes, particles, and other imperfections. Establish a filter information record and assign an identification number to each filter.

9.3 Equilibrate each filter in the conditioning environment (see 7.4) for at least 24 hours.

9.4 Following equilibration, weigh each filter and record the presampling weight with the filter identification number.

9.5 Install a preweighed filter in the sampler following the instructions provided in the sampler manufacturer's instruction manual.

9.6 Turn on the sampler and allow it to establish run-temperature conditions. Record the flow indicator reading and, if needed, the ambient temperature and barometric pressure. Determine the sampler flow rate (actual m^3/min) in accordance with the instructions provided in the sampler manufacturer's instruction manual. NOTE.—No onsite temperature or pressure measurements are necessary if the sampler's flow indicator does not require temperature or pressure corrections or if seasonal average temperature and average barometric pressure for the sampling site are incorporated into the sampler calibration (see step 8.2.4). If individual or daily temperature and pressure corrections are required, ambient temperature and barometric pressure can be obtained by on-site measurements or from a nearby weather station. Barometric pressure readings obtained from airports must be station pressure, not corrected to sea level, and may need to be corrected for differences in elevation between the sampling site and the airport.

9.7 If the flow rate is outside the acceptable range specified by the manufacturer, check for leaks, and if necessary, adjust the flow rate to the specified setpoint. Stop the sampler.

9.8 Set the timer to start and stop the sampler at appropriate times. Set the elapsed time meter to zero or record the initial meter reading.

9.9 Record the sample information (site location or identification number, sample date, filter identification number, and sampler model and serial number).

9.10 Sample for 24 ± 1 hours.

9.11 Determine and record the average flow rate (Q_a) in actual m^3/min for the sampling period in accordance with the instructions provided in the sampler manufacturer's instruction manual. Record the elapsed time meter final reading and, if needed, the average ambient temperature and barometric pressure for the sampling period (see note following step 9.6).

9.12 Carefully remove the filter from the sampler, following the sampler manufacturer's instruction manual. Touch only the outer edges of the filter.

9.13 Place the filter in a protective holder or container (e.g., petri dish, glassine envelope, or manila folder).

9.14 Record any factors such as meteorological conditions, construction activity, fires or dust storms, etc., that might be pertinent to the measurement on the filter information record.

9.15 Transport the exposed sample filter to the filter conditioning environment as soon as possible for equilibration and subsequent weighing.

9.16 Equilibrate the exposed filter in the conditioning environment for at least 24 hours under the same temperature and humidity conditions used for presampling filter equilibration (see 9.3).

9.17 Immediately after equilibration, reweigh the filter and record the postsampling weight with the filter identification number.

10.0 *Sampler Maintenance.*

10.1 The PM_{10} sampler shall be maintained in strict accordance with the maintenance procedures specified in the sampler manufacturer's instruction manual.

11.0 *Calculations.*

11.1 Calculate the average flow rate over the sampling period corrected to EPA reference conditions as Q_{std}. When the sampler's flow indicator is calibrated in actual volumetric units (Q_a), Q_{std} is calculated as:

$$\bar{Q}_{std} = \bar{Q}_a \times (P_{av}/T_{av})(T_{std}/P_{std})$$

where

$\bar{Q}_{std}$=average flow rate at EPA reference conditions, std m^3/min;

$\bar{Q}_a$=average flow rate at ambient conditions, m^3/min;

P_{av}=average barometric pressure during the sampling period or average barometric pressure for the sampling site, kPa (or mm Hg);

T_{av}=average ambient temperature during the sampling period or seasonal average ambient temperature for the sampling site, K;

T_{std}=standard temperature, defined as 298 K;

P_{std}=standard pressure, defined as 101.3 kPa (or 760 mm Hg).

11.2 Calculate the total volume of air sampled as:

$$V_{std} = \bar{Q}_{std} t$$

where

V_{std}=total air sampled in standard volume units, std m^3;

t=sampling time, min.

11.3 Calculate the PM_{10} concentration as:

$$PM_{10} = (W_f - W_i) \times 10^6 / V_{std}$$

where

PM_{10} =mass concentration of PM_{10}, μg/std m^3;

W_f, W_i=final and initial weights of filter collecting PM_{10}particles, g;

10^6=conversion of g to μg.

NOTE: If more than one size fraction in the PM_{10} size range is collected by the sampler, the sum of the net weight gain by each collection filter [$\Sigma(W_f - W_i)$] is used to calculate the PM_{10} mass concentration.

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[Part 50, Appendix J]

0013-9211/92/$0+.50

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[Appendix J added at 52 FR 24663, July 1, 1987; amended at 52 FR 29467, Aug. 7, 1987]

APPENDIX K TO PART 50—INTERPRETATION OF THE NATIONAL AMBIENT AIR QUALITY STANDARDS FOR PARTICULATE MATTER

1.0 *General.*

This appendix explains the computations necessary for analyzing particulate matter data to determine attainment of the 24-hour and annual standards specified in 40 CFR 50.6. For the primary and secondary standards, particulate matter is measured in the ambient air as PM_{10} (particles with an aerodynamic diameter less than or equal to a nominal 10 micrometers) by a reference method based on Appendix J of this part and designated in accordance with part 53 of this chapter, or by an equivalent method designated in accordance with part 53 of this chapter. The required frequency of measurements is specified in part 58 of this chapter.

Several terms used throughout this appendix must be defined. A "daily value" for PM_{10} refers to the 24-hour average concentration of PM_{10} calculated or measured from midnight to midnight (local time). The term "exceedance" means a daily value that is above the level of the 24-hour standard after rounding to the nearest 10 $\mu g/m^3$ (i.e., values ending in 5 or greater are to be rounded up). The term "average" refers to an arithmetic mean. All particulate matter standards are expressed in terms of expected annual values: expected number of exceedances per year for the 24-hour standards and expected annual arithmetic mean for the annual standards. The "expected annual value" is the number approached when the annual values from an increasing number of years are averaged, in the absence of long-term trends in emissions or meteorological conditions. The term "year" refers to a calendar year.

Although the discussion in this appendix focuses on monitored data, the same principles apply to modeling data, subject to EPA modeling guidelines.

2.0 *Attainment Determinations.*

2.1 *24-Hour Primary and Secondary Standards.*

Under 40 CFR 50.6(a) the 24-hour primary and secondary standards are attained when the expected number of exceedances per year at each monitoring site is less than or equal to one. In the simplest case, the number of expected exceedances at a site is determined by recording the number of exceedances in each calendar year and then averaging them over the past 3 calendar years. Situations in which 3 years of data are not available and possible adjustments for unusual events or trends are discussed in Sections 2.3 and 2.4. Further, when data for a year are incomplete, it is necessary to compute an estimated number of exceedances for that year by adjusting the observed number of exceedances. This procedure, performed by calendar quarter, is described in Section 3. The expected number of exceedances is then estimated by averaging the individual annual estimates for the past 3 years.

The comparison with the allowable expected exceedance rate of one per year is made in terms of a number rounded to the nearest tenth (fractional values equal to or greater than 0.05 are to be rounded up; e.g., an exceedance rate of 1.05 would be rounded to 1.1, which is the lowest rate for nonattainment).

2.2 *Annual Primary and Secondary Standards.*

Under 40 CFR 50.6(b), the annual primary and secondary standards are attained when the expected annual arithmetic mean PM_{10} concentration is less than or equal to the level of the standard. In the simplest case, the expected annual arithmetic mean is determined by averaging the annual arithmetic mean PM_{10} concentrations for the past 3 calendar years. Because of the potential for incomplete data and the possible seasonality in PM_{10} concentrations, the annual mean shall be calculated by averaging the four quarterly means of PM_{10} concentrations within the calendar year. The formulas for calculating the annual arithmetic mean are given in Section 4. Situations in which 3 years of data are not available and possible adjustments for unusual events or trends are discussed in Sections 2.3 and 2.4. The expected annual arith-

APPENDIX B

HEALTH AND SAFETY PLAN

NATIONAL PRESTO INDUSTRIES, INC. SITE
EAU CLAIRE, WISCONSIN

HEALTH AND SAFETY PLAN

PRE-DESIGN PILOT STUDIES LAGOON NO. 1 AND THE MELBY ROAD DISPOSAL SITE

PROJECT #497-8
AUGUST 1993

EDER ASSOCIATES
CONSULTING ENGINEERS, P.C.
Locust Valley, New York
Ann Arbor, Michigan
Madison, Wisconsin
Augusta, Georgia
Jacksonville, Florida
Trenton, New Jersey

HEALTH AND SAFETY PLAN
NATIONAL PRESTO INDUSTRIES
EAU CLAIRE, WISCONSIN

EDER PROJECT DIRECTOR: Gary A. Rozmus, P.E. (NAME) DATE _____

Senior Vice President (TITLE)

EDER PROJECT MANAGER: William Warren (NAME) DATE _____

Vice President (TITLE)

EDER SITE SAFETY MANAGER: Brian Pendergast (NAME) DATE _____

Environmental Scientist (TITLE)

_____

AMENDMENTS CONTAINED IN ATTACHMENT A

AMENDMENT 1. DATE _____

AMENDMENT 2. DATE _____

AMENDMENT 3. DATE _____

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GLOSSARY OF ACRONYMS

ANSI	-	AMERICAN NATIONAL STANDARDS INSTITUTE
APR	-	AIR PURIFYING RESPIRATOR
ACGIH	-	AMERICAN CONFERENCE OF GOVERNMENTAL INDUSTRIAL HYGIENISTS
CFR	-	CODE OF FEDERAL REGULATIONS
CGI	-	COMBUSTIBLE GAS INDICATOR
CSEP	-	CONFINED SPACE ENTRY PERMIT
HEPA	-	HIGH EFFICIENCY PARTICULATE AIR
HNU-PID	-	HNU PHOTOIONIZATION DETECTOR
HOT ZONE	-	EXCLUSION ZONE
IDLH	-	IMMEDIATELY DANGEROUS TO LIFE & HEALTH
MREM/hr	-	MILLI-ROENTGENS EQUIVALENT IN MAN PER HOUR
NIOSH	-	NATIONAL INSTITUTE FOR OCCUPATIONAL SAFETY & HEALTH
OSHA	-	OCCUPATIONAL SAFETY AND HEALTH ADMINISTRATION
OVA	-	ORGANIC VAPOR ANALYZER
PEL	-	PERMISSIBLE EXPOSURE LIMIT
PPB	-	PARTS PER BILLION
PPE	-	PERSONAL PROTECTION EQUIPMENT
PPM	-	PARTS PER MILLION
SCBA	-	SELF-CONTAINED BREATHING APPARATUS
SOP	-	STANDARD OPERATING PROCEDURE
SPCC	-	SPILL PREVENTION CONTROLS & COUNTERMEASURES
TLV	-	THRESHOLD LIMIT VALUE
TWA	-	TIME WEIGHTED AVERAGE

STATEMENT OF COMMITMENT TO WORKER HEALTH AND SAFETY

Eder Associates Consulting Engineers, P.C. (Eder) employees may be exposed to evident or potential risk from hazardous conditions. Eder's policy is to minimize the possibility of work-related injury through aware and qualified supervision, health and safety training, medical monitoring and the use of appropriate personal protective equipment. Eder has established a worker health and safety program to protect its personnel to the maximum reasonable extent. The Corporate Health and Safety Program is documented in Appendix A of the Eder Employee Handbook, which is issued to each employee.

This site-specific Health and Safety Plan (HASP) applies to Eder personnel and others at the National Presto Industries, Inc. (NPI) site where the site operations involve employee exposure or the reasonable possibility of employee exposure to safety or health hazards. This HASP describes emergency response procedures and actual and potential chemical hazards at the work site that have been identified by Eder. This HASP does not cover the hazards from operating machinery which is the responsibility of the operating contractor. This HASP provides information and guidance to contractors retained by Eder and to other parties who are outside of Eder's ability to control. Notwithstanding the intent of this HASP as site-specific hazard information and guidance, all contractors at the site are retained as independent contractors and are responsible for assuring the work site safety of their employees and others retained by them. This HASP is made available to all parties, however, Eder can not control the actions of others and all parties enter the work site with this understanding.

Eder will require that its personnel take certain safety precautions in accord with this HASP and Eder requests that others protect their personnel in a similar manner to assure work site safety. To assure work site safety, Eder may shut down the work site and request that any party leave the work site.

1.0 INTRODUCTION AND SITE ENTRY REQUIREMENTS

This document describes the health and safety guidelines developed for the NPI site to protect on-site personnel, visitors, and the public from physical harm and exposure to hazardous materials or wastes. In accordance with the Occupational Safety and Health Administration (OSHA) 29 CFR Part 1910.120 Hazardous Waste Operations and Emergency Response Final Rule, this HASP, including the Attachments, addresses potential and/or actual safety and health hazards associated with each phase of site operations, except that hazards from machinery operations are addressed by the operating contractor.

This site-specific HASP is based on information available at the time the plan was prepared. The HASP may be revised following an initial site visit by the Eder Site Manager and Eder Site Safety Officer, and when new information is received or conditions change. A written amendment will document all changes made to the plan, and will be included in Attachment A. All amendments will be acknowledged by the Eder Project Manager, Site Manager, and Site Safety Officer.

1.1 Training Requirements

All personnel entering the exclusion zone or decontamination zone (Section 6.1, Work Zones) must have completed the OSHA 29 CFR 1910.120(e) training requirements.

Documentation of Eder personnel training is maintained on file, and each Eder field personnel's record of 40-Hour OSHA Training, 8-Hour Refresher Training, and if applicable, Supervisor Training certificates will be maintained in the field office.

1.2 Medical Monitoring Requirements

All personnel (including visitors) entering the exclusion zone or decontamination zone must have completed the medical monitoring requirements under OSHA 29 CFR 1910.120(f).

Documentation of medical monitoring is the responsibility of each employer. If there are additional medical monitoring requirements for this site, evidence of compliance must also be included. Documentation of Eder personnel medical monitoring is maintained on file.

1.3 Fit-Testing Requirements

All personnel (including visitors) entering the exclusion zone or decontamination zone using a negative pressure air purifying respirator must have successfully passed a qualitative respirator fit-test in accordance with OSHA 29 CFR 1910.134 or the American National Standards Institute.

Documentation of fit-testing is the responsibility of each employer. Documentation of Eder personnel fit-testing is maintained on file.

NATIONAL PRESTO INDUSTRIES,INC. SITE
EAU CLAIRE, WISCONSIN

TABLE 1-1

HEALTH AND SAFETY TRAINING RECORDS

Eder Personnel	Attendance Date 40-Hour Health and Safety Training Course	Attendance Date 8-Hour Health and Safety Training Refresher Course	Attendance Date Supervisors Training	Date of Last Physical	Date of Last Fit Test
N. Andrianas	03/28/86	11/21/92	2/27/93	07/14/92	11/21/92
N. Brew	06/25/93	--	--	09/08/92	06/25/93
J. Barish	02/05/88	11/21/92	2/27/93	09/10/92	11/21/92
B. Battaglia	10/30/92	11/21/92	--	08/27/92	11/21/92
E. Beacon	06/10/88	11/21/92	--	06/09/92	11/21/92
K. Butler	08/27/92	11/21/92	--	07/21/92	11/21/92
D. Dallmann	04/02/92	04/03/93	04/03/92	04/93	04/03/93
M. Delong	03/90	11/25/92	05/91	02/09/93	11/25/92
M. Foley	06/19/87	--	6/20/87	--	--
A. Giaimo	10/30/92	11/21/92	--	10/22/92	11/21/92
J. Heaney	06/19/87	11/21/92	06/24/91	12/03/91	11/21/92
K. McHale	06/16/89	11/21/92	02/27/93	09/01/92	11/21/92
S. O'Brien	01/15/93	--	--	01/07/93	01/15/93
K. Pasterak	05/14/86	11/26/92	--	12/03/91	07/01/88
B. Pendergast	05/04/90	11/21/92	02/27/93	07/02/92	11/21/92
T. Perotto	10/16/91	10/12/92	--	01/07/93	10/12/92
V. Raykin	05/04/90	11/21/92	02/27/93	08/25/92	11/21/92
K. Savo	03/26/93	--	--	03/18/93	03/26/93
J. Valenti	09/14/90	11/21/92	02/27/93	12/10/91	11/21/92
E. Wildfang	11/92	--	--	11/03/92	11/92

1.4 Site Safety Plan Acceptance Acknowledgement

The Eder Site Safety Officer shall be responsible for informing all personnel entering the exclusion zone or decontamination zone of the contents of this plan and will request that each person sign the Safety Plan Acknowledgment Form in Attachment B. By signing the Safety Plan Acknowledgment Form, personnel recognize the hazards associated with the site and the policies and procedures that Eder will take to minimize exposure or adverse effects.

1.5 Daily Safety Meetings

Daily safety meetings will be held to ensure that all on-site personnel understand site conditions and operating procedures, to ensure that personal protective equipment is being used correctly, and to address questions and concerns that on-site personnel may have regarding health and safety. The meetings will be lead by the Eder Site Safety Officer. All personnel trained and prepared to enter the exclusion and decontamination zones will attend the daily safety meetings. The initial meeting will be detailed to explain all site safety issues to all site workers, while the time allocated for subsequent meetings will be kept to a minimum.

1.6 Key Personnel

The Eder Principal in Charge for this project is Gary A. Rozmus, Senior Vice President. The Eder Project Manger is William Warren, and the Site Safety Officer is Brian Pendergast.

1.7 Roles and Responsibilities

Gary Rozmus, is responsible for overall project administration. The Site Safety Officer will oversee daily safety issues. Each contractor (as an employer under OSHA) is responsible for the health and safety of its employees.

The Eder Site Safety Officer is also responsible for coordinating health and safety standards for all individuals on-site. The Site Safety Officer will meet the emergency response and hazardous materials handling training requirements of OSHA 29 CFR Part 1910.120, will have completed supervisors training, and will have had appropriate experience pertinent to the on-site work. The Site Safety Officer has the authority to order any and all site work to be suspended based on safety concerns, and is responsible for:

1. the indoctrination of all personnel with regard to all of the information in this HASP and any other safety requirements to be observed during site operations, including, but not limited to, decontamination procedures, designation of work zones and levels of protection, air monitoring, fit testing, and emergency procedures dealing with fire and medical situations;

2. coordination with the Project Manager and Site Manager regarding site safety decisions;

3. maintenance of the designation between the exclusion, decontamination, and support zones;

4. monitoring the condition and status of on-site hazards, and maintenance and implementation of the air quality monitoring program specified in this HASP;

5. maintenance of records of safety problems encountered, mitigative actions taken, and documentation of any chemical exposures or physical injuries of workers.

Any person who observes safety concerns or potential hazards that have not been addressed in the daily safety meetings should immediately report observations/concerns to the Eder Site Safety Officer or other appropriate key personnel.

2.0 SITE BACKGROUND AND SCOPE OF WORK

2.1 Site Background and Description

The National Presto Industries, Inc. (NPI) site comprises approximately 320 acres in Eau Claire, Wisconsin and is not presently an active manufacturing facility. The site was originally owned by the United States Government and operated between 1940 and 1947 by its contractors, the U.S. Rubber Company (Uniroyal) as a small arms ammunition plant, and Western Electric (AT&T) as a radar tube manufacturing plant. NPI purchased the site from the government in 1947. Between 1947 and 1954, NPI used the facility to produce consumer products, projectile fuzes, and military aircraft parts. Since 1954, all manufacturing activities at the NPI site have been dedicated to defense work for the Department of Defense (DOD). Between 1954 and 1959, the facility produced military aircraft parts and between 1966 and 1980 the facility produced 8-inch and 105 mm projectiles for the Department of the Army (DOA). Active production ceased in February 1980.

When high volume projectile production began in 1966, a wastewater disposal system was devised using a series of lagoons. Lagoon No. 1 was an existing gravel pit that had been used for stormwater percolation and to dispose of waste streams and wastewater generated at the NPI site. It is believed that these wastes were consistent with operations conducted at the NPI site, which included plating, degreasing, metal fabricating, machining, and painting. Lagoon No. 2 was constructed in 1966 and Lagoons 3 and 4 were constructed in 1969. Lagoon No. 1 was used as a settling pond and Lagoons 2, 3, and 4 were used as percolation ponds. There were no federal or state discharge permit requirements in existence at the time that the lagoons were constructed. A WPDES discharge permit was issued for the lagoons in 1976.

Waste forge compound, which in its virgin state consists of approximately equal parts of asphalt, graphite and mineral oil, is the primary waste material present in Lagoon No. 1. Volatile organic

compounds (VOCs) and metals became incorporated into the waste forge compound during the forging operations. Waste forge compound with a low solids content flowed by gravity and was pumped to Lagoon No. 1 with process wastewaters between 1966 and 1980. The waste forge compound and wastewater stream discharged to Lagoon No. 1 contained VOCs (primarily 1,1,1-trichloroethane) and metals which were introduced during the manufacturing process.

From 1966 to 1970, waste forge compound with a higher solids content was heated in a basement collection sump so that it could be pumped into drums. The drums were hauled to the Melby Road Disposal Site where the waste forge compound was emptied into trenches. Disposal of waste forge compound at the Melby Road Disposal Site ceased in 1970 after a reclamation and recycling program was developed and initiated by NPI. The Melby Road Disposal Site trenches were covered and the area was regraded in 1970.

The results of source characterization during the Remedial Investigation (RI) indicate the presence of VOCs and/or metals at the Melby Road Disposal Site and Lagoon No. 1. The most commonly found VOCs were 1,1,1-trichloroethane (TCA), trichloroethylene (TCE), tetrachloroethylene (PCE), 1,1-dichloroethylene (1,1-DCE), 1,2-dichloroethylene (1,2-DCE), and 1,1-dichloroethane (1,1-DCA).

The objective of the Lagoon No. 1 pilot study is to determine the feasibility of blending the waste forge compound for use as a secondary fuel at a regulated cement kiln. The objective of the Melby Road Disposal Site study is to attempt to define the extent of the contamination, the source of the TCA plume and hot spots, and the possibility of contaminants volatilizing from the waste forge compound and causing continuing groundwater contamination.

2.2 Scope of Work

Lagoon No.1

During the preparation of the Feasibility Study for the NPI site, NPI received a proposal from Waste Research & Reclamation (WRR) to remove and dispose of the Lagoon No. 1 waste forge compound by pumping, blending with waste oils and solvents and using it as a secondary fuel in an off-site cement kiln. WRR's proposal was based on the laboratory analyses of samples of Lagoon No. 1 waste forge compound and their previous experience with the material during the time that projectiles were produced at the NPI site.

A 20,000-gallon prototype pilot study of this alternative will be conducted. The objective of the pilot scale study is to determine the pumpability and consistency of the waste forge compound, and the feasibility of fuel blending and burning at an approved Boiler and Industrial Furnace (BIF) regulated cement kiln. The pilot scale study will be conducted by WRR and observed by Eder and USEPA/WDNR personnel.

WRR will place an 11-foot diameter by 10-foot high steel cylinder into the lagoon in the area between sampling reference points S1 and R2 used in WRR's May 1992 depth survey of Lagoon No. 1, as indicated on Figure 2. The cylinder will be equipped with two hydraulically operated slide gate openings located 1 foot above the bottom. The cylinder will have a work platform with guard rails, and a pump hoist tripod. The cylinder will be secured to the shore by guy wires to assure stability during the operation.

The cylinder will be placed on the lagoon bottom at a location where the waste forge compound is approximately 6 feet deep, and the 2-foot surface water layer will be pumped from the cylinder back into the lagoon. The two hydraulically operated slide gates will be opened to allow additional waste forge compound to enter the cylinder. A 4-inch hydraulically driven centrifugal pump will be lowered into the waste forge compound and the waste forge compound will be pumped to a tanker truck through a combination of 6-inch flexible hose and thin wall irrigation

pipe to reduce friction loss. The material will be transported from the NPI site to WRR in 4,000 gallon loads for testing. The tests conducted by WRR to assess the suitability of burning the waste forge compound as fuel for a BIF-regulated cement kiln will include entrained solids (volumetrically), fuel value (bomb calorimeter), entrained water (Carl Fischer titration), chloride and ash (bomb calorimeter). Three samples of waste forge compound will be collected and sent to Enseco-Wadsworth/ALERT Laboratory for Priority Pollutant analysis using CLP protocol. Waste forge compound sampling and analysis will be performed in accordance with the SAP. The samples will be collected either by probing (using a hollow metal rod or a single use weighted PVC bailer) through the waste forge compound in the cylinder, or by disconnecting the hose from the tanker to transfer some material to sample containers. The samples will be collected when the waste forge compound is pumped for the first, third, and fifth 4000-gallon loads.

The waste forge compound will be blended at WRR with waste solvents and oils to reduce its viscosity and screened through a vibrating screen to remove debris larger than 1/8 inch, which would foul the BIF feed nozzles, if necessary. The blended fuel will be shipped by tanker truck, either directly to the cement kiln, or to WRR's rail site in Altoona, Wisconsin, transferred to a tank car and shipped by rail to the cement kiln.

Melby Road Disposal Site

As the FS was being prepared for the NPI site, it became apparent that the Melby Road Disposal Site was not characterized to the extent required to effectively develop and evaluate potential remedial alternatives. Data gaps existed with respect to the vertical and areal extent of contamination and questions remained regarding the specific source of VOCs in groundwater. In addition, historical aerial photographs recently obtained from the Eau Claire County Health Department revealed the waste disposal area to be larger than originally delineated based on earlier photographs. Consequently, it is necessary to conduct additional field work, including sampling and laboratory analyses at the Melby Road Disposal Site to fully determine the nature

and extent of waste disposal and soil contamination, and to collect data to support the remedial alternative evaluation. The following discussion presents the proposed additional work.

Using a CAT 245 Trackhoe excavator or equivalent, a 24 foot deep inspection trench will be excavated, starting at the eastern portion of the waste forge compound disposal area (extent estimated from available information), and proceeding first northwest and then due west, as indicated on Figure 1. A second inspection trench will be excavated through the soil gas hot spot located in the northeast corner of the Melby Road Disposal Site. A third trench will bisect the southeast soil gas hotspot. Additional trenches or test pits will be excavated to determine the extent of the disposal trenches and contamination. These excavations will be located along the approximate boundaries of the disposal area shown on Figure 1, and as determined in field. Test pits may be excavated in place of trenches if it would be more efficient to use pits to determine the extent of the contamination. Field decisions would be based on headspace screening data and physical characteristics of the material observed in the inspection excavations. The excavated wastes and soil will be described with respect to color, texture, appearance, mineralogy, and moisture and sampled by Eder at the surface and analyzed in accordance with the Sampling and Analysis Plan (SAP). The inspection excavations will be excavated by scraping successive layers to the practicable reach of the excavating machine, and the excavated materials will be stockpiled for backfilling. The excavation faces will be scaled to provide a stable edge. All excavated material will be backfilled into the inspection excavations in the order in which it was removed to the extent practicable. If any wastes are excavated and subsequently backfilled, the location will be indicated in the field notebook. All excavations will be backfilled at the end of the work day. Excavation depth will be measured using a steel tape where practical.

Waste forge compound will be visually inspected and sampled by WRR to determine its suitability for burning as a secondary fuel, either as a liquid or a solid. Representative samples will be collected and analyzed by WRR for the parameters indicated in Section IV of the Work Plan.

Soil samples will be initially collected during the excavation work at 5-foot depth intervals vertically and 10-foot intervals horizontally and the headspace analyzed for TCA, TCE, and PCE using a portable GC. The sampling frequency may be adjusted, based on field observations, such as homogeneity of the subsurface material. Sampling and analysis will be performed in accordance with the SAP. Soil samples will be collected from the excavated material and submitted for laboratory analysis of VOCs to develop a correlation between headspace readings and contaminant concentrations. The number of samples to be collected for laboratory analysis will be determined based on field observations, such as visibly different waste materials.

Soil borings will be drilled to the water table and soil and waste samples collected to develop a vertical profile of the extent of the contamination after the excavation work is complete and the excavations are backfilled. Based on the current soil gas data, soil borings will be drilled in the three soil gas hot spots and in several other locations to develop the vertical profile. The actual number and location of the soil borings will be determined based on field observations and existing RI data. If high headspace readings are found to persist to the bottom of the excavations, soil borings will be drilled to the water table adjacent to the points of highest headspace readings to develop a vertical profile. Continuous sampling will be conducted throughout the depth of the waste (identified during the excavation work) using a hollow stem auger with a 24 inch split spoon. Samples would be collected at 5-foot intervals using split spoons from the soil column extending from the lower extent of the wastes to the water table. Waste samples will be visually identified and each sample will be described with respect to color, texture, appearance, mineralogy, moisture, and grain size. If wastes are found which are visually different than the wastes sampled and analyzed during the RI, then a laboratory analysis plan will be developed and reviewed with the EPA and WDNR for their approval. The soil samples will be field screened for headspace TCA, TCE, and PCE. At least three soil samples from each boring with detectable headspace levels representative of high, intermediate, and low concentrations will be sent to the laboratory for VOC analysis. If applicable, at least two soil samples with non-detectable headspace concentrations from each boring will be submitted for confirmatory laboratory analysis of VOCs. Additional confirming soil samples will be taken for laboratory analyses of VOCs, as

necessary to develop a correlation between headspace readings and the contaminant concentrations.

At least one sample of the waste forge compound will be collected from the split spoon for headspace analysis. A 40 milliliter VOA vial would be filled halfway and capped. The relative concentration of TCA and TCE in the headspace will be measured with the field GC, by withdrawing an aliquot from the headspace for analysis after 30 minutes, and 1, 2, 4, 8 and 24 hours (and possibly longer) at the temperature of the in-place waste, which will be determined using a thermometer. The headspace will be purged using ultra zero air after each aliquot is withdrawn to determine the offgas concentration during the time interval. After purging, the vial will be recapped with a new septum. An aliquot will then be withdrawn and analyzed using the GC to obtain a time "zero" headspace reading for the next time interval. This would provide a semi-quantitative determination of the amount of TCA and TCE that volatilizes from the waste forge compound over time.

Fugitive dust control will be performed as needed during waste material handling. The application of water sprays will be carefully controlled to suppress airborne dust without causing runoff. Excavated waste material will be stockpiled on double polyethylene sheeting. Stockpiles will be covered with single polyethylene sheeting during inclement weather, which will be weighted with soil to keep the sheeting in place, and placed so that runoff remains on-site. Sheeting will be a minimum 6 mil thickness. Where seams are required, adjacent sheets will overlap by at least 6 inches and will be joined with folded seams and sealing tape. The seams on successive layers will be staggered by a distance of at least 6 feet.

Stockpiled materials will be carefully removed from the sheeting using the backhoe. Stockpile residues will be removed manually using brooms and shovels to prevent damage to the sheeting. Sheeting may be reused at successive trench excavations, provided it is intact. Damaged sheeting and sheeting from the last excavation will be disposed of off-site.

All components of the excavating equipment that come in contact with the waste forge compound will be decontaminated upon leaving the NPI site using a steam cleaner. Rinse water will be contained and pumped into drums and placed in Lagoon No. 1. Steam cleaners and pumps will either be self powered or electric powered with a generator.

Equipment involved in the Lagoon No. 1 pilot study will be decontaminated near Lagoon No. 1. A decontamination station will be constructed near the Melby Road Disposal Site entrance to decontaminate equipment entering and leaving the work area. The station will be sized to accommodate the equipment, and will consist of a bermed area lined with double polyethylene sheeting of minimum 6 mil thickness. Where seams are required, adjacent sheets will overlap by at least six inches and will be joined with folded seams and sealing tape. The seams on successive layers will be staggered by a distance of at least six feet. The floor will be sloped to a collection sump. The sump contents will be transferred to and placed in Lagoon No. 1. After the last decontamination, the station will be closed by removing the sheeting, and grading the station level.

3.0 HAZARD ASSESSMENT

This Hazard Assessment identifies the activity-specific hazards associated with site operations and the standard operating procedures (SOPs) that should be implemented to reduce the hazards. This section identifies general physical hazards that can be expected at most sites, and presents an analysis of documented or potential chemical hazards at the site. Every effort will be made to reduce or eliminate these hazards. Hazards that cannot be eliminated must be guarded against by use of engineering controls and/or personal protective equipment.

3.1 Activity-Specific Hazards and Standard Operating Procedures

3.1.1 Trenching and Test Pitting Operations

Hazards

- Inhalation of volatile vapors and particulate contaminants;
- Skin contact with contaminants from excavated soil/materials or handling equipment;
- Cave-ins;
- Physical impact with equipment;
- Explosion/fire; and,
- Heat stress;
- Cold stress.

SOPS To Avoid Hazards

- Wear appropriate respiratory protection, if deemed necessary;
- Wear appropriate personal protective equipment (gloves, tyvek, overboots, etc.);
- Avoid the use of loose belts, drawstrings, loose straps that might catch on equipment;
- Keep work areas free of obstructions;
- Sloping and/or shoring of trench faces, and keeping at least 2 feet from edge of excavation (see articles related to heavy equipment and excavation below);
- Monitor air using a combustible gas indicator, and organic vapor analyzer (OVA), and supplemented with GC headspace analysis; and
- Ensure all site personnel are familiar with the symptoms of heat stress outlined in Attachment C.

3.1.2 Sample Collection

Hazards

- Inhalation of volatile vapors and particulate contaminants;
- Skin contact with contaminated soils, sediments, and water through cuts, abrasions, and dermal absorption;
- Heat stress;
- Cold Stress.

SOPS to Avoid Hazards

- Wear appropriate respiratory protection;
- Wear protective gloves during sampling;

- Monitor air in the breathing zone with OVA; and
- Ensure all site personnel are familiar with the symptoms of heat stress outlined in Attachment C.

3.1.3 Sampling Equipment Decontamination:

Hazards

- Inhalation of volatile vapors and mists;
- Skin contact with contaminants from splash;
- Slipping on wet surfaces; and,
- Heat stress.

SOPS to Avoid Hazards

- Wear appropriate respiratory protection if deemed necessary;
- Wear protective gloves during decontamination;
- Ensure that all wash and rinsewater are properly drained from the decontamination area;
- Monitor air with OVA; and
- Ensure all site personnel are familiar with the symptoms of heat stress outlined in Attachment C.

3.1.3 Operation of Heavy Equipment

The contractor will adhere to the specific guidelines for operating heavy equipment as outlined by OSHA in 29 CFR 1926.602. The excavation contractor's general guidelines will be amended to this report prior to the start of site work. The excavation contractor will be responsible for safety around the machinery.

3.1.4 Excavation

OSHA 29 CFR 1926.651, February 20, 1990 has set construction industry standards which include shoring and cutback requirements, equipment specifications, entry requirements, etc. To avoid exposure to site specific contaminants and to ensure acceptable atmospheric conditions, the following additional requirements apply:

- Air quality shall be tested before employees enter excavations over four feet deep if a hazardous atmosphere exists or is suspected to exist. If the Site Safety Officer determines that excavations are, by OSHA's definition "confined space," the excavations will not be entered until this plan is modified to include procedures for confined space entry. Only the Eder Health and Safety Officer can issue a confined space entry permit.

- Tests shall be conducted as often as necessary as determined by the Site Safety Officer to ensure atmospheric quality. These tests include but are not limited to tests for flammable gas, oxygen deficiency and/or toxic gas concentrations.

- When the Site Safety Officer identifies hazardous atmospheres, emergency rescue equipment must be on the work site (Level B PPE) and readily accessible to employees (29 CFR 1926.651(g)(2)(i). The use of Level B PPE is not anticipated, however, if required, this HASP must be amended prior to starting work in Level B PPE or requiring standby Level B PPE.

- Daily inspections will be conducted by the Site Safety Officer. No personnel will enter the excavation under any circumstances. All efforts will be made to allow excavations to vent naturally before any mechanical means are employed.

3.2 General Site Hazards

The following discussion is provided as additional information, although not all of these hazards may be encountered at the Sites.

Shock-Electrocution

All electrical power must have a ground fault circuit interrupter as part of the circuit. All equipment must be suitable and approved for the class of hazard. Applicable OSHA 29 CFR 1926 Subpart K standards for use of electricity shall apply.

Fall from Heights

Work in which a fall potentially exists will be performed using appropriate ladders and/or protection (i.e. body harness and lifeline). All work at this site is expected to be conducted at the ground surface.

Heat Stress

When the temperature exceeds 70°F and personnel are wearing protective clothing, a heat stress monitoring program shall be implemented as appropriate. Employees shall have access to break periods and beverages as necessary. All personnel routinely working on-site (including the support zone) shall be familiar with the symptoms and signs, and emergency care associated with heat stress, heat exhaustion, and heat stroke as discussed in Attachment C of this HASP.

Facial Injury and Inhalation

In accordance with 29 CFR 1910.151(c), all operations involving the potential for eye injury, splash, etc., must have approved eye wash units locally available. Protective eye wear shall be donned in Level D, when appropriate. (The full-face air purifying respirator required by Level

C and the pressure demand self-contained breathing apparatus mask required by Level B serve as eye protection.)

Fire

Operations involving the potential for fire hazards shall be conducted in a manner such that risk will be minimized. Non-sparking tools and fire extinguishers shall be used or available as appropriate. Sources of ignition shall be removed from work areas. When necessary, explosion-proof instruments and/or bonding and grounding will be used to prevent fire or explosion. (Also see discussion on methane, Section 3.3.)

Overhead and underground utilities shall be identified and/or inspected prior to conducting operations involving potential contact or interference.

3.3 Chemical Hazards

A summary table containing hazardous chemicals known at the NPI sites, and pertinent health information is contained in Attachment D. As additional chemicals are identified on-site and off-site Attachment D will be supplemented with the appropriate information.

Methane is a significant chemical hazard which may be encountered during trenching. The lower explosive limit of methane is 5%, the upper explosive limit is 15%. Continuous air monitoring during borings using a methane detection meter and a combustible gas indicator/oxygen meter is required. A carbon dioxide or dry chemical fire extinguisher should be available at the work area. It must be assumed that benzene is being read by the field PID instruments, since calibration will be to benzene.

4.0 PERSONAL PROTECTIVE EQUIPMENT

The selection of personal protective equipment (PPE) shall be conducted in accordance with the site air monitoring program, OSHA 29 CFR 1910.120(c) and (g), and 1910.132. Protective equipment shall be NIOSH-approved and its use for respiratory protection shall conform to OSHA 29 CFR Part 1910.133 and 1910.134 specifications; head protection shall conform to 1910.135; eye and face protection shall conform to 1910.133; and foot protection shall conform to 1910.136.

4.1 Activity-Specific Levels of Personal Protection

The required level of PPE is specific to the activity being conducted, and is based on air monitoring results (Section 5.0) and properties of identified contaminants and contaminants expected to be encountered (Section 3.3).

The excavation work at the Melby Road Disposal Site and field work at Lagoon No. 1 will be initially performed in Level C shall be worn. Air monitoring will be conducted continuously and recorded to determine whether Level B is required or if Level D conditions are suitable. If during sampling or trenching activities, air monitoring in the breathing zone indicates sustained PID VOC readings at 5 ppm or greater over background, the field team must shut down work or upgrade PPE to level B. A gas chromatograph may be used to identify specific compounds present in the breathing zone. If the identified compounds have Level C PPE capability, then work can continue downgraded to Level C. If this is done, then air samples for gas chromatograph analysis will be collected 4 times a day to verify the condition is sustained, or as determined by the site safety officer.

4.2 Level D

Level D PPE will be used when atmospheric conditions permit and the work precludes splashes, immersion or the potential for unexpected contact with harmful chemicals. Level D PPE consists of:

- Standard work uniform or coveralls (or tyvek, as needed);
- Steel toe and steel shank work boots;
- Hard hat;
- Gloves as needed; and
- Safety glasses as needed.

4.3 Level C

Level C PPE shall be donned when sustained concentrations of known total organic vapors in the breathing zone exceed background concentrations but are less than 5 ppm above background using a portable organic vapor analyzer (OVA, or equivalent). The compounds present will be determined using a gas chromatograph. The air purifying filter cartridges must be appropriate for contaminants identified or expected to be encountered. Level C PPE shall be donned when the contaminant identified has adequate warning properties and criteria for the use of APR have been met. The appropriate PPE level will be established by the Site Safety Officer. Unknowns are adequately defined as judged by the site safety officer. Level C PPE consists of:

- Chemical resistant or coated tyvek coveralls;
- Steel toe and steel shank workboots;
- Chemical resistant overboots or disposable boot covers;
- Disposable inner gloves (surgical gloves);
- Disposable outer gloves;
- Full-face APR fitted with organic vapor/dust and mist filters or filters appropriate for the identified contaminants expected to be encountered;

- Hard-hat;
- Splash shield, as needed; and,
- Ankles/wrists taped with duct tape.

4.4 Level B

Level B PPE shall be donned when sustained concentrations of measured total organic vapors in the breathing zone are greater than 5 ppm above background using a portable organic vapor analyzer (OVA, or equivalent). Level B PPE shall be donned if the IDLH of a known contaminant is exceeded. If a contaminant is identified or is expected to be encountered for which NIOSH and/or OSHA recommend the use of a positive pressure self-contained breathing apparatus (SCBA), Level B PPE shall be donned, even though the total organic vapors in the breathing zone may not exceed background by 5 ppm. If Level B PPE is required for a task, then at least two Eder personnel shall wear Level B at all times during the performance of that task and a third person will remain out of the work zone on standby with Level B equipment should a problem arise. Level B PPE consists of:

- Chemical resistant coveralls;
- Steel toe and steel shank workboots;
- Chemical resistant overboots or disposable boot covers;
- Disposable inner gloves;
- Disposable outer gloves;
- Supplied air SCBA or airline system with 5-minute egress system;
- Hard-hat; and,
- Ankles/wrists taped.

5.0 AIR MONITORING AND ACTION LEVELS

According to 29 CFR 1910.120(h) air monitoring shall be employed to identify and quantify airborne levels of hazardous substances and health hazards.

5.1 Routine Air Monitoring Requirements

Air monitoring using a portable organic vapor analyzer or equivalent, and a combustible gas indicator/oxygen meter shall be used when any of the following conditions apply:

- Initial site entry;
- The possibility of an IDLH condition or flammable atmosphere has developed;
- Work begins on a different portion of the site;
- Contaminants other than those previously identified have been discovered;
- A different task or activity is initiated;

All air monitoring data will be documented in a site log book. Air monitoring instruments will be calibrated and maintained in accordance with the manufacturer's specifications.

The initial site entry shall be conducted using:

- Combustible Gas Indicator(CGI)/Hydrogen Sulfide Indicator/Oxygen Meter;
- Organic Vapor Analyzer (OVA);
- MicroTip.

The following site entry and monitoring primary guidelines regarding actions to be taken based on routine air monitoring shall be applied. These are:

CGI readings of < 10% LEL: continue.

CGI readings of 10 to 20% LEL: proceed with caution.

CGI readings > 20% LEL: stop work.

OVA readings in breathing zone sustained at background: continue.

OVA readings in breathing zone sustained at levels greather than 5 ppm above background: Level B PPE.

5.2 Activity-Specific Air Monitoring

The following activity-specific air monitoring guidelines shall apply. All air monitoring results will be recorded in the site field log book.

Real-time air monitoring will be performed at the perimeter of the exclusion zone and qat the site boundary of each area. All monitoring data will be recorded in the field notebook.

Hourly real-time measurements of organic vapor concentrations will be made using a photoionization detector or a flame ionization detector. In addition, hourly real-time measurements of particulate concentrations will be made during the Melby Road Disposal Site excavation work using a light scattering aerosol monitor. Real-time air monitoring locations will be at four locations on the perimeter of the exclusion zones and at the site boundaries (one location upwind and two locations downwind).

Site perimeter ambient air monitoring will be conducted during the excavation operations at the Melby Road Disposal Site, using high volume air monitoring trains, in accord with the Sampling and Analysis Plan (SAP). Two ambient air monitoring stations will be located downwind and one station upwind. The ambient air monitoring will include respirable particulates (PM_{10}) and Total Suspended Particulates (TSP) for metals, and volatile organic compounds (VOCs) and polynuclear aromatic hydrocarbons (PAHs). The reference methods are indicated in Section II

of the SAP. Each ambient air monitoring station will consist of the equipment specified in the USEPA methods to measure TSP, PM_{10}, VOCs and PAHs. The SAP contains standard operating procedures (SOPs) for each method. A generator will be set up at each station immediately downwind of the air monitoring equipment. The sampling media from each station will be submitted to Ross Analytical Services, Inc. of Strongsville, Ohio for analysis.

Ambient air quality will be monitored each day for the duration of the trench and test pit operations at the Melby Road Disposal Site. Background ambient air monitoring will be conducted for an eight-hour period on the day before the excavation activity begins. If it is necessary to leave excavations open overnight, ambient air quality will be monitored for the overnight period. The overnight sampling run will begin after work activity stops for the day and will continue until work begins the next day. The ambient air monitoring results will be evaluated in relation to wind speed, wind direction, temperature, relative humidity, and barometric pressure. These meteorological data will be obtained hourly for the Chippewa Valley Regional Airport weather station (telephone number: 715-835-3163).

The residences in closest proximity to the Melby Road Disposal Site work area are located north of Melby Road. The two downwind air monitoring stations (based on the prevailing wind direction) are located along the Melby Road fenceline. The ambient air monitoring stations may be moved if there are sustained changes in wind direction during the field work. However, it will not be necessary to move the sampling trains in response to periodic shifts in wind direction because the ambient air quality data collected at the NPI site property line along Melby Road will be sufficient to evaluate off-site impacts.

Real-time air sampling can be conducted at locations in addition to those specified in this Work Plan as conditions warrant. For example, if sustained elevated organic vapor or particulate concentrations are measured near the work area, additional readings will be taken as the air sampling personnel moves away from the work area in the downwind direction (based on weather conditions recorded at the airport) towards the NPI site property line (the Melby Road fenceline) to evaluate the dissipation of contaminant concentrations in the air.

The excavation activity will be suspended if the real-time measurements of particulate or organic vapor concentrations (at the Melby Road fenceline) are sustained at levels above the following action levels during three consecutive hourly sampling events:

- PM_{10} > 450 ug/m^3
- organic vapors > 5 ppm above background levels

The PM_{10} action level is based on the National Ambient Air Quality Standard of 150 ug/m^3 (24 hour average) and prorated for an eight-hour work day. If the work is suspended due to high particulate concentrations at the NPI site boundary, water sprays will be used to reduce particulate levels in the air. Then, excavation will proceed using water to control particulate releases. If the work is suspended due to high organic vapor concentrations at the NPI site boundary, mitigation measures will be discussed with USEPA and WDNR, and appropriate measures will be implemented before proceeding with the excavation work.

6.0 SITE CONTROL AND STANDARD OPERATING PROCEDURES

6.1 Work Zones

The Eder Site Safety Officer shall designate an exclusion zone, a decontamination zone, and a support zone.

The exclusion zone is the area within which tasks requiring the OSHA 40-hour Hazardous Waste Operations and Emergency Response Operations training are carried out.

The removal of protective equipment shall occur within the designated decontamination zone. Disposable protective equipment shall be stored in receptacles kept in the decontamination zone, and non-disposable equipment will be decontaminated according to the procedures outlined in Section 7.0. All personnel and equipment will exit the exclusion zone via the decontamination zone. First aid equipment, an eye wash unit, and drinking water shall be kept in the decontamination trailer.

The support zone will be used for the command post, for vehicle parking, daily safety meetings, and supply storage. No decontamination will be permitted in the support zone. This HASP, the HASP attachments, a site map indicating the three work zones, and a telephone will be kept at the command post.

6.2 General Field Safety and Standard Operating Procedures

It is Eder's policy to practice administrative hazard control for all site areas by restricting entrance to exclusion zones to essential personnel, and by implementing SOPs.

- Personnel not specifically authorized to enter the exclusion zone will remain in the support zone.

- Prior to entering the exclusion or decontamination zones all personnel must be familiar with emergency incident procedures (Section 8.0), the locations of site safety, first aid and communication equipment, and the locations of the map to the hospital and list of emergency telephone numbers.

- The "buddy system" will be used at all times by all field personnel in the exclusion zone. No one is to perform field work alone. When in Level D, visual contact or radio contact should be maintained at all times. When in Level B, visual contact should be maintained at all times, and radio contact should be maintained with the decontamination or support zone.

- Whenever possible, avoid contact with contaminated and potentially contaminated surfaces. Walk around (not through) puddles and discolored surfaces. Do not kneel on the ground or place equipment on the ground. Protect equipment from contamination.

- All personnel exiting the exclusion zone must exercise the decontamination procedures described in Section 6.0 of this HASP.

- Facial hair that interferes with respirator fit will preclude admission to the exclusion zone. Contact lenses shall not be worn in the exclusion or decontamination zones, or if the worker may be expected to enter these zones under routine or emergency situations.

- Eating, drinking, or smoking is permitted only in designated areas in the support zone.

- Each worker must be supplied with and maintain his/her own personal protective equipment.

7.0 DECONTAMINATION PROCEDURES

In general, everything that enters the exclusion zone must either be decontaminated or properly discarded upon exit from the exclusion zone. All personnel must enter and exit the exclusion zone through the decontamination area. Due to the nature of the work to be conducted, the exclusion and decontamination zones may "float". Bags used to discard disposable personal protective clothing and equipment will be carried from location to location.

All boots and other potentially contaminated garments which have come in contact with contaminated soils will be cleaned with detergent/water solution and rinsed with water in wash tubs. The wash water, rinse water and residues will be collected and properly stored until sampling results are received and final disposition of the waste can be determined. Disposable PPE, including spent respirator cartridges and canisters, will be properly bagged and disposed. All contaminated boots, clothing, and equipment (eg. leather boots, equipment carrying straps) which cannot be decontaminated will be disposed of with the disposable garments.

The minimum measures for Level B removing and decontamination are:

- Deposit equipment on plastic drop cloths;
- Scrub outer boots and gloves with a solution of water and detergent and rinse off;
- Remove outer boots and outer gloves. Dispose of any disposable outer garments in waste receptacle provided;
- Remove tyvek/outer garment and place in receptacle provided;
- Remove inner gloves and deposit in receptacle provided; and,

- Remove SCBA and face piece and place on rack provided;
- Full shower including washing hair, face and hands.

The minimum measures for Level C removal and decontamination are:

- Deposit equipment on plastic drop cloths;
- Scrub outer boots and gloves with a solution of water and detergent and rinse off;
- Remove outer boots and outer gloves. Dispose of any disposable outer garments in receptacle provided;
- Remove tyvek/outer garment and place in receptacle provided;
- Remove first pair of inner gloves;
- Remove respirator (with "clean" inner gloves) and place on rack provided;
- Remove last pair of inner gloves and deposit in receptacle provided; and,
- Full shower including washing hair, face and hands.

The second last item to be removed should be the APR, and the last item to be removed should be the last of several pairs of surgical gloves. Wearing several pairs of inner gloves permits layers to be removed as needed during various stages of the doffing procedure, and, in the event that the APR has inadvertently become contaminated, wearing inner gloves to remove the APR guards against bare hands contacting the APR.

8.0 CONFINED SPACE

In general, a confined space is defined as a space or work area not designed or intended for normal human occupancy, with limited means of access and poor natural ventilation. Confined space entry is not anticipated at the NPI sites. In the event a confined space entry is to be necessary, the HASP will be amended and the requirements for a confined space entry will be followed, as per OSHA standard 29 CFR 1910.146.

9.0 EMERGENCY RESPONSE CONTINGENCY PLAN

It is essential that site personnel be prepared for an emergency. Emergencies can take many forms; illnesses or injuries, chemical exposure, fires, explosions, spills, leaks, releases of harmful contaminants, or sudden changes in the weather.

The list of emergency telephone numbers and map to the hospital will by posted in the command post. Site personnel should be familiar with the emergency incident procedures, and the locations of site safety, first aid, and communication equipment.

9.1 Emergency Equipment On-Site

Private Telephones:	Eder mobile phone. Nearest residence.
Two-Way Radios:	Eder site personnel.
Emergency Alarms	On-site vehicle horns*.
First Aid Kits:	On-site Eder vehicle/Command post.
Fire Extinguisher:	On-site Eder vehicle, excavator, work zones.**

* Horns: Air horns will be supplied to personnel at the discretion of the Site Manager or Site Safety Officer.

** Work Zones - There must be a chemical fire extinguisher present in the hot zone where Level B PPE is worn.

9.2 Emergency Telephone Numbers and Hospital Information

	EMERGENCY NUMBER	NON-EMERGENCY
Eau Claire Fire Department	911	839-5012
Eau Claire Police Department	911	839-4972
Sacred Heart Hospital (Trauma Center)	839-4222	
Luther Hospital	839-3242	
(Poison Control Center)	835-1515	
National Response Center	800-424-8802	

Emergency Route to Local Hospitals

Sacred Heart Hospital
900 West Claremont Avenue
Eau Claire, WI

Directions: Take Highway 53 south to Claremont Avenue (approx 5 miles). Turn right (west) on Claremont Ave. and continue approx. one mile to hospital.

Luther Hospital
1221 Whipple Street
Eau Claire, WI

Directions: Take Highway 53 south to Main Street. Go right (west) on Main Street to Farewell Street. Go left (south) on Farewell Street to lake Street. Go right on Lake Street over the bridge to Fifth Avenue. Make right on 5th Avenue to Chestnut Street. Go left on Chestnut Street and hospital is on the corner.

POST A COPY OF THE MAP IN THE OFFICE TRAILER FIELD VEHICLE

9.3 Personnel Responsibilities During an Emergency

As the administrator of the project, the Project Manager has primary responsibility for responding to and correcting emergency situations. In the absence of the Project Manager, the Site Safety Officer shall act as the Project Manager's on-site designee. Their responsibilities include:

- Take appropriate measures to protect personnel including: exit from the exclusion zone, total evacuation and securing of the site or up-grading or down-grading the level of protective clothing and respiratory protection;

- Ensure that appropriate Federal, State and local agencies are informed, and emergency response plans are coordinated; in the event of fire or explosion, the local fire department should be summoned immediately. In the event of an air release of toxic materials, the local authorities should be informed in order to assess the need for evacuation;

- Ensure that appropriate decontamination treatment or testing for exposed or injured personnel is obtained;

- Determine the cause of the incident and make recommendations to prevent the recurrence; and,

- Ensure that all required reports have been prepared.

9.4 Medical Emergencies

Any person who becomes ill or injured in the exclusion zone must be decontaminated to the maximum extent possible. If the injury or illness is minor, full decontamination should be completed and first aid administered prior to transport. First aid should be administered while waiting for an ambulance or paramedics. Any person transporting an injured/exposed person to

a clinic or hospital for treatment should take the directions to the hospital and information on the chemical exposure.

9.5 Fire or Explosion

In the event of a fire or explosion, the fire department should be summoned immediately. Upon their arrival the project manager or designated alternate will advise the fire commander of the location, nature and identification of the hazardous materials on-site. The contractor shall have access to stockpiled sand which will be used to extinguish fires by smothering them, prior to arrival of the fire department.

9.6 Evacuation Routes

Evacuation routes established by work area locations for this site will be highlighted on a site map and periodically reviewed during the daily safety meetings. As the work areas change the evacuation route and map will be updated accordingly, and the new route will be reviewed during the daily safety meetings.

Under conditions of extreme emergency, evacuation should be conducted immediately and without regard for equipment. The evacuation signal will be a continuous blast of a vehicle horn, if possible, and/or by verbal/radio communication. All site personnel shall:

- Keep upwind of smoke, vapors or spill location.
- Exit through the decontamination corridor if possible.
- If evacuation via the decontamination corridor is not possible, site personnel should remove contaminated clothing once they are in a safe location and leave it near the exclusion zone or in a safe place.

- The Project Manager or Site Manager will conduct a head count to assure all personnel have been evacuated safely. The head count will be verified with the site and/or exclusion zone entry/exit log.

- In the event that emergency site evacuation is necessary, all personnel are to escape the emergency situation and decontaminate to the maximum extent practical.

9.7 Spill Control Procedures

In the event of a leak or a release, site personnel will:

- Inform their supervisor immediately;

- Locate the source or the spillage and stop the flow if it can be done safely; and,

- Begin containment and recovery of the spilled materials. Equipment on-site shall be sufficient to handle any spills that may occur. Equipment shall be diked and containerized appropriately.

NATIONAL PRESTO INDUSTRIES, INC. SITE
EAU CLAIRE, WISCONSIN

TABLE 9-1

FIELD EQUIPMENT/SPILL CONTROL EQUIPMENT

Equipment	Use (Zone)
Steam Cleaner	Decontamination - interface between hot and cold zone
Mobile-Decontamination Unit Personnel Hygiene Traitor	Decontamination - field office
MicroTip	Exclusion zone - air monitoring
OVA	Exclusion zone - air monitoring
MSA-CGI	Exclusion zone - air monitoring
Trackhoe Excavator	Exclusion zone - sampling
Wind Direction 4-Speed Indicator	Exclusion zone - judge proper placement of equipment
Mobile phone	Cold zone - communication
Hand held radios	Exclusion zone - communication
Absorbent pads	Drum Sampling ARCA - Drum storage roll-off container

ATTACHMENT A

SITE SAFETY PLAN AMENDMENTS

SITE SAFETY PLAN AMENDMENT #____: _____

SITE NAME: _____

REASON FOR AMENDMENT: _____

_____

_____

_____

ALTERNATE PROCEDURES: _____

_____

_____

_____

_____

REQUIRED CHANGES IN PPE: _____

_____

_____

_____

_____ _____

NPI PROJECT SUPERINTENDENT (DATE)

_____ _____

EDER HEALTH AND SAFETY OFFICER (DATE)

LLV3760

SITE SAFETY PLAN AMENDMENT #____: _____

SITE NAME: _____

REASON FOR AMENDMENT: _____

_____

_____

_____

ALTERNATE PROCEDURES: _____

_____

_____

_____

_____

REQUIRED CHANGES IN PPE: _____

_____

_____

_____

_____ _____

NPI PROJECT SUPERINTENDENT (DATE)

_____ _____

EDER HEALTH AND SAFETY OFFICER (DATE)

LLV3760

SITE SAFETY PLAN AMENDMENT #____: _____

SITE NAME: _____

REASON FOR AMENDMENT: _____

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ALTERNATE PROCEDURES: _____

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REQUIRED CHANGES IN PPE: _____

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_____

_____ _____

NPI PROJECT SUPERINTENDENT (DATE)

_____ _____

EDER HEALTH AND SAFETY OFFICER (DATE)

LLV3760

ATTACHMENT B

SITE SAFETY ACKNOWLEDGMENT FORM

SITE SAFETY PLAN ACKNOWLEDGMENT FORM

I have been informed and understand the procedures set forth in the HASP and Amendments for the NPI Soil Vapor Extraction Pilot Test Project.

Printed Name	Signature	Representing	Date

LLV3760

ATTACHMENT C

HEAT STRESS/COLD STRESS

HEAT RELATED EMERGENCIES

Good judgment is essential. Pace yourself by knowing your limitations. Avoid over exertion. You are your best gauge for heat related emergencies. When in doubt, get out!

HEAT EXPOSURE

The human body stubbornly defends its constant core temperature of 99.6°F. To maintain this constant temperature, heat loss must equal heat gain. If heat loss exceeds heat gain, the body temperature will fall; conversely, if heat production exceeds heat loss, the temperature will rise. In a heat related emergency, the body's mechanisms for temperature regulation are overwhelmed. The body can no longer regulate core temperature, and the core temperature begins to rise. As this rise occurs, the body will begin to show the signs and symptoms of heat related emergencies. The sequence of illness may start with heat Cramps and progress into a more severe case or may go straight to Heat Stroke. The degree of illness will vary from person to person, depending on the nature of the exposure, physical conditioning and inherited traits.

PREVENTION

General

- Maintain good physical conditioning and control your blood pressure (avoid weight gain, smoking, etc.).
- Eat regularly and properly. Increase salt intake through food consumption during the hot season or hot spells and avoid the use of salt tablets.
- Regulate alcohol intake if you are going to be working in hot environments, either from ambient conditions or through the wearing of Chemical Protective Clothing.
- Obtain basic First Aid and CPR training.
- If you are on medication or have a chronic medical history, consult a physician prior to working in a hot environment.

On-Site/Scene

- If you anticipate field work, get acclimated and conditioned prior to working in high temperatures.
- Sufficient quantities of water should be consumed to help avoid heat related emergencies.

HEAT RELATED EMERGENCIES
SIGNS AND SYMPTOMS
EMERGENCY CARE

The work will involve the wearing of PPE at Level B and heat will have a great influence, slowing the work. If site related chemicals are such that splash conditions are unlikely than the site safety officer may downgrade the Level B dress to include cotton coveralls. The conditions of summer work dictate that special precautions be taken to ensure that heat related injuries are avoided. All field personnel are encouraged to drink plenty of liquids (i.e., gatorade or equivalent). This section presents signs and symptoms for heat related conditions and limitations on the work. Workers at the NPI Sites will be monitored for internal temperature hourly when temperatures are over 85°F.

Heat Rash

Also known as prickly heat, this is a condition affecting the skin. The condition occurs in situations where the skin remains wet most of the time. The sweat ducts become plugged, and a skin rash soon appears.

Signs and Symptoms

1. Skin rash over affected areas of the body.
2. Tingling or prickling sensation on the affected areas.

Emergency Care

1. Take shower after working in heat.
2. Dry the skin thoroughly.
3. Change underwear as needed.
4. Stay in cool place after work hours.
5. Avoid repeated exposure to heated environment until condition improves, when possible.

Heat Cramps

Heat cramps are muscle pains, usually in the lower extremities, the abdomen, or both, which occur secondary to profuse sweating with accompanying salt depletion. Heat cramps most often afflict people in good physical condition, who overwork in conditions of high temperature and humidity. Untreated, heat cramps may progress to heat exhaustion.

Treatment of heat cramps is aimed at eliminating the exposure and restoring the loss of salt and water.

Signs and Symptoms

1. Cramps in the extremities and abdomen which come on suddenly during vigorous activity. Heat cramps can be mild with only slight abdominal cramping and tingling in the extremities, but more commonly present intense and incapacitating pain in the abdomen and extremities.
2. Respiration rate will increase, decreasing after the pain subsides.
3. Pulse rate will increase.
4. Skin will be pale and moist.
5. Body temperature will be normal.
6. Loss of consciousness or airway maintenance are seldom problems with this condition.
7. Generalized weakness will be noted as the pain subsides.

Emergency Care

1. Move the worker to a cool environment. Have him lie down if he feels faint.

2. If the worker is not nauseated, he may be given 1 or 2 glasses of an electrolyte solution. Have the worker drink slowly. The use of salt tablets is not recommended, as they may precipitate nausea.

3. If the worker is nauseated, avoid giving anything by mouth until the nausea subsides.

4. Avoid massaging the cramping muscles. This rarely helps and may actually aggravate the pain.

5. As the salt and water level is replenished, the worker's pain will subside. He may wish to return to work, however, this is NOT recommended for a period of 12 hours. Further exertion may lead to heat exhaustion or heat stroke.

HEAT EXHAUSTION

Heat exhaustion represents a somewhat more severe response to salt and water loss, as well as an initial disturbance in the body's heat-regulating system. Like heat cramps, heat exhaustion tends to occur in persons working in hot environments. Heat exhaustion is likely in dehydrated and hypertensive people. Untreated Heat Exhaustion may progress to Heat Stroke.

Treatment of heat exhaustion is similar in principle to that of heat cramps.

Signs and Symptoms

1. Heat Exhaustion may come on suddenly or may be present with a headache, fatigue, dizziness, nausea with occasional abdominal cramping.
2. Sweating will be profuse.
3. Pulse rate will be rapid and weak.
4. Respiration rate will be rapid and shallow.
5. The skin will be pale and clammy.
6. The body temperature will be normal or decreased.
7. The worker could be irritable and restless.
8. Monitor the worker's level of consciousness and airway.

Emergency Care

1. Move the worker to a cool environment, take off as much of his clothing as possible, and place him in a supine position with his legs elevated.

2. Sponge the worker with cool water. If you fan the worker, avoid chilling. When the body chills, the muscles generate energy. When the body shivers, this energy is released in the form of heat and actually can increase the body temperature.

3. If this is a true medical emergency, prompt intervention by Emergency Medical Services is recommended.

HEAT STROKE

Heat Stroke is caused by a severe disturbance in the body's heat-regulating mechanism and is a profound emergency, with a mortality rate ranging from 25 to 50 percent. It is most common in men over 40, especially in alcoholics. It can also occur in people of any age having too much exposure to the sun or prolonged confinement in a hot atmosphere. Heat stroke comes on suddenly. As the sweating mechanism fails, the body temperature begins to rise precipitously, reaching 106°F (41°C) or higher within 10 to 15 minutes. If the situation is not corrected rapidly, the body cells - especially the very vulnerable cells of the brain - are literally cooked, and irreversible central nervous system damage occurs.

The treatment for Heat Stroke is aimed at maintaining vital functions and causing as rapid a temperature fall as possible.

Signs and Symptoms

1. The worker's pulse will be strong and pounding.
2. The skin will be hot, dry and flushed.
3. The worker may experience headache, dizziness, and dryness of mouth.
4. Seizures and coma occur.
5. Loss of consciousness and airway maintenance problems can occur.

Emergency Care

1. Establish an open airway.

2. Move the worker to a cool environment. Take off as much clothing as possible, and place him in a semi-reclining position with the feet elevated.

3. Use any means to cool the worker. Improvise with whatever is available. A bathtub filled with cold water and ice cubes is ideal. Remember, speed is essential; delay may result in permanent brain damage. Vigorous efforts to cool the worker must continue until the body temperature is below 103°F (38.9°C).

4. This is a true medical emergency; prompt intervention by Emergency Medical Services is recommended.

These are only guidelines for the care of Heat Related Emergencies. Actual training in emergency medical care or basic first aid is recommended.

HEAT STRESS

1. Heart rate (HR) should be monitored by the radial pulse for 30 seconds as soon as possible in the resting period.

   If at the beginning of the rest period a worker's radial pulse is measured and his heart rate exceeds 100 beats per minute, the worker's next work period should be reduced by 33%. Therefore, if the original work period was one hour, the following work cycle should be reduced to 40 minutes.

2. Administering salt tablets to prevent heat stress is not recommended due to a number of reasons: (a) sweat is hypotonic, therefore, adding salt to the body would only increase the body's need for water; (b) additional salt may interfere with a worker's predisposed physical condition (i.e., high blood pressure); and (c) increasing the sodium content in the body may cause an imbalance in the body's potassium content. Unless a physician recommends the use of soil tablets, individuals naturally obtain the necessary salt in their normal diet.

3. Heat Stroke is a true medical emergency. First aid should be directed toward immediate measures to cool the body quickly, as well as seeing that the victim receives medical attention as soon as possible.

   Prior to medical treatment, remove as much clothing as possible and proceed to cool the victim's body, taking care not to overchill the victim once his temperature falls below 102°F. One of the following cooling measures should be taken: (1) sponge the bare skin with cool water; (b) apply cold packs continuously; (c) wrap the victim in a sheet soaked with water; or (d) immerse the victim in a tub of cold water, while closely monitoring the victim's level of consciousness.

4. Prior to site activity, the field TEAM leader may make arrangements for heat stress monitoring (i.e., monitoring heart rate, body temperature and body water loss) during actual site work if conditions warrant these measures. In addition, he would want to ensure that the team members have been acclimatized to the particular environmental conditions and that personnel are aware of the signs and symptoms of heat illness and have been adequately trained in first aid procedures. As field team leader, one could also make sure there is sufficient personnel on site, so as to rotate work assignments, schedule work during hours of reduced temperatures, and ensure personnel do not consume alcoholic or caffeinated beverages but rather drink moderate levels of an electrolyte solution and eat well prior to commencing site work.

5. The worker could be experiencing a condition of heat rash. Allow workers to rest and relieve the itching associated with heat rash rather than return to work too soon. Itching workers may not follow stringent decon procedures or scratch where it itches on-site and risk cross contamination.

   Keeping the skin clean and dry will reduce the incidence of heat rash. This can be accomplished by wearing cotton garments (or other materials that absorb perspiration) underneath protective clothing. Upon removal of the protective clothing, the worker should wash and dry his skin thoroughly.

6. The sense of thirst is not an adequate regulator of water replacement during heat exposure. Therefore, as a general rule, the amount of water administered should replace the amount of water lost, and it should be administered at regular intervals throughout the day. For every ½ pound of water loss, 8 ounces of water should be ingested. Water should be replaced by drinking 2-4 ounce servings during every rest period. A recommended alternative to water is an electrolyte drink split 50/50 with water.

7. Although there is no specific test given during a baseline physical that would identify a person's intolerance to heat, there are physical factors and personal habits which may indicate possible intolerance to heat, such as, whether or not an individual smokes, one's dietary habit, body weight, as well as predisposed physical conditions such as high blood pressure, heart conditions, diabetes, or one's medication, that may influence an individual's ability to tolerate excessive heat.

8. Heat cramps are caused by profuse perspiration with inadequate fluid intake and salt replacement. Heat cramps most often afflict people in good physical condition who overwork in conditions of high temperature and humidity. Heat cramps usually come on suddenly during vigorous activity. Untreated, heat cramps may progress directly to heat exhaustion or heat stroke. First aid treatment: remove victim to a cool place and give sips of salted water (1 teaspoon of salt to 1 quart of water) - 4 ounces every 15 minutes over a period of one hour. A commercial preparation, e.g., Gatorade, may be used if split 50/50 with water.

The salted water or solution should mitigate the cramps. Manual pressure should not be applied to the cramped muscles.

TABLE C-1[1]

REQUIRED FREQUENCY OF HEAT STRESS MONITORING
FOR WORKERS IN IMPERMEABLE CLOTHING

Adjusted[2] Temperature (°F)	Work Time Allowed Before Monitoring Break (min.)
90 or above	15
87.5-90	30
82.5-87.5	60
77.5-82.5	90
72.5-77.5	120

(1) Adapted from Eastern Research Group and National Institute for Occupational Safety and Health, Occupational Safety and Health Guidance Manual for Super Activities. September 26, 1984, pp. 8-75.

(2) Calculate the adjusted air temperature (Ta adj) by using this equation:

$$\text{Ta adj °F} = \text{Ta °F} + (13 \times \% \text{ sunshine})$$

Measure air temperature (Ta) with a standard thermometer, with the bulb shielded from radiant heat. Then estimate percent sunshine (100 percent sunshine = no cloud cover and a sharp, distinct shadow; 0 percent sunshine = no shadows).

TABLE C-2

Heat Stress Indicator	When to Measure	If Exceeds . . .	Action
heart rate (pulse)	beginning of rest period	110 beats per minute	shorten next work period by 33%
oral temperature	beginning of rest period	99°F (after thermometer is under tongue for 3 minutes) 100.6°F	shorten next work period by 33% prohibit work in impermeable clothing
body weight	1. before workday begins (a.m.) 2. after workday ends (p.m.)		increase fluid intake

TABLE C-3[1]

SYMPTOMS OF HEAT STRESS

Heat rash results from continuous exposure to heat or humid air.

Heat cramps are caused by heavy sweating with inadequate fluid intake. Symptoms include:

- muscle spasms.
- pains in the hands, feet, and abdomen.

Heat exhaustion occurs when body organs attempt to keep the body cool. Symptoms include:

- pale, cool, moist skin.
- heavy sweating.
- dizziness.

Heat stroke is the most serious form of heat stress. Immediate action must be taken to cool the body before serious injury and death occur. Symptoms are:

- red, hot, dry skin.
- lack of perspiration.
- nausea.
- dizziness and confusion.
- strong, rapid pulse.
- coma.

(1) Reproduced from Occupational Safety and Health Guidance Manual for Superfund Activities (see Table A-1), p. 8-79.

Cold Stress (Hypothermia)

Cold stress is a function of cold, wetness and wind. A worker's susceptibility to cold stress can vary according to his/her physical fitness, degree of acclimatization to cold weather, age, and diet.

Prevention

Institute the following steps to prevent overexposure of workers to cold:

1. Maintain body core temperature at 96.8°F or above by encouraging workers to drink warm liquids during breaks (preferably not coffee) and wear several layers of clothing. Wool is recommended since it can keep the body warm even when the wool is wet.

2. Avoid frostbite by adequately covering hands, feet, and other extremities. Clothing such as insulated gloves or mittens, earmuffs, and hat liners should be worn. To prevent contact frostbite (from touching metal and cold surfaces below 20°F), workers should wear anti-contact gloves. Tool handles and control bars should be covered with insulating material.

3. Adjust work schedules if necessary, providing adequate rest periods. When feasible, rotate personnel and perform work during the warmer hours of the day.

4. Provide a heated enclosure for workers close to their work area. Workers should remove their outer layer(s) of clothing while in the shelter to allow for sweat evaporation.

5. In the event that wind barriers are constructed around an intrusive operation (such as drilling), the enclosure must be properly vented to prevent the build-up of toxic or explosive gasses or vapors. Care must be taken to keep any heat source away from flammable substances.

6. Using a wind chill chart such as the one in Table E-4, obtain the equivalent chill temperature (ECT) based on actual wind speed and temperature. Refer to the ECT when setting up work warm-up schedules, planning appropriate clothing, etc. Workers should use warming shelters at regular intervals at or below an ECT of 20°F. For exposed skin, continuous exposure should not be permitted at or below an ECT of -25°F.

7. Workers who become immersed in water or whose clothing becomes wet (from perspiration, rain, etc.) must immediately be provided a change of dry clothing whenever the air temperature is 25.6°F or below.

8. Maintain an optimal level of worker fitness by encouraging regular exercise, proper diet, etc. If possible, acclimatize workers to site conditions for several days before work begins.

Monitoring

Personnel should be aware of the symptoms of cold stress. If the following symptoms of systemic hypothermia are noticed in any worker, he/she should immediately go the warm shelter:

- heavy, uncontrollable shivering;
- excessive fatigue or drowsiness;
- loss of coordination;
- difficulty in speaking; and,
- frostbite (see below).

Frostbite is the generic term for local injury resulting from cold. The stages of frostbite and their symptoms are as follows:

1. frostbite or incipient frostbite:

    - sudden blanching or whitening of the skin.

2. superficial frostbite:

    - waxy or white skin which is firm to the touch (tissue underneath is still resilient).

3. deep frostbite:

    - tissues are cold, pale, and solid.

TABLE C-4[1]

COOLING POWER OF WIND ON EXPOSED FLESH EXPRESSED AS AN EQUIVALENT TEMPERATURE (UNDER CALM CONDITIONS)

Estimated Wind Speed (in mps)	Actual Temperature Reading (°F)P											
	50	40	30	20	10	0	-10	-20	-30	-40	-50	-60
	Equivalent Chill Temperature (°F)											
calm	50	40	30	20	10	0	-10	-20	-30	-40	-50	-60
5	48	37	27	16	6	-5	-15	-26	-36	-47	-57	-68
10	40	28	16	4	-9	-24	-33	-46	-58	-70	-83	-95
15	36	22	9	-5	-18	-32	-45	-58	-72	-85	-99	-112
20	32	18	4	-10	-25	-39	-53	-67	-82	-96	-110	-121
25	30	16	0	-15	-29	-44	-59	-74	-88	-104	-118	-133
30	28	13	-2	-18	-33	-48	-63	-79	-94	-109	-125	-140
35	27	11	-4	-20	-35	-51	-67	-82	-98	-113	-129	-145
40	26	10	-6	-21	-37	-53	-69	-85	-100	-116	-132	-148
(Wind speeds greater than 40 mph have little additional effect.)	LITTLE DANGER In < hr with dry skin. Maximum danger of false sense of security.				INCREASING DANGER Danger from freezing of exposed flesh within one minute.			GREAT DANGER Flesh may freeze within 30 seconds				
	Trenchfoot and immersion foot may occur at any point on this chart.											

Developed by U.S. Army Research Institute of Environmental Medicine, Natick, MA.

(1) Reproduced from American Conference of Governmental Industrial Hygienists, Threshold Limit Values and Biological Exposure Indices for 1985-1986, p. 01.

CHEMICAL HAZARD ASSESSMENT

Previous sampling and analytical data have indicated that the following chemical hazards, either documented or potential, exist at the site.

CONTAMINANT (Synonyms)	CHEM/PHYS. PROPERTIES	INCOMPATIBILITIES	TLV/PEL	IDLH	ROUTE	EXPOSURE SYMPTOMS	FIRST AID	COMMENTS
1,1 Dichloroethane (Ethyldiene)	FL.P: (oc)22 F. IP: 11.06 eV VP: 230 mm UEL: 16% LEL: 5.6%	Strong oxidizers and caustics	NIOSH/ OSHA 100 ppm	4,000 ppm	inh. ing. con.	Central nervous sys. depress. skin irrit., drowsiness	Irrig. immed.,soap flush Art. resp., immed. med.	
1,2-Dichloroethane	LEL: 6.2% UEL: 15.9% FL.P: 56 F VP: 100 mm	Dangerous fire hazard if exposed to heat, flame, or oxidizers. Explosive in vapor form when exposed to flame. Violent reaction when exposed to Al, ammonia, dimethylamine, isopropylamine, dinitrogen tetroxide. Reacts vigorously with oxidizers.	OSHA 50 ppm ACGIH 10 ppm		ing. inh. con.	Flaccid paralysis without anesthia, cough, jaundice, nausea or vomiting, hypermotility, diarrhea, ulceration or bleeding from the stomach, fatty liver degeneration, change in cardiac rate, cyanosis and coma, dermatitis, edema of the lungs, toxic effects on kidneys, and severe corneal effects. Smell and irritant effects warn of its presence at relatively safe concentrations.	Irrig immed., soap wash Immed. med.	
Tetrachloroethylene (1,1,2,2-Tetrachloro ethylene, Tetrachloro ethane)	FL.P: NA IP: 9.32 eV VP: 14 mm UEL: NA LEL: NA	Strong oxidizers Chemically active metals (Li, Be, Ba, caustic soda, sodium hydroxide, potash)	NIOSH Ca OSHA 25 ppm	Ca	inh. ing. con.	Irrit eyes, nose, throat; nau flush face, neck; verti, dizz, inco; head, som; skin eryt; liver damage;(carc)	Irr. immed. soap wash prompt, Resp support Medical attention immed	

1,1,1, Trichlorethane (methylchloroform)	FL.P: None IP: 11.00 eV VP: 100 mm UEL: 12.5% LEL: 7.5%	Strong Caustics Strong Oxidizers Chemically Active metals	NIOSH/ OSHA 350 ppm 15-min ceil. ST 450ppm	1,000 ppm	inh ing con	headache, lassitude poor equilibrium, irritated eyes dermatitis cardiac arrhythmias	eye: irrig, immed skin: soap wash promptly breath: art resp. swallow: medical attention immed
Trichloroethylene (Trichloroethene)	FL.P: 90 F. IP: 9.45 Ev VP: 58 mm UEL: 10.5% LEL: 8%	Strong caustics; when acidic reacts with alum.; chemically active metals; barium lithium, sodium, magnesium, titanium	NIOSH CA, 25ppm OSHA 50 ppm ST 200ppm	CA	inh. ing. con.	Headache, tremors, nausea, vomit, irrit. eyes (Carc)	Irrig. immed. soap wash Art. resp. immed. med.

ATTACHMENT D

CHEMICAL HAZARDS

References:

1. Sax, N. Irving and Lewis, Richard J.
   Dangerous Properties of Industrial Materials -
   7th Edition, 1989.

2. U.S. Department of Health and Human Services.
   NIOSH Pocket Guide to Chemical Hazards, June 1990.

SYNS:

ACETIC ACID-2,6-DIMETHYL-m-DIOXAN-4-YL ESTER
ACETOMETHOXAN
6-ACETOXY-2,4-DIMETHYL-m-DIOXANE
DDOA
DIMETHOXANE
2,6-DIMETHYL-m-DIOXAN-4-OL ACETATE
2,6-DIMETHYL-m-DIOXAN-4-YL ACETATE
DIOXIN (BACTERICIDE) (OBS.)
GIV GARD DXN
NCI-C56213

TOXICITY DATA:	CODEN:
mma-sat 5500 µg/plate	ENMUDM 8(Suppl 7),1,86
sln-dmg-par 1 pph	ENMUDM 7,677,85
orl-rat TDLo:948 g/kg/88W-I: CAR	JNCIAM 53,791,74
orl-rat LD50:1930 mg/kg	GCTB** 3/25/77

IARC Cancer Review: Animal Limited Evidence IMEMDT 15,177,77

THR: An experimental carcinogen. Moderately toxic by ingestion. See also ESTERS. When heated to decomposition it emits acrid smoke and fumes.

ABC500 ***HR: 2***

2'-ACETONAPHTHONE

CAS: 93-08-3 NIOSH: AL 2988000

mf: $C_{12}H_{10}O$ mw: 170.22

SYNS:

ORANGE CRYSTALS
β-ACETONAPHTHALENE
β-ACETYLNAPHTHALENE
2-ACETYLNAPHTHALENE
ACETONAPHTHONE
β-ACETONAPHTHONE
2-ACETONAPHTHONE
METHYL-β-NAPHTHYL KETONE
METHYL-2-NAPHTHYL KETONE
β-METHYL NAPHTHYL KETONE
1-(2-NAPHTHALENYL)ETHANONE
β-NAPHTHYL METHYL KETONE
2-NAPHTHYL METHYL KETONE

TOXICITY DATA:	CODEN:
skn-hmn 500 mg/24H	FCTXAV 13,681,75
orl-mus LD50:599 mg/kg	MDZEAK 8,244,67

Reported in EPA TSCA Inventory.

THR: Moderately toxic by ingestion. A human skin irritant. When heated to decomposition it emits acrid smoke and fumes.

ABC750 ***HR: 2***

ACETONE

CAS: 67-64-1 NIOSH: AL 3150000

DOT: 1090

mf: C_3H_6O mw: 58.09

PROP: Colorless liquid, fragrant mint-like odor. Mp: −94.6°, bp: 56.48°, ulc: 90, flash p: 0°F (CC), lel: 2.6%, uel: 12.8%, d: 0.7972 @ 15°, autoign temp: (color) 869°F, vap press: 400 mm @ 39.5°, vap d: 2.00. Misc in water, alc, and ether.

SYNS:

ACETON (GERMAN, DUTCH, POLISH)
DIMETHYLFORMALDEHYDE
DIMETHYLKETAL
DIMETHYL KETONE
KETONE PROPANE
β-KETOPROPANE
METHYL KETONE
PROPANONE
2-PROPANONE
PYROACETIC ACID
PYROACETIC ETHER
RCRA WASTE NUMBER U002

TOXICITY DATA:	CODEN:
skn-rbt 500 mg/24H MLD	28ZPAK -,42,72
eye-rbt 100 mg/24H MOD	28ZPAK -,42,72
cyt-smc 200 mmol/tube	HEREAY 33,457,47
sln-smc 47600 ppm	ANYAA9 407,186,83
cyt-ham:fbr 40 g/L	FCTOD7 22,623,84
ihl-mam TCLo:31500 µg/m³/24H (1-13D preg):REP	GTPZAB 26(6),24,82
orl-man TDLo:2857 mg/kg	34ZIAG -,64,69
orl-man TDLo:2857 mg/kg	DIAEAZ 15,810,66
ivn-rat LD50:5500 mg/kg	NPIRI* 1,1,74
ihl-man TDLo:440 µg/m³/6M	GISAAA 42(8)42,77
ihl-man TDLo:10 mg/m³/6H	GISAAA 42(8)42,77
orl-mus LD50:3000 mg/kg	PCJOAU 14,162,80
eye-hmn 500 ppm	JIHTAB 25,282,43
skn-rbt 395 mg open MLD	UCDS** 5/7/70
eye-rbt 3950 µg SEV	AJOPAA 29,1363,46
ihl-hmn TCLo:500 ppm:EYE	JIHTAB 25,282,43
ihl-man TCLo:12000 ppm/4H:CNS	AOHYA3 16,73,73
unk-man LDLo:1159 mg/kg	85DCAI 2,73,70
ihl-rat LCLo:16000 ppm/4H	AIHAAP 23,95,62
ipr-rat LDLo:500 mg/kg	JPPMAB 11,150,59
ihl-mus LCLo:110000 mg/m³/62M	AGGHAR 5,1,33
ipr-mus LD50:1297 mg/kg	SCCUR* -,1,61
orl-dog LDLo:24 g/kg	AEXPBL 18,218,1884
ipr-dog LDLo:8 g/kg	AEXPBL 18,218,1884
scu-dog LDLo:5 g/kg	AEXPBL 18,218,1884
skn-rbt LD50:20 g/kg	UCDS** 5/7/70
scu-gpg LDLo:5000 mg/kg	AGGHAR 5,1,33

On Community Right To Know List. Reported in EPA TSCA Inventory.

OSHA PEL: TWA 1000 ppm
ACGIH TLV: TWA 750 ppm; STEL 1000 ppm
DFG MAK: 1000 ppm (2400 mg/m³)
NIOSH REL: TWA 590 mg/m³

DOT Classification: Flammable Liquid, Label: Flammable Liquid

THR: Moderately toxic by various routes. A skin and severe eye irritant. Human systemic effects by inhalation: changes in EEG, changes in carbohydrate metabolism, nasal effects, conjunctiva irritation, respiratory system effects, nausea and vomiting, and muscle weakness. Human systemic effects by ingestion: coma, kidney damage, and metabolic changes. Narcotic in high concentration. In industry, no injurious effects have been reported other than skin irritation resulting from its defatting action, or headache from prolonged inhalation. A common air contaminant. Dangerous disaster hazard due to fire and explosion hazard; can react vigorously

with oxidizing materials. Potentially explosive reaction with nitric acid + sulfuric acid; bromine trifluoride; nitrosyl chloride + platinum; nitrosyl perchlorate; chromyl chloride; thiotrithiazyl perchlorate; and 2,4,6-trichloro-1,3,5-triazine + water. Reacts to form explosive peroxide products with 2-methyl-1,3-butadiene; hydrogen peroxide; and peroxomonosulfuric acid. Ignites on contact with activated carbon; chromium trioxide; dioxygen difluoride + carbon dioxide; and potassium-tert-butoxide. Reacts violently with bromoform; chloroform + alkalies; bromine; and sulfur dichloride. Incompatible with CrO; (nitric + acetic acid); NOCl; nitryl perchlorate; permonosulfuric acid; NaOBr; (sulfuric acid + potassium dichromate); (thio-diglycol + hydrogen peroxide); trichloromelamine; air; HNO_3; chloroform; and H_2SO_4. To fight fire, use CO_2, dry chemical, alcohol foam. For further information see Vol. 4, No. 3 of *DPIM Report*.

ABD000 HR: 3
ACETONE CHLOROFORM

CAS: 57-15-8 NIOSH: UC 0175000
mf: $C_4H_7Cl_3O$ mw: 177.46

PROP: Crystals, camphor odor. Mp: 97°, bp: 167°.

SYNS:
CHLORETONE
CLORTRAN
METHAFORM
SEDAFORM
β,β,β-TRICHLORO-tert-BUTYL ALCOHOL
HCP
ANHYDROUS CHLOROBUTANOL
CHLORBUTANOL
CHLORBUTOL
CHLOROBUTANOL
TRICHLORO-tert-BUTYL ALCOHOL
tert-TRICHLOROBUTYL ALCOHOL
1,1,1-TRICHLORO-2-METHYL-2-PROPANOL

TOXICITY DATA:	CODEN:
mmo-sat 20 μmol/plate	MUREAV 90,91,81
cyt-smc 10 mmol/tube	HEREAY 33,457,47
skn-rbt 850 μg MLD	XEURAQ MDDC-1715
eye-rbt 9180 μg/30S MLD	XEURAQ MDDC-1715
orl-dog LDLo: 238 mg/kg	AIPTAK 8,77,01
orl-rbt LDLo: 213 mg/kg	AIPTAK 8,77,01
par-frg LDLo: 800 mg/kg	AIPTAK 8,77,01

Reported in EPA TSCA Inventory.

THR: Poison by ingestion. Moderately toxic by parenteral route. A narcotic. A skin and eye irritant. Mutagenic data. See also CHLORAL HYDRATE, which acts similarly. Dangerous; can react with oxidizing materials. Combustible when exposed to heat or flame. When heated to decomposition it emits toxic fumes of Cl^-. See also PHOSGENE.

ABD250 HR: 3
ACETONE DIETHYL KETAL

CAS: 126-84-1 NIOSH: AL 4900000
mf: $C_7H_{16}O_2$ mw: 132.23

SYNS:
2,2-DIETHOXYPROPANE
USAF DO-44

TOXICITY DATA:	CODEN:
ipr-mus LD50: 125 mg/kg	NTIS** AD277-689

Reported in EPA TSCA Inventory.

THR: Poison by intraperitoneal route. When heated to decomposition it emits acrid smoke.

ABD500 HR: 3
ACETONE DIETHYLSULFONE

CAS: 115-24-2 NIOSH: TX 3850000
mf: $C_7H_{16}O_4S_2$ mw: 228.35

PROP: D: 1.183, mp: 127°-128°, bp: 300° (sl decomp), Sol in water, alc, and ether.

SYNS:
ACETONE BIS(ETHYL SULFONE)
2,2-BIS(ETHYLSULFONYL)PROPANE
DIETHYLSULFONDIMETHYLMETHANE
PROPANE DIETHYL SULFONE
SULFONAL
SULFONMETHANE

TOXICITY DATA:	CODEN:
unk-man LDLo: 147 mg/kg	85DCAI 2,73,70
orl-dog LDLo: 800 mg/kg	12VXA5 8,1003,68
orl-rbt LDLo: 3000 mg/kg	HBAMAK 4,1404,35
orl-gpg LDLo: 8500 mg/kg	HBAMAK 4,1404,35

THR: A human poison by unspecified route. Moderately toxic by ingestion. Mutagenic data. When heated to decomposition it emits toxic fumes of SO_x.

ABD750 HR: 3
ACETONE OIL

NIOSH: AL 6700000

DOT: 1091

PROP: (a) Standard: light, lemon-yellow. (b) Refined: almost water white. (c) Heavy: dark, orange-yellow. Bp: (a) 75-160°, (c) 80-225°. D: (a) 0.826-0.830, (b) 0.812, (c) 0.885-0.865.

DOT Classification: Flammable Liquid, Label: Flammable Liquid

THR: Dangerous fire and explosion hazard when exposed to heat or flame. Can react vigorously with oxidizing materials. Some carcinogenic activity. To fight fire, use CO_2, dry chemical.

ABE000 HR: 3
ACETONE PEROXIDE

PROP: Liquid. The trimeric form is crystalline. Mp: 97°. THR: No toxicity data. See PEROXIDES, ORGANIC. Flammable by spontaneous chemical reaction; can react vigorously with reducing materials. The trimeric form is shock-sensitive and static-electricity-sensitive and may detonate.

pounds. Reacts explosively with aniline at 240°C/7.6 bar. Can react vigorously with oxidizing materials. To fight fire, use water, CO_2, water mist or spray, dry chemical. See also ANILINE. For further information, see Vol. 4, No. 4 of *DPIM Report*.

BBL250 *HR: 3*

BENZENE

CAS: 71-43-2 NIOSH: CY 1400000

DOT: 1114

mf: C_6H_6 mw: 78.12

PROP: Clear, colorless liquid. Mp: 5.51°, bp: 80.093°-80.094°, flash p: 12°F (CC), d: 0.8794 @ 20°, autoign temp: 1044°F, lel: 1.4%, uel: 8.0%, vap press: 100 mm @ 26.1°, vap d: 2.77, ulc: 95-100.

SYNS:

(6)ANNULENE
BENZEEN (DUTCH)
BENZEN (POLISH)
BENZIN (OBS.)
BENZINE (OBS.)
BENZOL (DOT)
BENZOLE
BENZOLENE
BENZOLO (ITALIAN)
BICARBURET OF HYDROGEN
CARBON OIL
COAL NAPHTHA
CYCLOHEXATRIENE
FENZEN (CZECH)
MINERAL NAPHTHA
MOTOR BENZOL
NCI-C55276
NITRATION BENZENE
PHENE
PHENYL HYDRIDE
PYROBENZOL
PYROBENZOLE
RCRA WASTE NUMBER U019

TOXICITY DATA: CODEN:

skn-rbt 15 mg/24H open MLD	AIHAAP 23,95,62
eye-rbt 88 mg MOD	AMIHAB 14,387,56
eye-rbt 2 mg/24H SEV	28ZPAK -,23,72
skn-rbt 500 mg/24H MOD	28ZPAK -,23,72
slt-dmg-orl 11250 µmol/L	PMRSDJ 5,325,85
oms-hmn:lym 5 µmol/L	CNREA8 45,2471,85
mma-mus:emb 2500 mg/L	PMRSDJ 5,639,85
cyt-ham:lng 550 mg/L	PMRSDJ 5,427,85
sln-ham:lvr 62500 µg/L	PMRSDJ 5,397,85
ihl-rat TCLo:670 mg/m³/24H (15D pre/1-22D preg):REP	HYSAAV 33,327,68
ihl-rat TCLO:50 ppm/24H (7-14D preg):TER	JHEMA2 24,363,80
ihl-rat TCLO:150 ppm/24H (7-14D preg):TER	JHEMA2 24,363,80
ihl-man TCLo:200 mg/m³/78W-I:CAR,BLD	EJCAAH 7,83,71
ihl-hmn TCLo:10 ppm/8H/10Y-I:CAR,BLD	TRBMAV 37,153,78
orl-rat TDLo:52 g/kg/52W-I:CAR	MELAAD 70,352,79
ihl-rat TCLo:1200 ppm/6H/10W-I:ETA	PAACA3 25,75,84
orl-mus LD50:18250 mg/kg/2Y-C:CAR	NTPTR* NTP-TR-289,86
ihl-mus TCLo:300 ppm/6H/16W-I:ETA	TXAPA9 75,358,84
skn-mus TDLo:1200 g/kg/49W-I:NEO	BJCAAI 16,275,62
ipr-mus TDLo:1200 mg/kg/8W-I:NEO	TXAPA9 82,19,86
scu-mus TDLo:600 mg/kg/17W-I:ETA	KRANAW 9,403,32
par-mus TDLo:670 mg/kg/19W-I:ETA	KLWOAZ 12,109,33
ihl-hmn TC:150 ppm/15M/8Y-I:CAR,BLD	BLOOAW 52,285,78
orl-rat TD :52 g/kg/1Y-I:CAR	AJIMD8 4,589,83
orl-rat TD:10 g/kg/52W-I:CAR	MELAAD 70,352,79
ihl-hmn TC:150 ppm/15M/8Y-I:CAR,BLD	NEJMAG 271,872,64
ihl-man TC:150 ppm/11Y-I:CAR,BLD	BLUTA9 28,293,74
ihl-mus TC:1200 ppm/6H/10W-I:ETA	PAACA3 25,75,84
ihl-hmn LCLo:2 pph/5M	TABIA2 3,231,33
orl-hmn TDLo:130 mg/kg:CNS,GIT	AHYGAJ 31,336,1897
ihl-hmn LCLo:20000 ppm/5M	29ZUA8 -,-,53
ihl-hmn TCLo:210 ppm:CNS,GIT	27ZXA3 -,341,63
ihl-man TCLo:150 ppm/1Y-I:MET,BLD	BLUTA9 28,293,74
ihl-hmn TCLo:100 ppm:CNS,GIT,SKN	INMEAF 17,199,48
ihl-hmn LCLo:65 mg/m³/5Y:BLD	ARGEAR 44,145,74
orl-rat LD50:3400 mg/kg	NPIRI* 1,5,74
ihl-rat LC50:10000 ppm/7H	28ZRAQ -,113,60
ipr-rat LD50:2890 µg/kg	36YFAG -,302,77
orl-mus LD50:4700 mg/kg	HYSAAV 32,349,67
ihl-mus LC50:9980 ppm	JIHTAB 25,366,43
skn-mus LD50:48 mg/kg	NPIRI* 1,5,74
ipr-mus LD50:990 µg/kg	AGGHAR 18,109,60
orl-dog LDLo:2000 mg/kg	HBAMAK 4,1313,35
ihl-dog LCLo:146000 mg/m³	HBTXAC 1,324,56
ihl-cat LCLo:170000 mg/m³	HBTXAC 1,324,56
ivn-rbt LDLo:88 mg/kg	JTEHD6 -(Suppl-2),45,77
ipr-gpg LDLo:527 mg/kg	HBTXAC 1,42,56
scu-frg LDLo:1400 mg/kg	HBAMAK 4,1313,35
ihl-mam LCLo:20000 ppm/5M	AEPPAE 138,65,28

IARC Cancer Review: Human Limited Evidence IMEMDT 7,203,74; Animal Inadequate Evidence IMEMDT 7,-203,74; IARC Cancer Review: Animal Limited Evidence IMEMDT 29,93,82; Human Sufficient Evidence IMEMDT 29,93,82; NTP Carcinogenesis Studies (gavage); Clear Evidence: mouse, rat NTPTR* NTP-TR-289,86. EPA Genetic Toxicology Program. Reported in EPA TSCA Inventory. On Community Right To Know List..

OSHA PEL: TWA 1 ppm/8H; Pk 5 ppm/15M

ACGIH TLV: TWA 10 ppm (suspected human carcinogen); BEI (total phenol in urine at end of shift) 50 mg/L recommended as a mean value

DFG TRK: 8 ppm (26 mg/m³)

NIOSH REL: CL 1 ppm/60M

DOT Classification: Flammable Liquid, Label: Flammable Liquid

THR: A human poison by inhalation. An experimental poison by skin contact, intraperitoneal, intravenous and possibly other routes. Moderately toxic by ingestion and subcuta-

neous routes. A severe eye and moderate skin irritant. Human systemic effects by inhalation and ingestion: euphoria, somnolence, changes in REM sleep, changes in motor activity, nausea or vomiting, reduced number of blood platelets, other unspecified blood effects, dermatitis, and fever. A human carcinogen which produces myeloid leukemia and lymphomas by inhalation. An experimental carcinogen, neoplastigen, tumorigen, and teratogen. Other experimental animal reproductive effects. Human mutagenic data. A narcotic. In industry, inhalation is the primary route of chronic benzene poisoning. Poisoning by skin contact has been reported. Recent (1987) research indicates that effects are seen at less than 1 ppm. Exposures needed to be reduced to 0.1 ppm before no toxic effects were observed. Elimination is chiefly through the lungs. A common air contaminant.

A dangerous fire hazard when exposed to heat or flame. Explodes on contact with diborane; bromine pentafluoride; permanganic acid; peroxomonosulfuric acid; and peroxodisulfuric acid. Forms sensitive, explosive mixtures with iodine pentafluoride; silver perchlorate; nitryl perchlorate; nitric acid; liquid oxygen; ozone; arsenic pentafluoride + potassium methoxide (explodes above 30°C). Ignites on contact with sodium peroxide + water; dioxygenyl tetrafluoroborate; iodine heptafluoride; and dioxygen difluoride. Vigorous or incandescent reaction with hydrogen + Raney nickel (above 210°C); uranium hexafluoride; and bromine trifluoride. Can react vigorously with oxidizing materials, such as Cl_2; CrO_3; O_2; $NClO_4$; O_3; perchlorates; ($AlCl_3$ + $FClO_4$); (H_2SO_4 + permanganates); K_2O_2; ($AgClO_4$ + acetic acid); Na_2O_2. Moderate explosion hazard when exposed to heat or flame. Use with adequate ventilation. To fight fire, use foam, CO_2, dry chemical. For further information, see Vol. 4, No. 6 of *DPIM Report*.

Poisoning occurs most commonly via inhalation of the vapor, although benzene can penetrate the skin and cause poisoning. Locally, benzene has a comparatively strong irritating effect, producing erythema and burning, and, in more severe cases, edema and even blistering. Exposure to high concentrations of the vapor (3000 ppm or higher) may result from failure of equipment or spillage. Such exposure, while rare in industry, may cause acute poisoning, characterized by the narcotic action of benzene on the central nervous system. The anesthetic action of benzene is similar to that of other anesthetic gases, consisting of a preliminary stage of excitation followed by depression and, if exposure is continued, death through respiratory failure. The chronic, rather than the acute form, of benzene poisoning is important in industry. It is a recognized leukemogen. There is no specific blood picture occurring in cases of chronic benzol poisoning. The bone marrow may be hypoplastic, normal, or hyperplastic, the changes reflected in the peripheral blood. Anemia, leucopenia, macrocytosis, reticulocytosis, thrombocytopenia, high color index, and prolonged bleeding time may be present. Cases of myeloid leukemia have been reported. For the worker, repeated blood examinations are necessary, including hemoglobin determinations, white and red cell counts and differential smears. Where a worker shows a progressive drop in either red or white cells, or where the white count remains low, 5,000/mm_3 or the red count <4.0 million/mm_3, on two successive monthly examinations, he should be immediately removed from benzene exposure. Elimination is chiefly through the lungs, when fresh air is breathed. The portion that is absorbed is oxidized, and the oxidation products are combined with sulfuric and glycuronic acids and eliminated in the urine. This may be used as a diagnostic sign. Benzene has a definite cumulative action, and exposure to a relatively high concentration is not serious from the point of view of causing damage to the blood-forming system, provided the exposure is not repeated. In acute poisoning, the worker becomes confused and dizzy, complains of tightening of the leg muscles and of pressure over the forehead, then passes into a stage of excitement. If allowed to remain exposed, he quickly becomes stupefied and lapses into coma. In non-fatal cases, recovery is usually complete with no permanent disability. In chronic poisoning the onset is slow, with the symptoms vague; fatigue, headache, dizziness, nausea and loss of appetite, loss of weight and weakness are common complaints in early cases. Later, pallor, nosebleeds, bleeding gums, menorrhagia, petechiae and purpura may develop. There is great individual variation in the signs and symptoms of chronic benzene poisoning.

BBL500 ***HR: 2***

BENZENEACETALDEHYDE

CAS: 122-78-1 NIOSH: CY 1420000

mf: C_8H_8O mw: 120.16

PROP: Oily, colorless liquid which polymerizes and grows more viscous on standing. Odor similar to lilac and hyacinth. Has been crystallized, mp: 33-34°, d:(25/25) 1.023-1.030, bp: (10) 78°, n (20/D) 1.524-1.528. Sltly sol in water. Sol in alc, ether. One part is sol in two parts of 80% alc forming a clear solution.

SYNS:

HYACINTHIN
PAA
PHENYLACETALDEHYDE
PHENYLACETIC ALDEHYDE
PHENYLETHANAL
α-TOLUALDEHYDE
α-TOLUIC ALDEHYDE

TOXICITY DATA:	CODEN:
skn-hmn 2%/48H	FCTXAV 17,377,79
orl-rat LD50:1550 mg/kg	FCTXAV 17,377,79
orl-mus LD50:3890 mg/kg	FCTXAV 17,377,79
orl-gpg LD50:3890 mg/kg	FCTXAV 17,377,79

Reported in EPA TSCA Inventory.

THR: Moderately toxic by ingestion. Human skin irritant. When heated to decomposition it emits acrid smoke and irritating fumes. Used in perfumery. See also ALDEHYDES.

TOXICITY DATA:	CODEN:
eye-rbt 83 mg	AIHAAP 19,171,58
ihl-rat LC50:4020 ppm/4H	AIHAAP 19,171,58
orl-rat LD50:1500 mg/kg	AIHAAP 19,171,58
ipr-rat LD50:399 mg/kg	AIHAAP 19,171,58
ihl-mus LC50:2500 ppm/4H	AIHAAP 19,171,58

Reported in EPA TSCA Inventory.

OSHA PEL: TWA 10 ppm
ACGIH TLV: TWA 0.5 ppm
DFG MAK: 0.5 ppm (1.5 mg/m^3)
NIOSH REL: (n-Alkane Mono Thiols) CL 0.5 ppm/15M

DOT Classification: Flammable Liquid, Label: Flammable Liquid

THR: Poison by intraperitoneal route. Moderately toxic by inhalation and ingestion. An eye irritant. Dangerous fire hazard by exposure to heat, flame, sparks, or powerful oxidizers. Reacts violently with HNO_3. Incompatible with acids; acid fumes; oxidizing materials; heat; flame; sparks. To fight fire, use alcohol foam. When heated to decomposition it emits toxic SO_x. See also MERCAPTANS.

BOV000 ***HR: 3***

4-BUTANOLIDE

CAS: 96-48-0 NIOSH: LU 3500000
mf: $C_4H_6O_2$ mw: 86.10

PROP: Colorless liquid, mild odor. Mp: −44°, bp: 206°, flash p: 209°F (OC), d: 1.124 @ 25°/4°, vap d: 3.0.

SYNS:

gamma-6480	DIHYDRO-2(3H)-FURANONE
gamma-BL	4-HYDROXYBUTANOIC ACID LACTONE
BLO	γ-HYDROXYBUTYRIC ACID CYCLIC ESTER
BLON	4-HYDROXYBUTYRIC ACID γ-LACTONE
BUTYRIC ACID LACTONE	NCI-C55878
γ-BUTYROLACTONE	TETRAHYDRO-2-FURANONE
BUTYRYL LACTONE	
α-BUTYROLACTONE	
4-DEOXYTETRONIC ACID	
γ-HYDROXYBUTYROLACTONE	

TOXICITY DATA:	CODEN:
dnd-bcs 20 µL/disc	PMRSDJ 1,175,81
otr-ham:kdy 25 mg/L	PMRSDJ 1,638,81
orl-rat TDLo:25 g/kg (20D male):REP	ARANDR 10,239,83
skn-mus TDLo:50 g/kg/42W-I:ETA	JNCIAM 31,41,63
orl-rat LD50:1800 mg/kg	85GMAT -,31,82
ipr-rat LD50:1000 mg/kg	AITEAT 13,70,65
ipr-mus LD50:1100 mg/kg	AITEAT 13,70,65
ivn-rbt LDLo:500 mg/kg	AITEAT 13,70,65

IARC Cancer Review: Animal No Evidence IMEMDT 11,231,76. EPA Genetic Toxicology Program. Reported in EPA TSCA Inventory.

THR: Moderately toxic by ingestion, intravenous and intraperitoneal routes. An experimental tumorigen by skin contact. Experimental reproductive effects. Mutagenic data. Less acutely toxic than β-propiolactone. Combustible when exposed to heat or flame; can react with oxidizing materials. To fight fire, use foam, alcohol foam, CO_2, dry chemical. When heated decomposition it emits acrid and irritating fumes. For further information, see gamma Butyrolactone, Vol. 1, No. 3 of *DPIM Report*.

BOV250 ***HR: 3***

2-BUTANONE

CAS: 78-93-3 NIOSH: EL 6475000
DOT: 1193/1232
mf: C_4H_8O mw: 72.12

$CH_3CO{\cdot}CH_2CH_3$

PROP: Colorless liquid, acetone-like odor. Bp: 79.57°, fp: −85.9°, lel: 1.8%, uel: 11.5%, flash p: 22°F (TOC), d: 0.80615 @ 20°/20°, vap press: 71.2 mm @ 20°, autoign temp: 960°F, vap d: 2.42, ULC: 85-90.

SYNS:

AETHYLMETHYLKETON (GERMAN)	MEK
BUTANONE 2 (FRENCH)	METHYL ACETONE (DOT)
ETHYL METHYL CETONE (FRENCH)	METHYL ETHYL KETONE (ACGIH)
ETHYLMETHYLKETON (DUTCH)	METILETILCHETONE (ITALIAN)
ETHYL METHYL KETONE (DOT)	METYLOETYLOKETON (POLISH)
	RCRA WASTE NUMBER U159

TOXICITY DATA:	CODEN:
eye-hmn 350 ppm	JIHTAB 25,282,43
skn-rbt 500 mg/24H MOD	JIHTAB 25,282,43
skn-rbt 402 mg/24H MLD	TXAPA9 19,276,71
skn-rbt 13780 µg/24H open MLD	AIHAAP 23,95,62
eye-rbt 80 mg	TXAPA9 19,276,71
sln-smc 33800 ppm	MUREAV 149,339,85
ihl-rat TCLo:3000 ppm/7H (6-15D preg):REP	TXAPA9 28,452,74
ihl-rat TCLo:1000 ppm/(6-15D preg):TER	TXAPA9 28,452,74
ihl-hmn TCLo:100 ppm/5M:IRR	JIHTAB 25,282,43
orl-rat LD50:2737 mg/kg	TXAPA9 19,699,71
ihl-rat LCLo:2000 ppm/4H	JIHTAB 31,343,49
ihl-mus LC50:40 g/m^3/2H	85GMAT -,83,82
ipr-mus LD50:616 mg/kg	SCCUR* -,6,61
skn-rbt LD50:13 g/kg	UCDS** 5/7/70
ipr-gpg LDLo:2000 mg/kg	FCTXAV 15,611,77

Community Right To Know List. EPA Genetic Toxicology Program. Reported in EPA TSCA Inventory.

OSHA PEL: TWA 200 ppm
ACGIH TLV: TWA 200 ppm; STEL 300 ppm
DFG MAK: 200 ppm (590 mg/m^3)
NIOSH REL: (Ketones) TWA 590 mg/m^3

DOT Classification: Flammable Liquid, Label: Flammable Liquid

THR: Moderately toxic by ingestion, skin contact and intraperitoneal routes. Human systemic effects by inhalation: conjunctiva irritation and unspecified effects on the nose

and respiratory system. An experimental teratogen. Experimental reproductive effects. A strong irritant. Human eye irritation @ 350 ppm. Affects peripheral nervous system and central nervous system. See also KETONES. Dangerous fire hazard when exposed to heat or flame. Moderately explosive when exposed to flame. Reaction with hydrogen peroxide + nitric acid forms a heat and shock sensitive explosive product. Ignition on contact with potassium tert-butoxide. Mixture with 2-propanol will produce explosive peroxides during storage. Vigorous reaction with chloroform + alkali. Incompatible with chlorosulfonic acid; oleum. To fight fire, use alcohol foam, CO_2, dry chemical. When heated to decomposition it emits acrid smoke and fumes.

BOV625 ***HR: 3***

2-BUTANONE OXIME HYDROCHLORIDE

CAS: 4154-69-2

mf: $C_4H_{10}ClNO$ mw: 123.58

SYN: (2-HYDROXYLIMINIOBUTANE CHLORIDE)

THR: Decomposes violently above 50°C. When heated to decomposition it emits toxic fumes of Cl^- and NO_x.

BOV750 ***HR: 3***

BUTAZOLIDINE SODIUM

CAS: 129-18-0 NIOSH: UQ 8300000

mf: $C_{19}H_{20}N_2O_2 \cdot Na$ mw: 331.40

SYNS:

4-BUTYL-1,2-DIPHENYL-3,5-PYRAZOLIDINEDIONE SODIUM SALT
3,5-DIOXO-1,2-DIPHENYL-4-N-BUTYLPYRAZOLIDIN SODIUM
DIPHENYLDIOXOBUTYLPYRAZOLIDINE-BUTAZOLIDINE-SODIUM
PHENYLBUTAZONE SODIUM
SODIUM BUTAZOLIDINE
SODIUM PHENYLBUTAZONE
SODIUM SALT of PHENYLBUTAZONE

TOXICITY DATA:	CODEN:
orl-wmn LDLo: 16 mg/kg	AIMEAS 39,1096,53
scu-rat LD50: 360 mg/kg	ARZNAD 8,229,58
orl-mus LD50: 476 mg/kg	RPOBAR 2,314,70
ipr-mus LD50: 169 mg/kg	RPOBAR 2,314,70
ivn-rat LD50: 113 mg/kg	FRPSAX 13,922,58
scu-mus LD50: 271 mg/kg	FRPSAX 12,521,57
ivn-mus LD50: 94 g/kg	FRPSAX 13,922,58

THR: A human poison by ingestion. Human systemic effects by ingestion: respiratory system damage, agranulocytosis, and dermatitis. An experimental poison via subcutaneous, intravenous, and intraperitoneal routes. An anti-inflammatory drug. When heated to decomposition it emits toxic fumes of NO_x and Na_2O.

BOV800 ***HR: 3***

BUTEA FRONDOSA, seed extract

NIOSH: EM 2455000

PROP: Indian plant belonging to the family *Leguminosae* (IJEBA6 11,43,73).

SYN: PALASH SEED EXTRACT

TOXICITY DATA:	CODEN:
orl-rat TDLo: 250 mg/kg (1-5D preg): REP	IJPPAZ 13,239,69
orl-mus TDLo: 50 mg/kg (1-5D preg): REP	IJPPAZ 13,239,69
orl-mus LD50: 7500 mg/kg	IJPPAZ 13,239,69
ipr-mus LD50: 20 mg/kg	IJEBA6 11,43,73

THR: Poison by intraperitoneal route. Experimental reproductive effects.

BOV825 ***HR: 3***

BUTEDRIN

CAS: 5716-20-1 NIOSH: DN 9205000

mf: $C_{24}H_{38}N_2O_4 \cdot H_2O_4S$ mw: 516.72

SYNS:

BAMETAN SULFATE
BAMETHAN SULFATE
BASCURAT
BUPATOL
BUTIBATOL
α-[(BUTYLAMINO)METHYL]-p-HYDROXYBENZYL ALCOHOL SULFATE
BUTYLNORSYMPATOL
CYCLATE
ECLERIN
GARMIAN
PERIPHETOL
ROTESAR
VASCULAT
VASCULIT
VASCUNICOL
VASKULAT

TOXICITY DATA:	CODEN:
ipr-mus LD50: 210 mg/kg	NIIRDN 6,585,82
scu-mus LD50: 422 mg/kg	NIIRDN 6,585,82
ivn-mus LD50: 72 mg/kg	NIIRND 6,585,82

THR: Poison by intravenous and intraperitoneal routes. Moderately toxic by subcutaneous route. A vasodilator. When heated to decomposition it emits toxic fumes of SO_x and NO_x. See also SULFATES.

BOW000 ***HR: 3***

trans-2-BUTENAL

CAS: 123-73-9 NIOSH: GP 9625000

mf: C_4H_6O mw: 70.10

PROP: Water-white, mobile liquid; pungent, suffocating odor. Bp: 104°, fp: −76.0°, lel: 2.1%, uel: 15.5%, flash p: 55°F, d: 0.853 @ 20°/20°, vap d: 2.41, autoign temp: 450°F.

SYNS:

ALDEHYDE CROTONIQUE (FRENCH)
(E)-2-BUTENAL
CROTENALDEHYDE
CROTONALDEHYDE (ACGIH)
CROTONIC ALDEHYDE
1,2-ETHANEDIOL DIPROPANOATE (9CI)
ETHYLENE GLYCOL DIPROPIONATE (8CI)
ETHYLENE PROPIONATE
β-METHYL ACROLEIN
NCI-C56279
PROPYLENE ALDEHYDE
RCRA WASTE NUMBER U053
TOPANEL

TOXICITY DATA:	CODEN:
eye-hmn 45 ppm	AIHAAP 28,561,67
skn-rbt 500 mg open MLD	UCDS** 4/21/67
mmo-sat 250 μg/plate	ENMUDM 5(Suppl 1),3,83

SYNS:

(o-(2,6-DICHLOROANILINO)PHENYL)ACETIC ACID MONOSODIUM SALT	NERIODIN
	PROPHENATIN
	SODIUM (o-(2,6-DICHLOROANILINO)PHENYL)ACETATE
2-((2,6-DICHLOROPHENYL)AMINO)BENZENEACETIC ACID MONOSODIUM SALT	SODIUM (o-((2,6-DICHLOROPHENYL)AMINO)PHENYL)ACETATE
DICHRONIC	TSUDOHMIN
DICLOFENAC SODIUM	VALETAN
DICLOPHENAC SODIUM	VOLTAREN
GP 45840	VOLTAROL
KRIPLEX	

TOXICITY DATA:	CODEN:
orl-rat TDLo: 1 mg/kg (21D preg): TER	OYYAA2 27,117,84
orl-rat TDLo: 312 mg/kg (22W male): REP	KSRNAM 6,1521,72
orl-rat TDLo: 6 mg/kg (9-14D preg): TER	KSRNAM 6,1673,72
orl-rat LD50: 76500 µg/kg	OYYAA2 16,353,78
ipr-rat LD50: 25 mg/kg	NIIRDN 6,311,82
scu-rat LD50: 83 mg/kg	IYKEDH 5,106,74
ivn-rat LD50: 117 mg/kg	IYKEDH 5,106,74
orl-mus LD50: 125 mg/kg	ARZNAD 34,280,84
ipr-mus LD50: 130 mg/kg	IYKEDH 5,106,74
scu-mus LD50: 390 mg/kg	NIIRDN 6,311,82
ivn-mus LD50: 116 mg/kg	IYKEDH 5,106,74
orl-dog LD50: 59 mg/kg	KSRNAM 6,1521,72
ivn-dog LD50: 42 mg/kg	KSRNAM 6,1521,72
orl-rbt LD50: 157 mg/kg	KSRNAM 6,1521,72

THR: Poison by ingestion, intravenous, intraperitoneal and subcutaneous routes. An experimental teratogen. Experimental reproductive effects. An anti-inflammatory agent. When heated to decomposition it emits very toxic fumes of Cl^-, Na_2O and NO_x.

DEP400 ***HR: 3***

2-DICHLOROARSINOPHENOXATHIIN

CAS: 63834-20-8 NIOSH: SP 7000000

mf: $C_{12}H_7AsCl_2OS$ mw: 345.07

SYN: TL 472

TOXICITY DATA:	CODEN:
orl-rat LDLo: 250 mg/kg	NCNSA6 5,13,53
ihl-mus LCLo: 400 mg/m³/10M	NDRC** NDCrc-132,Dec,42

Arsenic and its compounds are on the Community Right To Know List.

OSHA PEL: TWA 0.5 mg(As)/m³

THR: Poison by ingestion and inhalation. See also ARSENIC COMPOUNDS. When heated to decomposition it emits very toxic fumes of As, Cl^- and SO_x.

DEP600 ***HR: 3***

o-DICHLOROBENZENE

CAS: 95-50-1 NIOSH: CZ 4500000

DOT: 1591

mf: $C_6H_4Cl_2$ mw: 147.00

PROP: Clear liquid. Mp: −17.5°, bp: 180-183°, fp: −22°, flash p: 151°F, d: 1.307 @ 20°/20°, vap d: 5.05, autoign temp: 1198°F, lel: 2.2%, uel: 9.2%.

SYNS:

CHLOROBEN	DIZENE
CHLORODEN	DOWTHERM E
CLOROBEN	NCI-C54944
DCB	ODB
o-DICHLORBENZENE	ODCB
o-DICHLOR BENZOL	ORTHODICHLOROBENZENE
1,2-DICHLOROBENZENE	ORTHODICHLOROBENZOL
DICHLOROBENZENE, ORTHO, liquid (DOT)	RCRA WASTE NUMBER U070
	SPECIAL TERMITE FLUID
DILANTIN DB	TERMITKIL
DILATIN DB	

TOXICITY DATA:	CODEN:
eye-rbt 100 mg/30S ms MLD	AMIHAB 17,180,58
spm-rat-ipr 250 mg/kg	JACTDZ 4(2),224,85
ihl-rat TCLo: 200 ppm/6H (6-15D preg): TER	FAATDF 5,190,85
ipr-rat TDLo: 50 mg/kg (1D male): REP	JACTDZ 4(1),224,85
orl-rat LD50: 500 mg/kg	WRPCA2 7,135,68
ihl-rat LCLo: 821 ppm/7H	AMIHAB 17,180,58
ipr-rat LD50: 840 mg/kg	MEPAAX 20,519,69
orl-mus LD50: 4386 g/kg	YKYUA6 32,471,81
ivn-mus LDLo: 400 mg/kg	JPBAA7 44,281,37
orl-rbt LD50: 500 mg/kg	85ARAE 3,32,76/77
ivn-rbt LDLo: 250 mg/kg	JPBAA7 44,281,37
orl-gpg LDLo: 2000 mg/kg	14CYAT 2,1336,63
ihl-gpg LCLo: 800 ppm/24H	JPBAA7 44,281,37

IARC Cancer Review: Human Inadequate Evidence IMEMDT 29,213,82; Animal Inadequate Evidence IMEMDT 29,213,82. Reported in EPA TSCA Inventory. Community Right To Know List.

OSHA PEL: CL 50 ppm
ACGIH TLV: CL 50 ppm (skin)
DFG MAK: 50 ppm (300 mg/m³)

DOT Classification: ORM-A, Label: None; IMO: Poison B; Label: St. Andrews Cross

THR: Poison by ingestion and intravenous routes. Moderately toxic by inhalation and intraperitoneal routes. An eye, skin, and mucous membrane irritant. Causes liver and kidney injury. An experimental teratogen and suspected carcinogen. Experimental reproductive effects. Mutagenic data. A pesticide. Flammable when exposed to heat or flame. Can react vigorously with oxidizing materials. To fight fire, use water, foam, CO_2 dry chemical. Slow reaction with aluminum may lead to explosion during storage in a sealed aluminum container. When heated to decomposition it emits toxic fumes of Cl^-. See also BENZENE CHLORIDE and CHLORINATED HYDROCARBONS, AROMATIC.

ihl-rat TCLo: 57 mg/m^3/4H (22W pre): TER	GISAAA 39(7),25,74
orl-rat LD50: 1120 mg/kg	HYSAAV 32,349,67
orl-mus LD50: 625 mg/kg	HYSAAV 32,349,67
ihl-mus LCLo: 10 g/m^3	GISAAA 20(8),19,55
skn-rbt LD50: 3890 mg/kg	UCDS** 3/23/70
unr-mam LD50: 807 mg/kg	GTPZAB 26(4),26,82

THR: Moderately toxic by ingestion, skin contact and possibly other routes. Mildly toxic by inhalation. An experimental teratogen. Other experimental reproductive effects by inhalation. When heated to decomposition it emits very toxic fumes of Cl^-. See also 1,2-DICHLOROETHANE; and CHLORINATED HYDROCARBONS, ALIPHATIC.

DFF809 **HR: 3**

1,1-DICHLOROETHANE

CAS: 75-34-3 NIOSH: KI 0175000
DOT: 2362
mf: $C_2H_4Cl_2$ mw: 98.96

PROP: Lel: 5.6%, uel: 11.4%.

SYNS:

AETHYLIDENCHLORID (GERMAN)	1,1-DICHLORAETHAN (GERMAN)
CHLORINATED HYDROCHLORIC ETHER	1,1-DICHLORETHANE
CHLORURE d' ETHYLIDENE (FRENCH)	1,1-DICLOROETANO (ITALIAN)
CLORURO DI ETILIDENE (ITALIAN)	ETHYLIDENE CHLORIDE
1,1-DICHLOORETHAAN (DUTCH)	ETHYLIDENE DICHLORIDE
	NCI-C04535
	RCRA WASTE NUMBER U076

TOXICITY DATA:	CODEN:
ihl-rat TCLo: 6000 ppm/7H (6-15D preg): TER	TXAPA9 28,452,74
orl-mus TDLo: 185 g/kg/78 W-I: ETA	NCITR* NCI-CG-TR-66,78
orl-mus TD : 1300 g/kg/78 W-I: ETA	NCITR* NCI-CG-TR-66,78
orl-rat LD50: 725 mg/kg	HYSAAV 32,349,67

EPA TSCA Chemical Inventory. NCI Carcinogenesis Bioassay (gavage); Inadequate Studies: mouse, rat NCITR* NCI-CG-TR-66,78.

OSHA PEL: TWA 100 ppm

DOT Classification: Flammable Liquid; Label: Flammable Liquid

THR: Moderately toxic by ingestion. An experimental tumorigen and teratogen. A suspected carcinogen. When heated to decomposition it emits very toxic fumes of Cl^-. See also 1,2-DICHLOROETHANE; and CHLORINATED HYDROCARBONS, ALIPHATIC.

DFF900 **HR: 3**

1,2-DICHLOROETHANE

CAS: 107-06-2 NIOSH: KI 0525000
DOT: 1184
mf: $C_2H_4Cl_2$ mw: 98.96

PROP: Colorless liquid, pleasant odor, sweet taste. Bp: 83.5°, ulc: 60-70, lel: 6.2%, uel: 15.9%, fp: −35.7°, flash p: 56°F, d: 1.257 @ 20°/4°, autoign temp: 775°F, vap press: 100 mm @ 29.4°, vap d: 3.35.

SYNS:

AETHYLENCHLORID (GERMAN)	sym-DICHLOROETHANE
1,2-BICHLOROETHANE	1,2-DICHLOROETHANE
BICHLORURE D'ETHYLENE (FRENCH)	DICHLOROETHYLENE
BORER SOL	1,2-DICLOROETANO (ITALIAN)
BROCIDE	DUTCH LIQUID
CHLORURE D'ETHYLENE (FRENCH)	DUTCH OIL
CLORURO DI ETHENE (ITALIAN)	EDC
1,2-DCE	ENT 1,656
DESTRUXOL BORER-SOL	ETHANE DICHLORIDE
1,2-DICHLOORETHAAN (DUTCH)	ETHYLEENDICHLORIDE (DUTCH)
1,2-DICHLOR-AETHAN (GERMAN)	ETHYLENE CHLORIDE
DICHLOREMULSION	ETHYLENE DICHLORIDE (ACGIH, DOT)
DI-CHLOR-MULSION	1,2-ETHYLENE DICHLORIDE
DICHLORO-1,2-ETHANE (FRENCH)	GLYCOL DICHLORIDE
α,β-DICHLOROETHANE	NCI-C00511
	RCRA WASTE NUMBER U077

TOXICITY DATA:	CODEN:
skn-rbt 600 mg open MLD	UCDS** 3/23/70
eye-rbt 63 mg SEV	UCDS** 3/23/70
mmo-sat 40 µmol/plate	CBINA8 20,1,78
msc-hmn: lym 100 mg/L	MUREAV 142,133,85
slt-mus-ipr 300 mg/kg	MUREAV 117,201,83
otr-ham: emb 200 µL/plate	EVSRBT 25,75,82
ihl-rat TCLo: 300 ppm/7H (6-15D preg): REP	BANRDU 5,149,80
orl-rat TDLo: 5286 mg/kg/69W-I: CAR	BANRDU 5,35,80
ihl-rat TCLo: 5 ppm/7H/78W-I: ETA	BANRDU 5,3,80
orl-mus TDLo: 3536 mg/kg/78W-I: CAR	BANRDU 5,35,80
ihl-mus TCLo: 5 ppm/7H/78W-I: ETA	BANRDU 5,3,80
skn-mus TDLo: 1120 g/kg/74W-I: NEO	JJIND8 63,1433,79
orl-rat TD : 38 g/kg/78W-I: CAR	NCITR* NCI-CG-TR-55,78
orl-mus TD : 76 g/kg/78W-I: CAR,TER	NCITR* NCI-CG-TR-55,78
orl-rat TD : 18 g/kg/78W-I: CAR	NCITR* NCI-CG-TR-55,78
orl-mus TD : 38 g/kg/78W-I: CAR,TER	NCITR* NCI-CG-TR-55,78
ihl-hmn TCLo: 4000 ppm/H: CNS,PNS,GIT	PCOC** -,500,66
orl-hmn TDLo: 428 mg/kg: GIT,CNS,PUL	SOMEAU 22,132,58
orl-man TDLo: 892 mg/kg: GIT,LIV	WILEAR 28,983,75
orl-hmn LDLo: 286 mg/kg: GIT,LIV	CLCEAL 86,203,47
orl-man LDLo: 714 mg/kg: CNS,CVS,PUL	KLWOAZ 48,822,70
orl-rat LD50: 670 mg/kg	FMCHA2 -,C99,83
ihl-rat LC50: 1000 ppm/7H	AMIHBC 4,482,51
scu-rat LDLo: 99 mg/kg	AMPLAO 51,346,51
orl-mus LD50: 489 mg/kg	TOXID9 1,26,81

DFH600 ***HR: 2***

O,O-DI(2-CHLOROETHYL)-O-(3-CHLORO-4-METHYLCOUMARIN-7-YL) PHOSPHATE

CAS: 321-55-1 NIOSH: GN 5250000

mf: $C_{14}H_{14}Cl_3O_6P$ mw: 415.60

SYNS:

O,O-BIS(2-CHLOROETHYL)-O-(3-CHLORO-4-METHYL-7-COUMARINYL) PHOSPHATE
2-CHLOROETHANOL HYDROGEN PHOSPHATE ESTER with 3-CHLORO-7-HYDROXY-4-METHYLCOUMARIN
2-CHLOROETHANOL PHOSPHATE DIESTER ESTER with 3-CHLORO-7-HYDROXY-4-METHYLCOUMARIN
3-CHLORO-7-HYDROXY-4-METHYLCOUMARIN BIS(2-CHLOROETHYL)PHOSPHATE
3-CHLORO-4-METHYL-UMBELLIFERONE BIS(2-CHLOROETHYL) PHOSPHATE
DI-(2-CHLOROETHYL)-3-CHLORO-4-METHYL-7-COUMARINYL PHOSPHATE
DI-(2-CHLOROETHYL)-3-CHLORO-4-METHYLCOUMARIN-7-YL PHOSPHATE
EUSTIDIL
GALLOXON
GALOXANE
96H60
HALOXON
HELMIRANE
HELMIRON
HELMIRONE
LOXON
LUXON
LXON

TOXICITY DATA:	CODEN:
dni-hmn:oth 10 mg/L	JTEHD6 10,143,82
orl-rat LD50:900 mg/kg	FAZMAE 17,108,73
ipr-ckn LD50:800 mg/kg	BCPCA6 16,1183,67
orl-dom LD50:763 mg/kg	AJVRAH 41,1857,80

THR: Moderately toxic by ingestion and intraperitoneal routes. Human mutagenic data. An anthelmintic. When heated to decomposition it emits very toxic fumes of PO_x and Cl^-. See also other coumarin entries.

DFH800 ***HR: 2***

DICHLOROETHYLENE

CAS: 25323-30-2 NIOSH: KV 9250000

DOT: 1150

mf: $C_2H_2Cl_2$ mw: 96.94

TOXICITY DATA:	CODEN:
ihl-mus LCLo:76 g/m³/2H	AEXPBL 83,235,18
ihl-gpg LCLo:155 g/m³/1H	AEXPBL 83,235,18
orl-mam LDLo:2500 mg/kg	UGLAAD 121,375,59

DOT Classification: Flammable Liquid; Label: Flammable Liquid

THR: Moderately toxic by ingestion. Mildly toxic by inhalation. Flammable when exposed to heat or flame. When heated to decomposition it emits toxic fumes of Cl^-. See also 1,1-DICHLOROETHYLENE.

DFI000 ***HR: 3***

1,1-DICHLOROETHYLENE ✱

CAS: 75-35-4 NIOSH: KV 9275000

mf: $C_2H_2Cl_2$ mw: 96.94

PROP: Colorless, volatile liquid. Bp: 31.6°, lel: 7.3%, uel: 16.0%, fp: −122°, flash p: 0°F (OC), d: 1.213 @ 20°/4°, autoign temp: 1058°F.

SYNS:

CHLORURE de VINYLIDENE (FRENCH)
1-1-DCE
1,1-DICHLOROETHENE
NCI-C54262
RCRA WASTE NUMBER U078
SCONATEX
VDC
VINYLIDENE CHLORIDE (II)
VINYLIDENE CHLORIDE (ACGIH)
VINYLIDENE DICHLORIDE
VINYLIDINE CHLORIDE

TOXICITY DATA:	CODEN:
mmo-sat 5 pph	MUREAV 57,141,78
mma-sat 3 pph/2H	MUREAV 58,183,78
dnd-rat-ihl 10 ppm	TXAPA9 53,357,80
dns-mus-ihl 50 ppm	TXAPA9 53,357,80
dns-mus-orl 200 mg/kg	TXCYAC 36,199,85
orl-rat TDLo:200 mg/kg (6-15D preg):TER	TXAPA9 49,189,79
ihl-rat TCLo:80 ppm/7H (6-15D preg):TER	TXAPA9 49,189,79
ihl-rat TCLo:55 ppm/6H (55D pre):REP	JTEHD6 3,965,77
ihl-rat TCLo:55 ppm/6H/52W-I:ETA	JTEHD6 4,15,78
ihl-mus TCLo:25 ppm/4H/52W-I	MELAAD 68,241,77
skn-mus TDLo:4840 mg/kg:NEO	JJIND8 63,1433,79
ihl-rat TC:150 ppm/4H/52W-I:ETA	MELAAD 68,241,77
ihl-mus TC:55 ppm/6H/13W-I:ETA	JTEHD6 7,909,81
ihl-mus TC:55 ppm/6H/52W-I:ETA	EVHPAZ 21,25,77
ihl-rat TC:55 ppm/6H/52W-I:ETA	EVHPAZ 21,25,77
ihl-rat TC:150 ppm/4H/52W-I:ETA	EVHPAZ 21,45,77
ihl-rat TC:55 ppm/6H/28W-I:ETA	JTEHD6 7,909,81
ihl-hmn TCLo:25 ppm:CNS,LIV,KID	CHINAG (11),463,76
orl-rat LD50:200 mg/kg	DCTODJ 1,63,77
ihl-rat LCLo:10000 ppm/24H	EXMPA6 20,187,74
ihl-mus LC50:98 ppm/22H	JTEHD6 3,913,77
orl-dog LDLo:5750 mg/kg	QJPPAL 7,205,34
ivn-dog LDLo:225 mg/kg	QJPPAL 7,205,34
scu-rbt LDLo:3700 mg/kg	QJPPAL 7,205,34

IARC Cancer Review: Human Inadequate Evidence IMEMDT 39,195,86; Animal Sufficient Evidence IMEMDT 19,439,79; Animal Limited Evidence IMEMDT 39,195,86; Human Inadequate Evidence IMEMDT 19,-439,79. EPA Genetic Toxicology Program. Reported in EPA TSCA Inventory. Community Right To Know List.

ACGIH TLV: TWA 5 ppm; STEL 20 ppm

THR: Poison by inhalation, ingestion and intravenous routes. Moderately toxic by subcutaneous route. An experimental carcinogen, neoplastigen, tumorigen and teratogen. Human systemic effects by inhalation: general anesthesia, liver and kidney changes. Experimental reproductive effects. Mutagenic data. See also VINYL CHLORIDE. A very dangerous fire hazard when exposed to heat or flame. Moderately explosive in the form of gas when exposed to heat or flame. It forms explosive peroxides upon exposure

to air. Potentially explosive reaction with chlorotrifluoroethylene at 180°C. Reaction with ozone forms dangerous products. Explosive reaction with perchloryl fluoride when heated above 100°C. Also can explode spontaneously. Reacts violently with chlorosulfonic acid; HNO_3; oleum. Can react vigorously with oxidizing materials. To fight fire, use alcohol foam, CO_2, dry chemical. When heated to decomposition it emits toxic fumes of Cl^-.

DFI200 ***HR: 1***

cis-DICHLOROETHYLENE

CAS: 156-59-2 NIOSH: KV 9420000

mf: $C_2H_2Cl_2$ mw: 96.94

HCCl=CHCl

PROP: Colorless liquid, pleasant odor. Mp: −80.5°, bp: 59°, lel: 9.7%, uel: 12.8%, flash p: 39°F, d: 1.2743 @ 25°/4°, vap press: 400 mm @ 41.0°, vap d: 3.34.

SYN: 1,2-DICHLOROETHYLENE

TOXICITY DATA:	CODEN:
mmo-smc 100 mmol/L	TCMUD8 4,365,84
mma-smc 40 mmol/L	TCMUD8 4,365,84
mrc-smc 100 mmol/L	TCMUD8 4,365,84
dns-rat:lvr 4300 µmol/L	CRNGDP 5,1629,84
ihl-mus LCLo:65000 mg/m³/2H	AHBAAM 116,131,36
ihl-cat LCLo:20000 mg/m³/6H	AHBAAM 116,131,36

Reported in EPA TSCA Inventory.

THR: Mildly toxic by by ingestion and inhalation. In high concentration it is irritating and narcotic. Has produced liver and kidney injury in experimental animals. A suspected carcinogen. Mutagenic data. Sometimes thought to be nonflammable, however, it is a dangerous fire hazard when exposed to heat or flame. Reaction with solid caustic alkalies or their concentrated solutions produces chloracetylene gas which ignites spontaneously in air. Reacts violently with N_2O_4; KOH; Na; NaOH. Moderate explosion hazard in the form of vapor when exposed to flame. Can react vigorously with oxidizing materials. To fight fire, use water spray, foam, CO_2, dry chemical. When heated to decomposition it emits toxic fumes of Cl^-. See also 1,1-DICHLOROETHYLENE and CHLORINATED HYDROCARBONS, ALIPHATIC. For further information, see Vol. 4, No. 3 of ***DPIM Report***.

DFI600 ***HR: 1***

trans-1,2-DICHLOROETHYLENE

CAS: 156-60-5 NIOSH: KV 9400000

mf: $C_2H_2Cl_2$ mw: 96.94

PROP: Flash p: 35.6°F, lel: 9.7%, uel: 12.8%.

SYN:

TRANS-ACETYLENE DICHLORIDE TRANS-DICHLOROETHYLENE

TOXICITY DATA:	CODEN:
ihl-hmn TCLo:4800 mg/m³/10M	AHBAAM 116,131,36
ipr-rat LD50:7536 mg/kg	TXCYAC 7,141,77
ihl-mus LCLo:75000 mg/m3/2H	AHBAAM 116,131,36
ipr-mus LD50:4019 mg/kg	TXCYAC 7,141,77
ihl-cat LCLo:43000 mg/m3/6H	AHBAAM 116,131,36

Reported in EPA TSCA Inventory.

THR: Mildly toxic to humans by inhalation. Mildly toxic experimentally by inhalation and intraperitoneal routes. A very dangerous fire hazard when exposed to heat or flame. Violent reaction with difluoromethylene dihypofluorite. Forms shock-sensitive explosive mixtures with dinitrogen tetraoxide. Reaction with solid caustic alkalies or their concentrated solutions produces chloracetylene gas which ignites spontaneously in air. Reacts violently with N_2O_4; KOH; Na; NaOH. Moderate explosion hazard in the form of vapor when exposed to flame. Can react vigorously with oxidizing materials. To fight fire, use water spray, foam, CO_2, dry chemical. When heated to decomposition it emits toxic fumes of Cl^-. See also 1,1-DICHLOROETHYLENE and CHLORINATED HYDROCARBONS, ALIPHATIC. For further information, see Vol. 4, No. 3 of ***DPIM Report***.

DFI800 ***HR: 3***

1,2-DICHLOROETHYLENE CARBONATE

CAS: 3967-55-3 NIOSH: JH 7400000

mf: $C_3H_2Cl_2O_3$ mw: 156.95

SYN: 4,5-DICHLORO-2-OXO-1,3-DIOXOLANE

TOXICITY DATA:	CODEN:
scu-mus TDLo:648 mg/kg/54W-I:ETA	JNCIAM 48,1431,72

THR: An experimental tumorigen. When heated to decomposition it emits toxic fumes of Cl^-.

DFJ000 ***HR: 3***

DICHLORO(ETHYLENEDIAMMINE)PLATINUM(II)

CAS: 14096-51-6 NIOSH: TP 2497100

mf: $C_2H_8Cl_2N_2Pt$ mw: 326.11

SYNS:

ETHYLENEDIAMINEDICHLORIDE PLATINUM (II) PLATINUM ETHYLENEDIAMMINE DICHLORIDE

TOXICITY DATA:	CODEN:
mmo-sat 2 µg/plate	MUREAV 77,45,80
mma-sat 2 µg/plate	MUREAV 77,45,80
dnd-esc 100 mmol/L	CBINA8 16,39,77
dni-hmn:oth 25 µmol/L	IJCNAW 6,207,70
oms-mam:lym 10 µmol/L	BCPCA6 23,1659,74
ipr-mus LDLo:14 mg/kg	BCPCA6 2,187,73

THR: Poison by intraperitoneal route. Human mutagenic data. See also PLATINUM COMPOUNDS. When heated to decomposition it emits very toxic fumes of Cl^- and NO_x.

TOXICITY DATA:	CODEN:
ims-rat TDLo:50 mg/kg:ETA	CNREA8 29,506,69

THR: An experimental tumorigen. When heated to decomposition it emits acrid smoke and irritating fumes.

EGP500 ***HR: 2***

ETHYL BENZENE

CAS: 100-41-4 NIOSH: DA 0700000
DOT: 1175
mf: C_8H_{10} mw: 106.18

PROP: Colorless liquid, aromatic odor. Misc in alcohol and ether, insol in NH_3; sol in SO_2. Bp: 136.2°, fp: −94.9°, flash p: 59°F, d: 0.8669 @ 20°/4°, autoign temp: 810°F, vap press: 10 mm @ 25.9°, vap d: 3.66, lel: 1.2%, uel: 6.8%.

SYNS:

AETHYLBENZOL (GERMAN)	ETILBENZENE (ITALIAN)
EB	ETYLOBENZEN (POLISH)
ETHYLBENZEEN (DUTCH)	NCI-C56393
ETHYLBENZOL	PHENYLETHANE

TOXICITY DATA:	CODEN:
skn-rbt 15 mg/24H open MLD	AIHAAP 23,95,62
eye-rbt 100 mg	AJOPAA 29,1363,46
sce-hmn:lym 1 mmol/L	MUREAV 116,379,83
ihl-rat TCLo:97 ppm/7H (15D preg):REP	BATTL* JAN,81
ihl-rat TCLo:985 ppm/7H (1-19D preg):TER	BATTL* JAN,81
ihl-rat TCLo:96 ppm/7H (1-19D preg):TER	BATTL* JAN,81
ihl-hmn TCLo:100 ppm/8H: EYE,CNS,PUL	AIHAAP 31,206,70
orl-rat LD50:3500 mg/kg	AMIHAB 14,387,56
ihl-rat LCLo:4000 ppm/4H	AIHAAP 23,95,62
ihl-mus LCLo:50 g/m3/2H	GTPZAB 5(5),3,61
ipr-mus LD50:2272 mg/kg	ARTODN 58,106,85
skn-rbt LD50:17800 mg/kg	FCTXAV 13,803,75
ihl-gpg LCLo:10000 ppm	PHRPA6 45,1241,30

Reported in EPA TSCA Inventory. EPA Genetic Toxicology Program. Community Right To Know List.

OSHA PEL: TWA 100 ppm (skin)
ACGIH TLV: TWA 100 ppm; STEL 125 ppm; BEI: 2 g/L (mandelic acid in urine at end of shift)
DFG MAK: 100 ppm (440 mg/m^3)

DOT Classification: Flammable Liquid, Label: Flammable Liquid

THR: Moderately toxic by ingestion and intraperitoneal route. Mildly toxic by inhalation and skin contact. An experimental teratogen. Human systemic effects by inhalation: eye, sleep and pulmonary changes. An eye and skin irritant. Human mutagenic data. The liquid is an irritant to the skin and mucous membranes. A concentration of 0.1% of the vapor in air is an irritant to human eyes, and a concentration of 0.2% is extremely irritating at first, then causes dizziness, irritation of the nose and throat and a sense of constriction in the chest. Exposure of guinea pigs to 1% concentration has been reported as causing ataxia, loss of consciousness, tremor of the extremities and finally death through respiratory failure. The pathological findings were congestion of the brain and lungs with edema. No data are available regarding the effect of chronic exposure.

A very dangerous fire and explosion hazard when exposed to heat or flame; can react vigorously with oxidizing materials. To fight fire, use foam, CO_2, dry chemical. When heated to decomposition it emits acrid smoke and irritating fumes. For further information, see Vol. 2, No. 6 of *DPIM Report*.

EGQ000 ***HR: 2***

α-ETHYLBENZENEMETHANOL

CAS: 93-54-9 NIOSH: DO 5470000
mf: $C_9H_{12}O$ mw: 136.21

SYNS:

EJIBIL	PHENICOL
α-ETHYLBENZYL ALCOHOL	PHENYCHOLON
ETHYL PHENYL CARBINOL	PHENYLAETHYLCARBINOL (GERMAN)
FELICUR	1-PHENYLPROPANOL
FELITROPE	1-PHENYL-1-PROPANOL
FENICOL	α-HYDROXYPROPYLBENZENE
LIVONAL	1-PHENYLPROPYL ALCOHOL
	SH 261

TOXICITY DATA:	CODEN:
orl-rat LD50:1600 mg/kg	ARZNAD 12,347,62
orl-mus LD50:500 mg/kg	AIPTAK 116,154,58
scu-mus LD50:700 mg/kg	AIPTAK 116,154,58

THR: Moderately toxic by ingestion and subcutaneous route. When heated to decomposition it emits acrid smoke and irritating fumes.

EGR000 ***HR: 2***

ETHYL BENZOATE

CAS: 93-89-0 NIOSH: DH 0200000
mf: $C_9H_{10}O_2$ mw: 150.19

PROP: Colorless, aromatic liquid. Mp: −34.6°, bp: 213.4°, flash p: >204°F, d: 1.048 @ 20°/20°, vap press: 1 mm @ 44.0°, vap d: 5.17, autoign temp: 914°F. Insol in water; misc in petroleum, alcohol, chloroform, and ether.

SYNS:

BENZOIC ETHER	ESSENCE OF NIOBE

TOXICITY DATA:	CODEN:
skn-rbt 10 mg/24H open MLD	AMIHBC 10,61,54
eye-rbt 500 mg open	AMIHBC 10,61,54
orl-rat LD50:2100 mg/kg	JPETAB 84,358,45
skn-cat LDLo:10 g/kg	JPETAB 84,358,45
orl-rbt LD50:2630 mg/kg	JPETAB 84,358,45

Reported in EPA TSCA Inventory.

EHH000 ***HR: 1***

ETHYL CHLORIDE

CAS: 75-00-3 NIOSH: KH 7525000
DOT: 1037
mf: C_2H_5Cl mw: 64.52

PROP: Colorless liquid or gas; ether-like odor, sol in water at 0.45; misc in alcohol and ether, burning taste. Bp: 12.3°, lel: 3.8%, uel: 15.4%, fp: −139°, flash p: −58°F (CC), d: 0.9214 @ 0°/4°, autoign temp: 966°F, vap press: 1000 mm @ 20° vap d: 2.22.

SYNS:
AETHYLCHLORID (GERMAN)
AETHYLIS
AETHYLIS CHLORIDUM
ANODYNON
CHELEN
CHLOORETHAAN (DUTCH)
CHLORETHYL
CHLORIDUM
CHLOROAETHAN (GERMAN)
CHLOROETHANE
CHLORURE D'ETHYLE (FRENCH)
CHLORYL
CHLORYL ANESTHETIC
CLOROETANO (ITALIAN)
CLORURO DI ETILE (ITALIAN)
ETHER CHLORATUS
ETHER HYDROCHLORIC
ETHER MURIATIC
ETYLU CHLOREK (POLISH)
HYDROCHLORIC ETHER
KELENE
MONOCHLORETHANE
MURIATIC ETHER
NARCOTILE
NCI-C06224

TOXICITY DATA:	CODEN:
ihl-rat LC50: 160 g/m^3/2H	85GMAT -,66,82
ihl-mus LC50: 146 g/m^3/2H	85GMAT -,66,82
ihl-gpg LCLo: 40000 ppm/45M	XPHBAO 185,1,29

Reported in EPA TSCA Inventory. Community Right To Know List.

OSHA PEL: TWA 1000 ppm
ACGIH TLV: TWA 1000 ppm

DOT Classification: Flammable Liquid, Label: Flammable Liquid; Flammable Gas; Label; Flammable Gas

THR: Mildly toxic by inhalation. An irritant to skin, eyes and mucous membranes. The liquid is harmful to the eyes and can cause some irritation. In the case of guinea pigs, the symptoms attending exposure are similar to those caused by methyl chloride, except that the signs of lung irritation are not as pronounced. It gives some warning of its presence because it is irritating, but it is possible to tolerate exposure to it until one becomes unconscious. It is the least toxic of all the chlorinated hydrocarbons. It can cause narcosis, although the effects are usually transient. A priority pollutant.

A very dangerous fire hazard when exposed to heat or flame; can react vigorously with oxidizing materials. Severe explosion hazard when exposed to flame. Reacts with water or steam to produce toxic and corrosive fumes. Incompatible with potassium. To fight fire, use carbon dioxide. When heated to decomposition it emits toxic fumes of phosgene and Cl^-. See also CHLORINATED HYDROCARBONS, ALIPHATIC. For further information, see Vol. 1, No. 4 of *DPIM Report*.

EHH500 ***HR: 1***

ETHYL CHLORO BENZENE

CAS: 1331-31-3 NIOSH: CZ 0700000
mf: C_8H_9Cl mw: 140.62

PROP: Clear, colorless liquid. Mp: −62.6°, bp: 184.3°, flash p: 147°F, d: 1.05 @ 25°/25°, vap press: 1 mm @ 19.2°, vap d: 4.86.

SYN: CHLOROETHYLBENZENE

TOXICITY DATA:	CODEN:
skn-rbt 10 mg/24H open	JIHTAB 30,63,48
eye-rbt 500 mg	AJOPAA 29,1363,46
orl-rat LD50: 5000 mg/kg	JIHTAB 30,63,48
skn-rbt LD50: 18 g/kg	JIHTAB 30,63,48

THR: Mildly toxic by ingestion and skin contact. A skin and eye irritant. Flammable when exposed to heat or flame; can react vigorously with oxidizing materials. To fight fire, use foam, CO_2, dry chemical. When heated to decomposition it emits acrid smoke and irritating fumes. See also CHLORINATED HYDROCARBONS, AROMATIC, and CHLOROBENZENE.

EHI500 ***HR: 3***

7-(2-(ETHYL-2-CHLOROETHYL)AMINOETHYLAMINO)BENZ(c)ACRIDINE DIHYDROCHLORIDE

CAS: 4310-69-4 NIOSH: CU 3440000
mf: $C_{23}H_{24}ClN_3 \cdot 2ClH$ mw: 450.87

SYNS:
N'-BENZ(c)ACRIDIN-7-YL-N-(2-CHLOROETHYL)-N-ETHYL-1,2-ETHANEDIAMINE DIHYDROCHLORIDE
7-(2-(2-CHLOROETHYLETHYLAMINO)ETHYLAMINO)BENZ(c)ACRIDINE DIHYDROCHLORIDE
ICR 311

TOXICITY DATA:	CODEN:
ivn-mus TDLo: 4500 µg/kg: NEO	CNREA8 36,2423,76
ivn-mus LDLo: 4500 µg/kg	CNREA8 36,2423,76

THR: Poison by intravenous route. An experimental neoplastigen. When heated to decomposition it emits very toxic fumes of NO_x and Cl^-.

EHJ000 ***HR: 3***

7-(3-(ETHYL-2-(CHLOROETHYLAMINO)PROPYLAMINO))BENZ(c)ACRIDINE DIHYDROCHLORIDE

CAS: 4251-89-2 NIOSH: CU 3460000
mf: $C_{24}H_{26}ClN_3 \cdot 2ClH$ mw: 464.90

SYN: ICR 292

TOXICITY DATA:	CODEN:
mmo-sat 500 ng/plate	MUREAV 136,185,84
pic-esc 60 ng/plate	CNREA8 43,2819,83

HET500 ***HR: 3***

2,4,6,2',4',6'-HEXANITRODIPHENYLAMINE

CAS: 131-73-7 NIOSH: JJ 9275000

mf: $C_{12}H_5N_7O_{12}$ mw: 439.24

SYNS:

BIS(2,4,6-TRINITRO-PHENYL) -AMIN (GERMAN)
DPA
ESANITRODIFENILAMINA (ITALIAN)
HEXANITRODIFENYLAMINE (DUTCH)
HEXANITRODIPHENYLAMINE
HEXANITRODIPHENYLAMINE (FRENCH)
2,2',4,4',6,6'-HEXANITRODIPHENYLAMINE
HEXYL (GERMAN, DUTCH)

TOXICITY DATA: CODEN:

mmo-sat 228 nmol/plate MUREAV 136,209,84
mma-sat 456 nmol/plate MUREAV 136,209,84
orl-rat TDLo: 14 g/kg/76W-C: NEO NATUAS 180,509,57

Reported in EPA TSCA Inventory.

THR: An experimental neoplastigen. Mutagenic data. A powerful and violent explosive used as a booster explosive; its use is superior to TNT. It is not as good for this purpose as tetryl, but is extremely stable and much safer to handle. See also NITRO COMPOUNDS OF AROMATIC HYDROCARBONS.

HET675 ***HR: 3***

HEXANITROETHANE

CAS: 918-37-6

mf: $C_2N_6O_{12}$ mw: 300.06

THR: A powerful oxidant which explodes above 140°C. Explosive reaction with boron. Hypergolic reaction with dimethyl hydrazine or other strong organic bases. Forms powerfully explosive mixtures with nitrogen containing organic compounds (e.g., 2-nitroaniline). Upon decomposition it emits toxic fumes of NO_x. See also NITRO COMPOUNDS.

HEU000 ***HR: 2***

HEXANOIC ACID

CAS: 142-62-1 NIOSH: MO 5250000

DOT: 1706

mf: $C_6H_{12}O_2$ mw: 116.18

PROP: Oily, colorless liquid; odor of Limburger cheese. Bp: 205.0°, fp: −3.4°, flash p: 215°F (COC), d: 0.9295 @ 20°/20°, vap press: 0.18 mm @ 20°, vap d: 4.0, autoign temp: 716°F. Slightly sol in water; very sol in ethanol, ether.

SYNS:

BUTYLACETIC ACID
CAPROIC ACID
n-CAPROIC ACID
CAPRONIC ACID
HEXACID 698
n-HEXANOIC ACID
n-HEXOIC ACID
PENTIPORMIC ACID
PENTYLFORMIC ACID

TOXICITY DATA: CODEN:

skn-rbt 10 mg/24H open MLD AMIHBC 10,61,54
skn-rbt 465 mg open MLD UCDS** 11/2/71
eye-rbt 695 µg SEV AJOPAA 29,1363,46
oms-nml:oth 10 mmol/L CHROAU 40,1,73
cyt-nml:oth 10 mmol/L CHROAU 40,1,73
orl-rat LD50:3000 mg/kg JIHTAB 26,269,44
orl-mus LD50:5 g/kg 85GMAT -,32,82
ihl-mus LC50:4100 mg/m³/2H 85GMAT -,32,82
ipr-mus LD50:3180 mg/kg JPPMAB 21,85,69
scu-mus LD50:3180 mg/kg JPPMAB 21,85,69
skn-rbt LD50:630 mg/kg AMIHBC 10,61,54
skn-gpg LD50:4635 mg/kg JIHTAB 26,269,44

Reported in EPA TSCA Inventory.

DOT Classification: Corrosive Material; Label: Corrosive

THR: Moderately toxic by ingestion, skin contact, intraperitoneal, and subcutaneous routes. Mutagenic data. Corrosive. A skin and severe eye irritant. Combustible when exposed to heat or flame; can react with oxidizing materials. To fight fire, use CO_2, dry chemical, fog, mist. When heated to decomposition it emits acrid smoke and fumes.

HEU500 ***HR: 1***

HEXANOIC ACID, VINYL ESTER (MIXED ISOMERS)

NIOSH: MO 8450000

mf: $C_8H_{14}O_2$ mw: 142.22

TOXICITY DATA: CODEN:

skn-rbt 10 mg/24H open MLD AIHAAP 23,95,62
orl-rat LD50:20 g/kg AIHAAP 23,95,62
ihl-rat LCLo:4000 ppm/4H AIHAAP 23,95,62

THR: Mildly toxic by ingestion and inhalation. A skin irritant. When heated to decomposition it emits acrid smoke and fumes. See also ESTERS.

HEV000 ***HR: 3***

2-HEXANONE ✳

CAS: 591-78-6 NIOSH: MP 1400000

mf: $C_6H_{12}O$ mw: 100.18

PROP: Clear liquid. Mp: −56.9°, bp: 127.2°, lel: 1.22%, uel: 8.0%, flash p: 95°F (OC), d: 0.830 @ 0°/4°, vap press: 10 mm @ 38.8°, vap d: 3.45, autoign temp: 991°F. Slightly sol in H_2O; sol in alc, ether.

SYNS:

BUTYL METHYL KETONE
n-BUTYL METHYL KETONE
HEXANONE-2
MBK
METHYL n-BUTYL KETONE (ACGIH)
MNBK

TOXICITY DATA: CODEN:

eye-rbt 100 mg open AMIHBC 10,61,54
ihl-rat TCLo:1000 ppm/6H (1-21D preg):TER EESADV 5,291,81
ihl-rat TCLo:2000 ppm/6H (1-21D preg):REP EESADV 5,291,81
ihl-hmn TCLo:1000 ppm: EYE,CNS,GIT NPIRI* 1,78,74

orl-rat LD50:2590 mg/kg	AMIHBC 10,61,54
ihl-rat LC50:8000 ppm/4H	NPIRI* 1,78,74
ipr-rat LDLo:914 mg/kg	RalRL# 01MAR74
orl-mus LDLo:1000 mg/kg	UCPHAQ 2,217,49
skn-rbt LD50:4800 mg/kg	NPIRI* 1,78,74
orl-gpg LDLo:914 mg/kg	RalRL# 01MAR74

Reported in EPA TSCA Inventory.

OSHA PEL: TWA 100 ppm
ACGIH TLV: TWA 5 ppm (skin)
NIOSH REL: (Ketones) TWA 4 mg/m^3

THR: Moderately toxic by ingestion and intraperitoneal routes. Mildly toxic by inhalation and skin contact. Experimental teratogenic and reproductive effects. Human systemic effects by inhalation: unspecified eye effects, headache, nausea or vomiting. An eye irritant. Dangerous fire and explosion hazard when exposed to heat or flame; can react with oxidizing materials. To fight fire, use alcohol foam, CO_2, dry chemical. See also KETONES.

HEV500 ***HR: 2***

3-HEXANONE

CAS: 589-38-8 NIOSH: MP 1576000
mf: $C_6H_{12}O$ mw: 100.18

PROP: Colorless liquid. Bp: 124°, d: 0.813 @ 21.8°/4°, flash p: 57.2°F (OC).

SYNS:
AETHYLPROPYLKETON (GERMAN) ETHYL PROPYL KETONE

TOXICITY DATA:	CODEN:
orl-rat LD50:3360 mg/kg	TXAPA9 28,313,74
ihl-rat LCLo:4000 ppm/4H	TXAPA9 28,313,74
skn-rbt LD50:3170 mg/kg	TXAPA9 28,313,74
scu-gpg LDLo:700 mg/kg	BDKS** -,-,34

Reported in EPA TSCA Inventory.

THR: Moderately toxic by ingestion, skin contact and subcutaneous routes. Mildly toxic by inhalation. A very dangerous fire hazard when exposed to heat or flame; can react vigorously with oxidizing materials. To fight fire, use foam, CO_2, dry chemical. When heated to decomposition it emits acrid smoke and fumes. See also KETONES.

HEW000 ***HR: 3***

1-HEXANOYLAZIRIDINE

CAS: 45776-10-1 NIOSH: CM 7890000
mf: $C_8H_{15}NO$ mw: 141.24

SYNS:
1-CAPROYLAZIRIDINE HEXANOYLETHYLENEIMINE
CAPROYLETHYLENEIMINE

TOXICITY DATA:	CODEN:
cyt-rat-ipr 50 mg/kg	BJPCAL 9,306,54
scu-rat TDLo:495 mg/kg/19W-I: NEO	BJPCAL 9,306,54
scu-mus TDLo:360 mg/kg/41W-I:ETA	BJPCAL 9,306,54
scu-rat TD :525 mg/kg/17W-I: NEO	BJPCAL 9,306,54

THR: An experimental neoplastigen and tumorigen. Mutagenic data. When heated to decomposition it emits toxic fumes of NO_x.

HEY000 ***HR: 3***

HEXAPYRIDINEIRON(II) TRIDECACARBONYL TETRAFERRATE(2$^-$)

CAS: 23129-50-2
mf: $C_{43}H_{30}Fe_5N_6O_{13}$ mw: 1117.9

SYN: HEXAKIS(PYRIDINE)IRON(II) TRIDECACARBONYLTETRAFERRATE(2-)

THR: Ignites spontaneously in air. When heated to decomposition it emits toxic fumes of NO_x. See also CARBONYLS.

HEY500 ***HR: 2***

HEXASODIUM TETRAPHOSPHATE

CAS: 14986-84-6 NIOSH: XF 1700000
mf: $Na_6O_{13}P_4$ mw: 469.82

SYNS:
HEXANATRIUMTETRAPOLYPHOSPHAT (GERMAN) HEXASODIUM TETRAPOLYPHOSPHATE

TOXICITY DATA:	CODEN:
orl-mus LD50:3920 mg/kg	ARZNAD 7,445,57
scu-mus LD50:875 mg/kg	ARZNAD 7,445,57

Reported in EPA TSCA Inventory.

THR: Moderately toxic by ingestion and subcutaneous routes. When heated to decomposition it emits toxic fumes of Na_2O and PO_x. See also PHOSPHATES.

HEZ000 ***HR: 3***

1,3,5-HEXATRIENE

CAS: 2235-12-3 NIOSH: MP 5425000
mf: C_6H_8 mw: 80.14

SYN: DIVINYLETHYLENE

TOXICITY DATA:	CODEN:
eye-rbt 369 mg	IHFCAY 6,1,67
orl-rat LD50:210 mg/kg	IHFCAY 6,1,67
ihl-rat LCLo:100000 ppm/15M	IHFCAY 6,1,67
skn-rbt LD50:6730 mg/kg	IHFCAY 6,1,67

Reported in EPA TSCA Inventory.

THR: Poison by ingestion. Mildly toxic by skin contact and inhalation. An eye irritant. When heated to decomposition it emits acrid smoke and fumes.

THR: A poison by ingestion, inhalation, and skin contact. A skin irritant. When heated to decomposition it emits acrid smoke and fumes. See also ACETYLENE COMPOUNDS and ALCOHOLS.

HFF300 ***HR: 3***

4-HEXEN-1-YN-3-ONE

CAS: 13061-80-8 NIOSH: MQ 0350000

mf: C_6H_6O mw: 94.12

SYN: 4-HEXENE-1-YNE-3-ONE

TOXICITY DATA:	CODEN:
skn-rbt 10 mg/24H open MLD	AIHAAP 23,95,62
orl-rat LD50:71 mg/kg	AIHAAP 23,95,62
ihl-rat LCLo:13 ppm/4H	AIHAAP 23,95,62
skn-rbt LD50:100 mg/kg	AIHAAP 23,95,62

THR: A poison by ingestion, inhalation, and skin contact. A skin irritant. When heated to decomposition it emits acrid smoke and fumes. See also ACETYLENE COMPOUNDS and KETONES.

HFF500 ***HR: 3***

HEXOBENDINE DIHYDROCHLORIDE

CAS: 50-62-4 NIOSH: DI 0230000

mf: $C_{30}H_{44}N_2O_{10}\cdot 2ClH$ mw: 665.68

SYNS:

ANDIAMINE	REOXYL
N,N'-DIMETHYL-N,N'-BIS(3-(3',-4',5'-TRIMETHOXYBENZOXY) PROPYL)ETHYLENEDIAMINE DIHYDROCHLORIDE	

TOXICITY DATA:	CODEN:
orl-rat LD50:2550 mg/kg	GNRIDX 3,77,69
scu-rat LD50:930 mg/kg	GNRIDX 3,77,69
ivn-rat LD50:52 mg/kg	GNRIDX 3,77,69
orl-mus LD50:682 mg/kg	GNRIDX 3,77,69
scu-mus LD50:328 mg/kg	GNRIDX 3,77,69
ivn-mus LD50:35200 µg/kg	GNRIDX 3,77,69

THR: Poison by subcutaneous and intravenous routes. Moderately toxic by ingestion. When heated to decomposition it emits toxic fumes of NO_x and HCl. See also ESTERS.

HFG000 ***HR: 3***

HEXOCYCLIUM

CAS: 6004-98-4 NIOSH: TM 3150000

mf: $C_{21}H_{36}N_2O_5S$ mw: 428.61

PROP: Crystals. Mp: 200-210°, sltly sol in chloroform, insol in ether, sol in H_2O.

SYNS:

4-(β-CYCLOHEXYL-β-HYDROXY-PHENETHYL)-1,1-DIMETHYL PIPERAZINIUM SULFATE	TRAL

TOXICITY DATA:	CODEN:
mmo-sat 32 µg/plate	JEPTDQ 4,345,80
orl-mus LD50:600 mg/kg	27ZIAQ -,-,65
ipr-mus LD50:55 mg/kg	27ZIAQ -,119,73
scu-mus LD50:360 mg/kg	27ZIAQ -,119,73
ivn-mus LD50:11 mg/kg	27ZIAQ -,119,73

THR: Poison by intraperitoneal, subcutaneous, and intravenous routes. Moderately toxic by ingestion. Mutagenic data. When heated to decomposition it emits very toxic fumes of NO_x and SO_x.

HFG500 ***HR: 3***

HEXONE

CAS: 108-10-1 NIOSH: SA 9275000

DOT: 1245

mf: $C_6H_{12}O$ mw: 100.18

$CH_3CO{\cdot}CH_2CH(CH_3)_2$

PROP: Clear liquid. Bp: 118°, lel: 1.4%, uel: 7.5%, flash p: 62.6°F, d: 0.803, fp: −80.2°, autoign temp: 858°F, vap press: 16 mm @ 20°, d: 3.45.

SYNS:

HEXON (CZECH)	4-METHYL-PENTAN-2-ON (DUTCH, GERMAN)
ISOBUTYL-METHYLKETON (CZECH)	2-METHYL-4-PENTANONE
ISOBUTYL METHYL KETONE	4-METHYL-2-PENTANON (CZECH)
ISOPROPYLACETONE	4-METHYL-2-PENTANONE
METHYL-ISOBUTYL-CETONE (FRENCH)	METILISOBUTILCHETONE (ITALIAN)
METHYLISOBUTYLKETON (DUTCH, GERMAN)	4-METILPENTAN-2-ONE (ITALIAN)
METHYL ISOBUTYL KETONE (ACGIH,DOT)	MIBK
METYLOIZOBUTYLOKETON (POLISH)	MIK
	RCRA WASTE NUMBER U161
	SHELL MIBK

TOXICITY DATA:	CODEN:
eye-hmn 200 ppm/15M	JIHTAB 28,262,46
skn-rbt 500 mg/24H MLD	28ZPAK -,42,72
eye-rbt 40 mg SEV	UCDS** 4/25/58
eye-rbt 500 mg/24H MLD	28ZPAK -,42,72
orl-rat LD50:2080 mg/kg	UCDS** 4/25/58
ihl-rat LC50:8000 ppm/4H	28ZPAK -,42,72
ipr-mus LD50:268 mg/kg	SCCUR* -,7,61

Community Right To Know List.

OSHA PEL: TWA 100 ppm
ACGIH TLV: TWA 50 ppm; STEL 75 ppm
NIOSH REL: (Ketones) TWA 200 mg/m^3

DOT Classification: Flammable Liquid; Label: Flammable Liquid

THR: A poison by intraperitoneal route. Moderately toxic by ingestion. Mildly toxic by inhalation. Very irritating to the skin, eyes and mucous membranes. A human systemic irritant by inhalation. Narcotic in high concentration. Dangerous fire hazard when exposed to heat, flame or oxidizers. Ignites on contact with potassium-tert-butoxide. Moderately explosive in the form of vapor when exposed to heat or flame. May form explosive peroxides upon exposure to air. Can react vigorously with reducing materials.

To fight fire, use alcohol foam, CO_2, dry chemical. Incompatible with air; potassium-tert-butoxide. See also KETONES.

HFG550 ***HR: 3***

HEXOPAL

CAS: 6556-11-2 NIOSH: NM 7535400

mf: $C_{42}H_{30}N_6O_{12}$ mw: 810.71

PROP: Crystals. Mp: 254.3-254.9°. Practically insol in water; sol in dil acids.

SYNS:

DILCIT
DILEXPAL
ESANTENE
INOSITOL HEXANICOTINATE
m-INOSITOL HEXANICOTINATE
meso-INOSITOL HEXANICOTINATE
myo-INOSITOL HEXANICOTINATE
INOSITOL NIACINATE
INOSITOL NICOTINATE
HAMOVANNID
HEXANICIT
HEXANICOTINOYL INOSITOL
HEXANICOTOL
HEXA-3-PYRIDINECARBOXYLATE-myo-INOSITOL (9CI)
LINODIL
MESONEX
MESOTAL
PALOHEX

TOXICITY DATA:	CODEN:
scu-rat LD50:1180 mg/kg	NIIRDN 6,77,82
ivn-rat LD50:268 mg/kg	NIIRDN 6,77,82
ipr-mus LD50:6400 mg/kg	OYYAA2 7,149,73
ivn-mus LD50:345 mg/mg	NIIRDN 6,77,82

THR: Poison by intravenous route. Moderately toxic by subcutaneous route. When heated to decomposition it emits toxic fumes of NO_x.

HFG600 ***HR: 3***

HEXOPRENALINE DIHYDROCHLORIDE

CAS: 4323-43-7 NIOSH: DO 6349000

mf: $C_{22}H_{32}N_2O_6 \cdot 2ClH$ mw: 493.48

SYNS:

N,N'-BIS(2-(3',4'-DIHYDROXYPHENYL)-2-HYDROXYETHYL)HEXAMETHYLENEDIAMINE DIHYDROCHLORIDE
ST-1512 DIHYDROCHLORIDE

TOXICITY DATA:	CODEN:
ivn-rat TDLo:12 mg/kg (9-14D preg):TER	KSRNAM 6,983,72
orl-mus TDLo:12 mg/kg (7-12D preg):REP	KSRNAM 6,983,72
ivn-mus TDLo:1200 µg/kg (7-12D preg):TER	KSRNAM 6,983,72
orl-rat LD50:10 g/kg	OYYAA2 26,811,83
ipr-rat LD50:139 mg/kg	KSRNAM 6,1286,72
scu-rat LD50:143 mg/kg	KSRNAM 6,1286,72
ivn-rat LD50:58 mg/kg	OYYAA2 26,811,83
orl-mus LD50:2036 mg/kg	KSRNAM 6,1286,72
ipr-mus LD50:133 mg/kg	KSRNAM 6,1286,72
scu-mus LD50:110 mg/kg	KSRNAM 6,1286,72
ivn-mus LD50:88 mg/kg	KSRNAM 6,1286,72

THR: Poison by subcutaneous, intravenous and intraperitoneal routes. Moderately toxic by ingestion. An experimental teratogen. Experimental reproductive effects. When heated to decomposition it emits toxic fumes of NO_x and HCl.

HFG650 ***HR: 3***

HEXOPRENALINE SULFATE

CAS: 32266-10-7 NIOSH: DO 6350000

mf: $C_{22}H_{32}N_2O_6 \cdot H_2O_4S$ mw: 518.64

SYNS:

N,N'-BIS(2-(3',4'-DIHYDROXYPHENYL)-2-HYDROXYETHYL)HEXAMETHYLENEDIAMINE SULFATE
ST-1512 SULFATE

TOXICITY DATA:	CODEN:
orl-rat TDLo:66 mg/kg (7-17D preg):TER	OYYAA2 27,239,84
orl-mus TDLo:6 mg/kg (7-12D preg):TER	KSRNAM 6,983,72
ipr-rat LD50:145 mg/kg	NIIRDN 6,745,82
scu-rat LD50:150 mg/kg	NIIRDN 6,745,82
ipr-mus LD50:159 mg/kg	NIIRDN 6,745,82
scu-mus LD50:274 mg/kg	NIIRDN 6,745,82

THR: Poison by subcutaneous and intraperitoneal routes. An experimental teratogen. Experimental reproductive effects. When heated to decomposition it emits toxic fumes of SO_x and NO_x. See also SULFATES.

HFH500 ***HR: 3***

p-HEXOXYBENZOIC ACID-3-(2'-METHYLPIPERIDINO)PROPYL ESTER

CAS: 63916-83-6 NIOSH: DH 1450000

mf: $C_{22}H_{35}NO_3$ mw: 361.58

TOXICITY DATA:	CODEN:
scu-mus LD50:222 mg/kg	RCPRAN 15,143,54
ivn-mus LD50:23 mg/kg	RCPRAN 15,143,54

THR: Poison by subcutaneous and intravenous routes. When heated to decomposition it emits toxic fumes of NO_x. See also ESTERS.

HFI500 ***HR: 1***

HEXYL ACETATE

CAS: 142-92-7 NIOSH: AI 0875000

mf: $C_8H_{16}O_2$ mw: 144.24

PROP: Colorless liquid. D: 0.878, mp: −60.9°, bp: 171.5°, insol in water, very sol in alc and ether.

SYNS:

ACETIC ACID HEXYL ESTER
n-HEXYL ACETATE
1-HEXYL ACETATE
HEXYL ALCOHOL, ACETATE
HEXYL ETHANOATE

TOXICITY DATA:	CODEN:
orl-rat LD50:42 g/kg	TXAPA9 28,313,74

Reported in EPA TSCA Inventory.

THR: Mildly toxic by ingestion. When heated to decomposition it emits acrid smoke and fumes. See also ESTERS.

ivn-rbt LD50: 36 mg/kg	IJNEAQ 5,305,66
orl-qal LD50: 1 g/kg	AECTCV 12,355,83

EPA Genetic Toxicology Program.

THR: Poison by intraperitoneal and intravenous routes. Moderately toxic by ingestion and subcutaneous routes. An experimental teratogen. Experimental reproductive effects. Mutagenic data. A minor tranquilizer. When heated to decomposition it emits very toxic fumes of HCl and NO_x.

MDQ500 *HR: 3*

l-METHAMPHETAMINE HYDROCHLORIDE

CAS: 826-10-8 NIOSH: SH 5250000

mf: $C_{10}H_{15}N \cdot ClH$ mw: 185.72

PROP: Crystals; bitter taste. Mp: 170-175°. Sol in H_2O, alc and chloroform; almost insol in ether.

SYNS:

ADIPEX	"METH"
l-DESOXYEPHEDRINE HYDROCHLORIDE	l-N-METHYL-β-PHENYLISOPROPYLAMINE HYDROCHLORIDE
(−)-N-α-DIMETHYLPHENETHYLAMINE HYDROCHLORIDE	"SPEED"
	SYNDROX

TOXICITY DATA:	CODEN:
ivn-mus TDLo: 15 mg/kg (9-11D preg): TER	TJADAB 4,131,71
ivn-rbt TDLo: 6 mg/kg (12-15D preg): TER	TJADAB 4,131,71
ipr-rat LD50: 25 mg/kg	27ZQAG -,346,72
scu-rat LD50: 30 mg/kg	27ZQAG -,346,72
ipr-mus LD50: 70 mg/kg	JPETAB 89,382,47
scu-mus LD50: 180 mg/kg	27ZQAG -,346,72
ivn-mus LD50: 33 mg/kg	27ZQAG -,346,72
orl-dog LD50: 10 mg/kg	27ZQAG -,346,72
ivn-dog LD50: 2700 μg/kg	PSEBAA 118,557,65
scu-cat LD50: 50 mg/kg	27ZQAG -,346,72

THR: Poison by ingestion, intravenous, intraperitoneal, and subcutaneous routes. An experimental teratogen. Experimental reproductive effects. A powerful central nervous system stimulant. *Caution:* Excessive use may lead to tolerance and habituation. When heated to decomposition it emits very toxic fumes of HCl and NO_x. See also BENZEDRINE.

MDQ750 *HR: 3*

METHANE

CAS: 74-82-8 NIOSH: PA 1490000

DOT: 1971/1972

mf: CH_4 mw: 16.05

PROP: Colorless, odorless, tasteless gas. Mp: −182.6°. Bp: −161.5°, lel: 5.3%, uel: 15%, fp: −183.2°. D: 0.554 @ 0°/4° (air = 1) or 0.7168 g/L, autoign temp: 650°, vap d: 0.6, flash p: −368.6°F. Sol in water, alc and ether.

SYNS:

FIRE DAMP	METHANE, REFRIGERATE LIQUID (DOT)
MARSH GAS	METHYL HYDRIDE
METHANE, COMPRESSED (DOT)	

Reported in EPA TSCA Inventory.

DOT Classification: Flammable Gas; Label: Flammable Gas

THR: A simple asphyxiant. Very dangerous fire and explosion hazard when exposed to heat or flame. Reacts violently with powerful oxidizers (e.g., bromine pentafluoride; chlorine trifluoride; chlorine; fluorine; iodine heptafluoride; dioxygenyl tetrafluoroborate; dioxygen difluoride; trioxygen difluoride; liquid oxygen; ClO_2; NF_3; OF_2). Incompatible with halogens or interhalogens; air (forms explosive mixtures). Explosive in the form of vapor when exposed to heat or flame. To fight fire, stop flow of gas, CO_2 or dry chemical. See also ARGON for a description of asphyxiants.

MDQ800 *HR: 3*

METHANE BORONIC ANHYDRIDE-PYRIDINE COMPLEX

mf: $CH_3BO \cdot C_5H_5N$ mw: 120.95

THR: Ignites spontaneously in air. When heated to decomposition it emits toxic fumes of NO_x. See also ANHYDRIDES, PYRIDINE, and BORON COMPOUNDS.

MDR000 *HR: 3*

METHANE DICHLORIDE *

CAS: 75-09-2 NIOSH: PA 8050000

DOT: 1593

mf: CH_2Cl_2 mw: 84.93

PROP: Colorless, volatile liquid. Bp: 39.8°, lel: 15.5% in O_2, uel: 66.4% in O_2, fp: −96.7°, d: 1.326 @ 20°/4°, autoign temp: 1139°F, vap press: 380 mm @ 22°, vap d: 2.93.

SYNS:

AEROTHENE MM	METHYLENE CHLORIDE (ACGIH, DOT)
CHLORURE de METHYLENE (FRENCH)	METHYLENE DICHLORIDE
DCM	METYLENU CHLOREK (POLISH)
DICHLOROMETHANE (DOT)	NCI-C50102
FREON 30	RCRA WASTE NUMBER U080
METHYLENE BICHLORIDE	SOLMETHINE

TOXICITY DATA:	CODEN:
skn-rbt 810 mg/24H SEV	JETOAS 9,171,76
eye-rbt 162 mg MOD	JETOAS 9,171,76
eye-rbt 10 mg MLD	TXCYAC 6,173,76
eye-rbt 17500 mg/m³/10M	TXCYAC 6,173,76
dni-hmn: fbr 5000 ppm/1H-C	MUREAV 81,203,81
cyt-ham: ovr 5 g/L	MUREAV 116,361,83
dni-ham: lng 5000 ppm/1H-C	MUREAV 81,203,81
sce-ham: lng 5000 ppm/1H-C	MUREAV 81,203,81
ihl-rat TCLo: 4500 ppm/24H (1-17D preg): REP	TXAPA9 52,29,80
ihl-mus TCLo: 1250 ppm/7H (6-15D preg): REP	TXAPA9 32,84,75
ihl-rat TCLo: 3500 ppm/6H/2Y-I: CAR	FAATDF 4,30,84
ihl-mus TCLo: 2000 ppm/5H/2Y-C: CAR	NTPTR* NTP-TR-306,86

ihl-rat TCLo:500 ppm/6H/2Y: ETA	TXAPA9 48,A185,79
orl-hmn LDLo:357 mg/kg: PNS,CNS	34ZIAG -,390,69
ihl-hmn TCLo:500 ppm/1Y-I: CNS,CVS	ABHYAE 43,1123,68
ihl-hmn TCLo:500 ppm/8H:CNS	SCIEAS 176,295,72
orl-rat LD50:2136 mg/kg	PPGDS* JAN81
ihl-rat LC50:88000 mg/m^3/30M	FAVUAI 7,35,75
ihl-mus LC50:14400 ppm/7H	NIHBAZ 191,1,49
ipr-mus LD50:1500 mg/kg	TXAPA9 9,139,66
scu-mus LD50:6460 mg/kg	TXAPA9 4,354,62
orl-dog LDLo:3000 mg/kg	QJPPAL 7,205,34
ihl-dog LCLo:14108 ppm/7H	NIHBAZ 191,1,49
ipr-dog LDLo:950 mg/kg	TXAPA9 10,119,67
scu-dog LDLo:2700 mg/kg	QJPPAL 7,205,34
ivn-dog LDLo:200 mg/kg	QJPPAL 7,205,34
ihl-cat LCLo:43400 mg/m^3/4.5H	AHBAAM 116,131,36
orl-rab LDLo:1900 mg/kg	HBTXAC 1,94,56
ihl-rbt LCLo:10000 ppm/7H	JIHTAB 26,8,44
scu-rbt LDLo:2700 mg/kg	QJPPAL 7,205,34
ihl-gpg LCLo:5000 ppm/2H	FLCRAP 1,197,67

IARC Cancer Review: Human Inadequate Evidence IMEMDT 41,43,86; Animal Inadequate Evidence IMEMDT 20,449,79; Animal Sufficient Evidence IMEMDT 41,43,86. NTP Carcinogenesis Studies (inhalation); Clear Evidence: mouse, rat NTPTR* NTP-TR-306,86. Reported in EPA TSCA Inventory. EPA Genetic Toxicology Program. Community Right To Know List.

OSHA PEL: TWA 500 ppm; CL 1000 ppm; Pk 2000/5M/2H

ACGIH TLV: TWA 50 ppm, Suspected Carcinogen

NIOSH REL: (To Methylene Chloride) TWA 75 ppm; Pk 500 ppm/15M

DOT Classification: Poison B; Label: St. Andrews Cross

THR: Poison by intravenous route. Moderately toxic by ingestion, subcutaneous and intraperitoneal routes. Mildly toxic by inhalation. An experimental carcinogen and tumorigen. Human systemic effects by ingestion and inhalation: paresthesia, somnolence, altered sleep time, convulsions, euphoria, and change in cardiac rate. An experimental teratogen. Experimental reproductive effects. An eye and severe skin irritant. Human mutagenic data. It is flammable in the range of 12-19% in air but ignition is difficult. It will not form explosive mixtures with air at ordinary temperatures. Mixtures in air with methanol vapor are flammable. It will form explosive mixtures with an atmosphere having a high oxygen content; in liquid O_2; N_2O_4; K; Na; NaK. Explosive in the form of vapor when exposed to heat or flame. Reacts violently with Li; NaK; potassium-tert-butoxide; (KOH + n-methyl-n-nitrosourea). It can be decomposed by contact with hot surfaces and open flame, and then yield toxic fumes which are irritating and give warning of their presence. When heated to decomposition it emits highly toxic fumes of phosgene and Cl^-. See also CHLORINATED HYDROCARBONS, ALIPHATIC.

MDR250 HR: 3

METHANESULFONIC ACID

CAS: 75-75-2 NIOSH: PB 1140000

mf: CH_4O_3S mw: 96.11

PROP: Solid. D: 1.4812 @ 18°/4°, mp: 20°, bp: 167° @ 10 mm. Sol in water, alc and ether. Corrosive to iron, steel, brass, copper and lead.

SYN: WSQ 1

TOXICITY DATA:	CODEN:
orl-rat LDLo:200 mg/kg	KODAK* 21MAY71
ipr-rat LDLo:50 mg/kg	KODAK* 21MAY71
orl-qal LD50:1000 mg/kg	JRPFA4 48,371,76

Reported in EPA TSCA Inventory.

THR: Poison by ingestion and intraperitoneal routes. May be corrosive to skin, eyes and mucous membranes. Explosive reaction with ethyl vinyl ether. Incompatible with hydrogen fluoride. When heated to decomposition it emits toxic fumes of SO_x. See also SULFONATES.

MDR750 HR: 3

METHANESULFONYL FLUORIDE

CAS: 558-25-8 NIOSH: PB 2975000

mf: CH_3FO_2S mw: 98.10

SYNS:
FUMETTE MSF
METHANESULPHONYL FLUORIDE

TOXICITY DATA:	CODEN:
orl-rat LD50:2 mg/kg	IAEC** 17JUN74
ihl-rat LCLo:140 mg/m^3	31ZOAD 1,287,68
ipr-rat LD50:3 mg/kg	NATUAS 173,33,54
scu-rat LD50:3500 µg/kg	28ZEAL 4,271,69
scu-mus LDLo:3500 µg/kg	31ZOAD 1,287,68
ivn-mus LD50:1 mg/kg	IAEC** 17JUN74
scu-dog LDLo:3500 µg/kg	31ZOAD 1,287,68
ivn-dog LD50:5620 µg/kg	IAEC** 17JUN74
scu-rbt LDLo:3500 µg/kg	31ZOAD 1,287,68
ivn-rbt LD50:3370 µg/kg	IAEC** 17JUN74

EPA Extremely Hazardous Substances List. Reported in EPA TSCA Inventory.

THR: Poison by ingestion, inhalation, intraperitoneal, intravenous, and subcutaneous routes. When heated to decomposition it emits very toxic fumes of F^- and SO_x. See also FLUORIDES and SULFONATES.

MDR775 HR: 3

METHANETELLUROL

CAS: 25284-83-7

mf: CH_4Te mw: 143.64

THR: A poison. Ignites spontaneously in air. Explodes on contact with oxygen at room temperature. When heated to decomposition it emits toxic fumes of Te. See also TELLURIUM COMPOUNDS.

scu-mus LD50:1250 µg/kg	JPETAB 67,153,39
ivn-mus LD50:475 µg/kg	JPETAB 79,127,43
ipr-gpg LD50:10900 µg/kg	AIPTAK 144,416,63
scu-gpg LD50:4800 µg/kg	AIPTAK 144,416,63
ivn-gpg LD50:390 µg/kg	AIPTAK 144,416,63
orl-bwd LD50:5600 µg/kg	TXAPA9 21,315,72

EPA Extremely Hazardous Substances List.

THR: Poison by ingestion, intraperitoneal, intravenous and subcutaneous routes. When heated to decomposition it emits very toxic fumes of SO_x and NO_x. See also STRYCHNINE and SULFATES.

SMP400 HR: 2

STS 557

CAS: 65928-58-7 NIOSH: RC 8899500

mf: $C_{20}H_{25}NO_2$ mw: 311.46

SYN: 17-α-CYANOMETHYL-17-β-HYDROXY-ESTRA-4,9(10)-DIEN-3-ONE

TOXICITY DATA:	CODEN:
scu-rat TDLo:8 mg/kg (1D preg):REP	ATSUDG 4,248,80
orl-mky TDLo:600 µg/kg (3D pre):REP	FESTAS 40,688,83
orl-mus LD50:4000 mg/kg	PHARAT 34,319,79
ipr-mus LDLo:1 g/kg	EXCEDS 81,175,83
scu-mus LDLo:5000 mg/kg	PHARAT 34,319,79
orl-rbt LDLo:1 g/kg	EXCEDS 81,175,83
ipr-rbt LDLo:1500 mg/kg	EXCEDS 81,175,83

Cyanide and its compounds are on the Community Right To Know List. EPA Genetic Toxicology Program.

THR: Moderately toxic by ingestion, subcutaneous and intraperitoneal routes. Experimental reproductive effects. When heated to decomposition it emits toxic fumes of NO_x and CN^-. See also NITRILES.

SMP500 HR: 3

STYPHNIC ACID

CAS: 82-71-3 NIOSH: VH 3540000

DOT: 0219

mf: $C_6H_3N_3O_8$ mw: 245.12

PROP: Hexagonal, yellow crystals; astringent taste. Mp: (dry) 175.5°. Very sol in alc, ether.

SYNS:

2,4-DIHYDROXY-1,3,5-TRINITRO-BENZENE	2,4,6-TRINITRO-1,3-BENZENEDIOL
1,3-DIHYDROXY-2,4,6-TRINITRO-BENZENE	2,4,6-TRINITRORESORCINOL
3-HYDROXY-2,4,6-TRINITROPHE-NOL	TRINITRORESORCINOL (DOT)
2,4,6-TRINITROBENZENE-1,3-DIOL	TRINITRORESORCINOL, DRY (DOT)
	TRINITRORESORCINOL, wetted with less than 20% water (DOT)

Reported in EPA TSCA Inventory.

DOT Classification: Class A Explosive; Label: Explosive A

THR: Very explosive. Upon decomposition it emits toxic fumes of NO_x. See also NITRO COMPOUNDS OF AROMATIC HYDROCARBONS and EXPLOSIVES, HIGH.

SMQ000 HR: 3

STYRENE

CAS: 100-42-5 NIOSH: WL 3675000

DOT: 2055

mf: C_8H_8 mw: 104.16

$$C_6H_5CH{=}CH_2$$

PROP: Colorless, refractive, oily liquid. Mp: −31°, bp: 146°, lel: 1.1%, uel: 6.1%, flash p: 88°F, d: 0.9074 @ 20°/4°, autoign temp: 914°F, vap d: 3.6, fp: −33°, ulc: 40-50. Very sltly sol in water; misc in alc, ether.

SYNS:

CINNAMENE	STYRENE MONOMER (ACGIH)
CINNAMENOL	STYRENE MONOMER, inhibited (DOT)
DIAREX HF 77	STYROL (GERMAN)
ETHENYLBENZENE	STYROLE
NCI-C02200	STYROLENE
PHENETHYLENE	STYRON
PHENYLETHENE	STYROPOR
PHENYLETHYLENE	VINYLBENZEN (CZECH)
STIROLO (ITALIAN)	VINYLBENZENE
STYREEN (DUTCH)	VINYLBENZOL
STYREN (CZECH)	

TOXICITY DATA:	CODEN:
skn-hmn 500 mg nse	INMEAF 17,199,48
skn-rbt 500 mg open MLD	UCDS** 12/13/63
skn-rbt 100% MOD	AMIHAB 14,387,56
eye-rbt 18 mg	AJOPAA 29,1363,46
mma-sat 1 µmol/plate	MUREAV 56,147,77
mmo-smc 1 mmol/L	BSIBAC 59,233,83
mrc-smc 1 mmol/L	BSIBAC 59,233,83
dns-hmn:lym 100 µmol/L	CRNGDP 3,681,82
dni-hmn:hla 28 mmol/L	MUREAV 93,447,82
cyt-hmn:lym 300 ppm/72H	MUREAV 58,277,78
sce-hmn:lym 500 µmol/L	ATSUDG 7,286,84
dnd-mus-ipr 10 mmol/kg	CALEDQ 21,9,83
sce-mus-ihl 46400 µg/kg/4D-I	TXAPA9 55,37,80
sce-mus-ihl 125 ppm/4D-I	APTOD9 19,A34,80
hma-mus/smc 1 g/kg	MUREAV 40,317,76
orl-rat TDLo:8600 mg/kg (1-22D preg/21D post):REP	NTOTDY 7,23,85
ihl-rat TCLo:300 ppm/7H (6-15D preg):TER	TXCYAC 11,335,78
ihl-rat TCLo:1500 µg/m³/24H (1-22D preg):TER	GISAAA 39(11),65,74
ihl-hmn LCLo:10000 ppm/30M	29ZWAE -,77,68
ihl-hmn TCLo:600 ppm:NOSE,EYE	AMIHAB 14,387,56
ihl-hmn TCLo:20 µg/m³:EYE	GISAAA 26(8),11,61
orl-rat LD50:5000 mg/kg	AMIHAB 14,387,56
ihl-rat LC50:24 g/m³/4H	GTPZAB 26(8),53,82
ipr-rat LD50:1220 mg/kg	GTPZAB 26(8),53,82
orl-mus LD50:316 mg/kg	NCILB* NCI-E-C-72-3252,73
ihl-mus LC50:21600 mg/m³/2H	GTPZAB 26(8),53,82
ipr-mus LD50:660 mg/kg	ARZNAD 19,617,69

ivn-mus LD50:90 mg/kg ARZNAD 19,617,69
ihl-gpg LCLo:12 mg/m^3/14H JIHTAB 24,295,42

IARC Cancer Review: Animal Sufficient Evidence IMEMDT 19,231,79; Human Inadequate Evidence IMEMDT 19,231,79. NCI Carcinogenesis Bioassay (gavage); Inadequate Studies: mouse, rat NCITR* NCI-CG-TR-170,79; (gavage). Reported in EPA TSCA Inventory. EPA Genetic Toxicology Program. Community Right To Know List.

OSHA PEL: TWA 100 ppm; CL 200; Pk 600/5M/3H
ACGIH TLV: TWA 50 ppm; STEL: 100 ppm (skin); BEI: mandelic acid in urine at end of shift 1 gram/L, styrene in mixed-exhaled air prior to shift 40 ppb, styrene in mixed-exhaled air during shift 18 ppm, styrene in blood end of shift 0.55 mg/L, styrene in blood prior to shift 0.02 mg/L
DFG MAK: 100 ppm (420 mg/m^3)
NIOSH REL: (Styrene) TWA 50 ppm; CL 100 ppm

DOT Classification: Flammable Liquid; Label: Flammable Liquid; Flammable or Combustible Liquid; Label: Flammable Liquid

THR: Experimental poison by ingestion, inhalation and intravenous routes. Moderately toxic experimentally by intraperitoneal route. Mildly toxic to humans by inhalation. A suspected human carcinogen. An experimental carcinogen and teratogen. Human systemic effects by inhalation: eye and olfactory changes. It can cause irritation and violent itching of the eyes @ 200 ppm, lacrimation, and severe human eye injuries. Its toxic effects are usually transient and result in irritation and possible narcosis. Experimental reproductive effects. Human mutagenic data. A human skin irritant. An experimental skin and eye irritant.

The monomer has been involved in several industrial explosions. It is a storage hazard above 32°C. A very dangerous fire hazard when exposed to flame, heat or oxidants. Explosive in the form of vapor when exposed to heat or flame. Reacts with oxygen above 40°C to form a heat-sensitive explosive peroxide. Violent or explosive polymerization may be initiated by alkali metal-graphite composites; butyllithium; dibenzoyl peroxide; other initiators (e.g., azoisobutyronitrile; di-tert-butyl peroxide). Reacts violently with chlorosulfonic acid; oleum; sulfuric acid; chlorine + iron(III) chloride (above 50°C). May ignite when heated with air + polymerizing polystyrene. Can react vigorously with oxidizing materials. To fight fire, use foam, CO_2, dry chemical. When heated to decomposition it emits acrid smoke and irritating fumes. For further information, see Vol. 6, No. 2 of *DPIM Report*.

SMQ500 *HR: 2*
STYRENE POLYMER
CAS: 9003-53-6 NIOSH: WL 6475000
mf: $(C_8H_8)_n$
DOT: 2211

SYNS:
A 3-80
AFCOLENE
ATACTIC POLYSTYRENE
BACTOLATEX
BAKELITE SMD 3500
BASF III
BEXTRENE XL 750
BICOLASTIC A 75
BUSTREN
CADCO 0115
CARINEX GP
COPAL Z
COSDEN 550
DENKA QP3
DIAREX 43G
DORVON
DOW 860
DYLENE
DYLITE F 40
ESBRITE
ESCOREZ 7404
ESTYRENE G 20
ETHENYLBENZENE HOMOPOLYMER
FOSTER GRANT 834
GEDEX
HI-STYROL
HOSTYREN S
HT-F 76
IT 40
KB (POLYMER)
KRASTEN 1.4
LACQREN 550
LUSTREX
MX 5517-02
NBS 706
OWISPOL GF
PICCOLASTIC
POLIGOSTYRENE
POLYSTROL D
POLYSTYRENE
POLYSTYRENE BEADS (DOT)
POLYSTYRENE LATEX
POLYSTYROL
PRINTEL'S
REXOLITE 1422
RHODOLNE
SHELL 300
STYRAFOIL
STYRAGEL
STYRENE POLYMERS
STYROFOAM
STYROLUX
STYRON
TOPOREX 855-51
TROLITUL
UBATOL U 2001
VESTYRON
VINYLBENZENE POLYMER
VINYL PRODUCTS R 3612

TOXICITY DATA:
imp-rat TDLo:19 mg/kg:ETA
ihl-mus LC50:120 mg/m^3/10M

CODEN:
CNREA8 15,333,55
APFRAD 35,461,77

IARC Cancer Review: Animal Limited Evidence IMEMDT 19,231,79. Reported in EPA TSCA Inventory.

DOT Classification: Other Regulated Material; Label: None

THR: An experimental tumorigen by implant. When heated to decomposition it emits acrid smoke and irritating fumes. See also POLYMERS, INSOLUBLE.

SMR000 *HR: 1*
STYRENE POLYMER with 1,3-BUTADIENE
CAS: 9003-55-8 NIOSH: WL 6478000

SYNS:
AFCOLAC B 101
ANDREZ
BASE 661
1,3-BUTADIENE-STYRENE COPOLYMER
BUTADIENE-STYRENE POLYMER
1,3-BUTADIENE-STYRENE POLYMER
BUTADIENE-STYRENE RESIN
BUTAKON 85-71
DIAREX 600
DIENOL S
DOW 209
DOW LATEX 612
DST 50
DURANIT
EDISTIR RB 268
ETHENYLBENZENE POLYMER with 1,3-BUTADIENE
GOODRITE 1800X73
HISTYRENE S 6F
HYCAR LX 407
K 55E
KOPOLYMER BUTADIEN STYRENOVY (CZECH)
KRO 1
LITEX CA
LYTRON 5202

PROP: Liquid. D: 1.588 @ 20/4°, bp: 129-130°. Sol in water; misc in alc, ether.

SYNS:
NCI-C52459 RCRA WASTE NUMBER U208

TOXICITY DATA:	CODEN:
skn-rbt 500 mg/24H	AMPMAR 35,593,74
eye-rbt 100 mg SEV	AMPMAR 35,593,74
orl-mus TDLo:129 g/kg/2Y-I: CAR	NTPTR* NTP-TR-237,82
orl-mus TD:258 g/kg/2Y-I:CAR	NTPTR* NTP-TR-237,82

IARC Cancer Review: Animal Limited Evidence IMEMDT 41,87,86. NTP Carcinogenesis Bioassay (gavage); Clear Evidence: mouse NTPTR* NTP-TR-237,82; (gavage); No Evidence: rat NTPTR* NTP-TR-237,82. Reported in EPA TSCA Inventory.

THR: An experimental carcinogen. A skin and severe eye irritant. Incompatible with dinitrogen tetraoxide; 2,4-dinitrophenyl disulfide; potassium; potassium hydroxide; nitrogen tetroxide; sodium; sodium potassium alloy. When heated to decomposition it emits very toxic fumes of Cl^-. For further information, see Vol. 4, No. 3 of *DPIM Report*.

TBQ250 *HR: 3*
1,1,2,2-TETRACHLOROETHYLENE

CAS: 127-18-4 NIOSH: KX 3850000
DOT: 1897
mf: C_2Cl_4 mw: 165.82

PROP: Colorless liquid; chloroform-like odor. Mp: −23.35°, bp: 121.20°, d: 1.6311 @ 15°/4°, vap press: 15.8 mm @ 22°, vap d: 5.83.

SYNS:
ANKILOSTIN
ANTISOL 1
CARBON BICHLORIDE
CARBON DICHLORIDE
CZTEROCHLOROETYLEN (POLISH)
DIDAKENE
DOW-PER
ENT 1,860
ETHYLENE TETRACHLORIDE
FEDAL-UN
NCI-C04580
NEMA
PERAWIN
PERCHLOORETHYLEEN, PER (DUTCH)
PERCHLOR
PERCHLORAETHYLEN, PER (GERMAN)
PERCHLORETHYLENE
PERCHLORETHYLENE, PER (FRENCH)
PERCHLOROETHYLENE (ACGIH, DOT)
PERCLENE
PERCLOROETILENE (ITALIAN)
PERCOSOLVE
PERK
PERKLONE
PERSEC
RCRA WASTE NUMBER U210
TETLEN
TETRACAP
TETRACHLOORETHEEN (DUTCH)
TETRACHLORAETHEN (GERMAN)
TETRACHLOROETHENE
TETRACHLOROETHYLENE (DOT)
TETRACLOROETENE (ITALIAN)
TETRALENO
TETRALEX
TETRAVEC
TETROGUER
TETROPIL

TOXICITY DATA:	CODEN:
skn-rbt 810 mg/24H SEV	JETOAS 9,171,76
eye-rbt 162 mg MLD	JETOAS 9,171,76
mmo-sat 50 µL/plate	NIOSH* 5AUG77
mma-sat 200 µL/plate	NIOSH* 5AUG77
dns-hmn:lng 100 mg/L	NTIS** PB82-185075
otr-rat:emb 97 µmol/L	ITCSAF 14,290,78
ihl-rat TCLo:1000 ppm/24H (14D pre/1-22D preg):TER	APTOD9 19,A21,80
ihl-rat TCLo:900 ppm/7H (7-13D preg):REP	TJADAB 19,41A,79
ihl-mus TCLo:300 ppm/7H (6-15D preg):TER	TXAPA9 32,84,75
orl-mus TDLo:195 g/kg/50W-I: CAR	NCITR* NCI-CG-TR-13,77
orl-mus TD :240 g/kg/62W-I: CAR	NCITR* NCI-CG-TR-13,77
ihl-hmn TCLo:96 ppm/7H: PNS,EYE,CNS	NTIS** PB257-185
ihl-man TCLo:280 ppm/2H: EYE,CNS	AMIHBC 5,566,52
ihl-man TCLo:600 ppm/10M: EYE,CNS	AMIHBC 5,566,52
ihl-man LDLo:2857 mg/kg: CNS,PUL	MLDCAS 5,152,72
orl-rat LD50:8850 mg/kg	NPIRI* 1,96,74
ihl-rat LCLo:4000 ppm/4H	JOCMA7 4,262,62
orl-mus LD50:8100 mg/kg	NTIS** PB257-185
ihl-mus LC50:5200 ppm/4H	APTOA6 9,303,53
ipr-mus LD50:4700 mg/kg	NTIS** PB257-185
orl-dog LDLo:4000 mg/kg	AJHYA2 9,430,29
ipr-dog LD50:2100 mg/kg	TXAPA9 10,119,67
ivn-dog LDLo:85 mg/kg	QJPPAL 7,205,34
orl-cat LDLo:4000 mg/kg	AJHYA2 9,430,29
orl-rbt LDLo:5000 mg/kg	AJHYA2 9,430,29
scu-rbt LDLo:2200 mg/kg	QJPPAL 7,205,34

IARC Cancer Review: Animal Limited Evidence IMEMDT 20,491,79. NCI Carcinogenesis Bioassay (gavage); Clear Evidence: mouse NCITR* NCI-CG-TR-13,77; (inhalation); Clear Evidence: mouse, rat NTPTR* NTP-TR-311,86; (gavage); Inadequate Studies: rat NCITR* NCI-CG-TR-13,77. Reported in EPA TSCA Inventory. EPA Genetic Toxicology Program. Community Right To Know List.

OSHA PEL: TWA 100 ppm; CL 200 ppm; Pk 300ppm/5M/3H
ACGIH TLV: TWA 50 ppm (skin); STEL 200 ppm
DFG MAK: 50 ppm (345 mg/m^3); BAT: blood 100 µg/dl
NIOSH REL: (Tetrachloroethylene) Minimize workplace exposure.

DOT Classification: Poison B; Label: St. Andrews Cross; ORM-A; Label: None

THR: Experimental poison by intravenous route. Moderately toxic to humans by inhalation with the following effects: local anesthetic, conjunctiva irritation, general anesthesia, hallucinations, distorted perceptions, coma and pulmonary changes. Moderately experimentally toxic by ingestion, inhalation, intraperitoneal and subcutaneous routes. An experimental carcinogen and teratogen. Experimental reproductive effects. Human mutagenic data. An

eye and severe skin irritant. The liquid can cause injuries to the eyes; however, with proper precautions it can be handled safely. The symptoms of acute intoxication from this material are the result of its effects upon the nervous system. Can cause dermatitis, particularly after repeated or prolonged contact with the skin. Irritates the gastrointestinal tract upon ingestion. It may be handled in the presence or absence of air, water, and light with any of the common construction materials at temperatures up to 140°C. This material is extremely stable and resists hydrolysis. A common air contaminant. Reacts violently under the proper conditions with Ba; Be; Li; N_2O_4; metals; NaOH. When heated to decomposition it emits highly toxic fumes of Cl^-. Used in commercial dry cleaning and as a degreasing solvent. See also CHLORINATED HYDROCARBONS, ALIPHATIC. For further information, see Perchloroethylene, Vol. 1, No. 2 of *DPIM Report*.

TBQ255 ***HR: 2***

TETRACHLOROETHYLENE CARBONATE

CAS: 22432-68-4

mf: $C_3Cl_4O_3$ mw: 225.84

THR: Reacts with tributylamine to form the toxic phosgene gas. When heated to decomposition it emits toxic fumes of Cl^-.

TBQ275 ***HR: 3***

TETRACHLOROETHYLENE OXIDE

CAS: 16650-10-5 NIOSH: KI 8760000

mf: C_2Cl_4O mw: 181.82

SYNS:

EPOXYPERCHLOROVINYL
PCEO
TETRACHLOROEPOXYETHANE

TOXICITY DATA:	CODEN:
otr-ham:emb 4300 µmol/L	JJIND8 69,531,82
skn-mus TDLo:300 mg/kg/66W-I:CAR	CNREA8 43,159,83
scu-mus TDLo:20 mg/kg/70W-I:ETA	CNREA8 43,159,83

THR: An experimental carcinogen and tumorigen. Mutagenic data. When heated to decomposition it emits toxic fumes of Cl^-.

TBQ300 ***HR: 3***

2,3,4,5-TETRACHLOROHEXATRIENE

NIOSH: MP 5425500

mf: $C_6H_4Cl_4$ mw: 217.90

TOXICITY DATA:	CODEN:
orl-rat LD50:370 mg/kg	85GMAT -,108,82
ihl-rat LCLo:670 mg/m^3/2H	85GMAT -,108,82
orl-mus LD50:290 mg/kg	85GMAT -,108,82
ihl-mus LCLo:190 mg/m^3/2H	85GMAT -,108,82

THR: Poison by inhalation and ingestion. When heated to decomposition it emits toxic fumes of Cl^-. See also CHLORINATED HYDROCARBONS, ALIPHATIC.

TBQ500 ***HR: 3***

TETRACHLOROHYDROQUINONE

CAS: 87-87-6 NIOSH: MX 7700000

mf: $C_6H_2Cl_4O_2$ mw: 247.88

SYNS: USAF DO-62

TOXICITY DATA:	CODEN:
dnd-omi 100 µmol/L	MUREAV 145,71,85
dnd-mam:lym 50 mmol/L	MUREAV 145,71,85
orl-mus LD50:500 mg/kg	ARTODN 40,63,78
ipr-mus LD50:25 mg/kg	NTIS** AD277-689

Reported in EPA TSCA Inventory.

THR: Poison by intraperitoneal route. Moderately toxic by ingestion. Mutagenic data. When heated to decomposition it emits toxic fumes of Cl^-.

TBQ750 ***HR: 3***

TETRACHLOROISOPHTHALONITRILE

CAS: 1897-45-6 NIOSH: NT 2600000

mf: $C_8Cl_4N_2$ mw: 265.90

SYNS:

BRAVO
BRAVO 6F
BRAVO-W-75
CHLOROALONIL
CHLOROTHALONIL
CHLORTHALONIL (GERMAN)
DAC 2797
DACONIL
DACONIL 2787 FLOWABLE FUNGICIDE
DACOSOIL
1,3-DICYANOTETRACHLOROBENZENE
EXOTHERM
EXOTHERM TERMIL
FORTURF
NCI-C00102
NOPCOCIDE
SWEEP
TCIN
m-TCPN
TERMIL
2,4,5,6-TETRACHLORO-3-CYANOBENZONITRILE
m-TETRACHLOROPHTHALONITRILE
TPN (pesticide)

TOXICITY DATA:	CODEN:
orl-rat TDLo:142 g/kg/80W-C:CAR	NCITR* NCI-CG-TR-41,78
orl-rat LD50:10 mg/kg	85ARAE 4,75,76
orl-mus LD50:6 g/kg	INHEAO 4,11,66
ipr-mus LD50:2500 mg/kg	INHEAO 4,11,66

IARC Cancer Review: Animal Limited Evidence IMEMDT 30,319,83. NCI Carcinogenesis Bioassay (feed); Clear Evidence: rat NCITR* NCI-CG-TR-41,78. Cyanide and its compounds are on the Community Right To Know List. Reported in EPA TSCA Inventory. EPA Genetic Toxicology Program.

THR: Moderately toxic by intraperitoneal route. Mildly toxic by ingestion. An experimental carcinogen. When heated to decomposition it emits very toxic fumes of Cl^-, NO_x, and CN^-. Used as a fungicide. See also NITRILES.

TBR000 ***HR: 3***

TETRACHLORONAPHTHALENE

CAS: 1335-88-2 NIOSH: QK 3700000

mf: $C_{10}H_4Cl_4$ mw: 265.94

TGK750 **HR: 3**

TOLUENE

CAS: 108-88-3 NIOSH: XS 5250000

mf: C_7H_8 mw: 92.15

DOT: 1294

PROP: Colorless liquid; benzol-like odor. Mp: −95 to −94.5°, bp: 110.4°, flash p: 40°F (CC), ulc: 75-80, lel: 1.27%, uel: 7%, d: 0.866 @ 20°/4°, autoign temp: 996°F, vap press: 36.7 mm @ 30°, vap d: 3.14. Insol in water; sol in acetone; misc in absolute alc, ether, chloroform.

SYNS:

ANTISAL 1a
METHACIDE
METHYLBENZENE
METHYLBENZOL
NCI-C07272
PHENYLMETHANE
RCRA WASTE NUMBER U220
TOLUEEN (DUTCH)
TOLUEN (CZECH)
TOLUOL
TOLUOL (DOT)
TOLUOLO (ITALIAN)
TOLU-SOL

TOXICITY DATA: CODEN:

eye-hmn 300 ppm	JIHTAB 25,282,43
skn-rbt 435 mg MLD	UCDS** 7/23/70
skn-rbt 500 MOD	FCTOD7 20,563,82
eye-rbt 870 µg MLD	UCDS** 7/23/70
eye-rbt 2 mg/24H SEV	28ZPAK -,23,72
eye-rbt 100 mg/30S rns MLD	FCTOD7 20,573,82
oms-grh-ihl 562 mg/L	MUREAV 113,467,83
dns-rat:lvr 30 umol/L	SinJF# 26OCT82
cyt-rat-ihl 5400 µg/m³/16W-I	GTPZAB 25(7),33,81
cyt-rat-scu 12 g/kg/12D-I	GTPZAB 17(3),24,73
mnt-mus-orl 200 mg/kg	MUREAV 147,294,85
mnt-mus-ipr 433 µg/kg/24H	ARTODN 58,106,85
ihl-rat TCLo:1500 mg/m³/24H (1-8D preg):TER	TXCYAC 11,55,78
orl-mus TDLo:9 g/kg (6-15D preg):TER	TJADAB 19,41A,79
ihl-hmn TCLo:200 ppm: BRN,CNS,BLD	JAMAAP 123,1106,43
ihl-man TCLo:100 ppm: CNS	WEHRBJ 9,131,72
orl-rat LD50:5000 mg/kg	AMIHAB 19,403,59
ihl-rat LCLo:4000 ppm/4H	AIHAAP 30,470,69
ipr-rat LDLo:800 mg/kg	TXAPA9 1,156,59
ivn-rat LD50:1960 mg/kg	MELAAD 54,486,63
unr-rat LD50:6900 mg/kg	GISAAA 45(12),64,80
ihl-mus LC50:5320 ppm/8H	JIHTAB 25,366,43
ipr-mus LD50:1120 µg/kg	AGGHAR 18,109,60
unr-mus LD50:2000 mg/kg	GISAAA 45(12),64,80
skn-rbt LD50:12124 mg/kg	AIHAAP 30,470,69
ihl-gpg LCLo:1600 ppm	JIDHAN 10,261,28
scu-frg LDLo:920 mg/kg	AEPPAE 130,250,28

Community Right To Know List. Reported in EPA TSCA Inventory. EPA Genetic Toxicology Program.

OSHA PEL: TWA 200 ppm; CL 300; Pk 500/10M

ACGIH TLV: TWA 100 ppm; STEL 150 ppm; BEI: toluene in venous blood end of shift 1 mg/L

DFG MAK: 100 ppm (375 mg/m³); BAT: blood end of shift 340 µg/dl

NIOSH REL: (Toluene) TWA 100 ppm; CL 200 ppm/10M

DOT Classification: Flammable Liquid; Label: Flammable Liquid

THR: Poison by intraperitoneal route. Moderately toxic by intravenous, subcutaneous and possibly other routes. Mildly toxic by inhalation. An experimental teratogen. Human systemic effects by inhalation: CNS recording changes, hallucinations or distorted perceptions, motor activity changes, antipsychotic, psychophysiological test changes and bone marrow changes. Experimental reproductive effects. Mutagenic data. A human eye irritant. An experimental skin and severe eye irritant.

Toluene is derived from coal tar, and commercial grades usually contain small amounts of benzene as an impurity. Inhalation of 200 ppm of toluene for 8 hours may cause impairment of coordination and reaction time; with higher concentrations (up to 800 ppm) these effects are increased and are observed in a shorter time. In the few cases of acute toluene poisoning reported, the effect has been that of a narcotic, the workman passing through a stage of intoxication into one of coma. Recovery following removal from exposure has been the rule. An occasional report of chronic poisoning describes an anemia and leucopenia, with biopsy showing a bone marrow hypoplasia. These effects, however, are less common in people working with toluene, and they are not as severe. At 200-500 ppm, headache, nausea, eye irritation, loss of appetite, a bad taste, lassitude, impairment of coordination and reaction time are reported, but are not usually accompanied by any laboratory or physical findings of significance. With higher concentrations, the above complaints are increased and in addition, anemia, leukopenia and enlarged liver may be found in rare cases. A common air contaminant.

A very dangerous fire hazard when exposed to heat, flame or oxidizers. Explosive in the form of vapor when exposed to heat or flame. Explosive reaction with 1,3-dichloro-5,5-dimethyl-2,4-imidazolididione; dinitrogen tetraoxide; concentrated nitric acid: H_2SO_4 + HNO_3; N_2O_4; $AgClO_4$; BrF_3; UF_6. Forms an explosive mixture with tetranitromethane. Can react vigorously with oxidizing materials. To fight fire, use foam, CO_2, dry chemical. When heated to decomposition it emits acrid smoke and irritating fumes. For further information, see Vol. 7, No. 5 of *DPIM Report*.

TGL500 **HR: 3**

TOLUENEDIAMINE

CAS: 25376-45-8 NIOSH: XS 9445000

mf: $C_7H_{10}N_2$ mw: 122.19

DOT: 1709

SYNS:

ar-METHYLBENZENEDIAMINE
DIAMINOTOLUENE
METHYLPHENYLENEDIAMINE
TOLYLENEDIAMINE

Community Right To Know List. Reported in EPA TSCA Inventory.

TIM000 **HR: 1**

1,1,2-TRICHLORO-2,2-DIFLUOROETHANE

CAS: 354-21-2 NIOSH: KI 1435000

mf: $CHCl_3F_2$ mw: 157.37

SYNS:

1,1-DIFLUORO-1,2,2-TRICHLOROETHANE; FREON FLUOROCARBON 122

TOXICITY DATA:	CODEN:
orl-rat LDLo: 7500 mg/kg	HXPHAU 20(Pt 1),459,66
ihl-rat LCLo: 4000 ppm/4H	UCMH** 15NOV62

THR: Mildly toxic by ingestion and inhalation. When heated to decomposition it emits very toxic fumes of F^- and Cl^-. See also CHLORINATED HYDROCARBONS, ALIPHATIC and FLUORIDES.

TIM500 **HR: 1**

TRICHLORO ESTERTIN

NIOSH: WH 8240000

SYN: ESTERTRICHLOROSTANNANE

TOXICITY DATA:	CODEN:
unr-rat LD50: 5500 mg/kg	TIUSAD 107,1,76

OSHA PEL: TWA 0.1 mg(Sn)/m^3

ACGIH TLV: TWA 0.1 mg(Sn)/m^3 (skin)

NIOSH REL: (Organotin Compounds) TWA 0.1 mg(Sn)/m^3

THR: When heated to decomposition it emits toxic fumes of Cl^-. See also TIN COMPOUNDS and ESTERS.

TIM750 **HR: 3**

1,1,1-TRICHLOROETHANE *

CAS: 71-55-6 NIOSH: KJ 2975000

DOT: 2831

mf: $C_2H_3Cl_3$ mw: 133.40

PROP: Colorless liquid. Bp: 74.1°, fp: −32.5°, flash p: none, d: 1.3376 @ 20°/4°, vap press: 100 mm @ 20.0°. Insol in water; sol in acetone, benzene, carbon tetrachloride, methanol, ether.

SYNS:

AEROTHENE TT
CHLOROETENE
CHLOROETHENE
CHLOROTHANE NU
CHLOROTHENE
CHLOROTHENE (INHIBITED)
CHLOROTHENE NU
CHLOROTHENE VG
CHLORTEN
INHIBISOL
METHYLCHLOROFORM
METHYL CHLOROFORM (ACGIH, DOT)
METHYLTRICHLOROMETHANE
NCI-C04626
RCRA WASTE NUMBER U226
SOLVENT 111
STROBANE
α-T
1,1,1-TCE
1,1,1-TRICHLOORETHAAN (DUTCH)
1,1,1-TRICHLORAETHAN (GERMAN)
TRICHLORO-1,1,1-ETHANE (FRENCH)
α-TRICHLOROETHANE
1,1,1-TRICLOROETANO (ITALIAN)
TRI-ETHANE

TOXICITY DATA:	CODEN:
eye-man 450 ppm/8H	BJIMAG 28,286,71
skn-rbt 5 g/12D-I MLD	AIHAAP 19,353,58
skn-rbt 500 mg/24H MOD	28ZPAK -,28,72
eye-rbt 100 mg MLD	AIHAAP 19,353,58
eye-rbt 2 mg/24H SEV	28ZPAK -,28,72
dnr-esc 500 mg/L	PMRSDJ 1,195,81
otr-mus:emb 20 mg/L	CALEDQ 28,85,85
orl-rat TDLo: 43 mg/kg (1-22D preg/21D post): TER	TJADAB 29(2),25A,84
ihl-rat TCLo: 2100 ppm/24H (14D pre/1-20D preg): TER	TOXID9 1,28,81
ihl-man LCLo: 27 g/m^3/10M	JOCMA7 8,358,66
ihl-man TCLo: 350 ppm: CNS	WEHSAL 10,82,73
orl-hmn TDLo: 670 mg/kg: GIT	NTIS** PB257-185
ihl-hmn TCLo: 920 ppm/70M: EYE,CNS	AIHAAP 19,353,58
ihl-man TCLo: 200 ppm/4H: CNS	ATSUDG 5,96,82
orl-rat LD50: 10300 mg/kg	NTIS** PB257-185
ihl-rat LC50: 18000 ppm/4H	28ZPAK -,28,72
ipr-rat LD50: 5100 mg/kg	NTIS** PB257-185
orl-mus LD50: 11240 mg/kg	NTIS** PB257-185
ihl-mus LC50: 3911 ppm/2H	SAIGBL 13,226,71
ipr-mus LD50: 4700 mg/kg	TXAPA9 13,287,68
orl-dog LD50: 750 mg/kg	FMCHA2 -,C242,83
ipr-dog LD50: 3100 mg/kg	TXAPA9 10,119,67
ivn-dog LDLo: 95 mg/kg	HBTXAC 5,72,59
ihl-cat LCLo: 600 mg/m^3/4H	85GMAT -,38,82
orl-rbt LD50: 5660 mg/kg	AIHAAP 19,353,58
skn-rbt LDLo: 1 g/kg	85GMAT -,38,82
scu-rbt LDLo: 500 mg/kg	HBTXAC 5,72,59
orl-gpg LD50: 9470 mg/kg	AIHAAP 19,353,58

IARC Cancer Review: Animal Inadequate Evidence IMEMDT 20,515,79. NCI Carcinogenesis Bioassay (gavage); Inadequate Studies: mouse, rat NCITR* NCI-CG-TR-3,77. Community Right To Know List.- Reported in EPA TSCA Inventory. EPA Genetic Toxicology Program.

OSHA PEL: TWA 350 ppm

ACGIH TLV: TWA 350 ppm; STEL 450 ppm

DFG MAK: 200 ppm (2080 mg/m^3); BAT: blood 55 μg/dl

NIOSH REL: (1,1,1-Trichloroethane) CL 350 ppm/15M

DOT Classification: ORM-A; Label: None; Poison B; Label: St Andrews Cross

THR: Poison by intravenous route. Moderately toxic by ingestion, inhalation, skin contact, subcutaneous and intraperitoneal routes. An experimental teratogen. Human systemic effects by ingestion and inhalation: conjunctiva irritation, hallucinations or distorted perceptions, motor activity changes, irritability, aggression, hypermotility, diarrhea, nausea or vomiting and other gastrointestinal changes. Experimental reproductive effects. Mutagenic data. A human skin irritant. An experimental skin and severe eye irritant. Narcotic in high concentrations. Causes a proarrhythmic activity which sensitizes the heart to epinephrine-induced arrhythmias. This sometimes will cause cardiac arrest, particularly when this material is massively inhaled as in drug abuse for euphoria.

Under the proper conditions it can undergo hazardous reactions with aluminum oxide + heavy metals; dinitrogen tetraoxide; inhibitors; metals (e.g., magnesium; aluminum; potassium; potassium-sodium alloy); sodium hydroxide; N_2O_4; oxygen. When heated to decomposition it emits toxic fumes of Cl^-. Used as a cleaning solvent, a chemical intermediate to produce vinylidene chloride, and as a propellant in aerosol cans. See also CHLORINATED HYDROCARBONS, ALIPHATIC. For further information see methyl chloroform, Vol. 2, No. 5 of *DPIM Report*.

TIN000 *HR: 3*

1,1,2-TRICHLOROETHANE

CAS: 79-00-5 NIOSH: KJ 3150000
mf: $C_2H_3Cl_3$ mw: 133.40

PROP: Liquid; pleasant odor. Bp: 114°, fp: −35°, d: 1.4416 @ 20°/4°, vap press: 40 mm @ 35.2°.

SYNS:
ETHANE TRICHLORIDE
NCI-C04579
RCRA WASTE NUMBER U227
β-T
1,1,2-TRICHLORETHANE
β-TRICHLOROETHANE
1,2,2-TRICHLOROETHANE
TROJCHLOROETAN(1,1,2) (POLISH)
VINYL TRICHLORIDE

TOXICITY DATA:	CODEN:
skn-rbt 500 mg open MLD	UCDS** 6/28/72
skn-rbt 810 mg/24H SEV	JETOAS 9,171,76
eye-rbt 162 mg MLD	JETOAS 9,171,76
skn-gpg 1440 mg/15M	APTOA6 41,298,77
otr-mus:emb 25 mg/L	CALEDQ 28,85,85
cyt-gpg-skn 2880 µg/kg	APTOA6 41,298,77
dnd-mam:lym 1 mmol/L	TODED5 11,243,82
orl-mus TDLo:532 mg/kg (14D male):REP	DCTODJ 8,333,85
orl-mus TDLo:76 g/kg/78W-I: CAR	NCITR* NCI-CG-TR-74,78
orl-mus TD :152 g/kg/78W-I: CAR	NCITR* NCI-CG-TR-74,78
orl-rat LD50:580 mg/kg	AIHAAP 30,470,69
ihl-rat LCLo:500 ppm/8H	AIHAAP 30,470,69
orl-mus LD50:378 mg/kg	DCTODJ 8,333,85
ipr-mus LD50:494 mg/kg	TXAPA9 9,139,66
scu-mus LD50:227 mg/kg	JPETAB 123,224,58
orl-dog LDLo:500 mg/kg	AJHYA2 16,325,32
ipr-dog LD50:450 mg/kg	TXAPA9 10,119,67
ivn-dog LDLo:95 mg/kg	QJPPAL 7,205,34
ihl-cat LCLo:13100 mg/m³/4.5H	AHBAAM 116,131,36
skn-rbt LD50:3730 mg/kg	AIHAAP 30,470,69
scu-rbt LDLo:500 mg/kg	QJPPAL 7,205,34

IARC Cancer Review: Animal Limited Evidence IMEMDT 20,533,79. NCI Carcinogenesis Bioassay (gavage); No Evidence: rat NCITR* NCI-CG-TR-74,78; (gavage); Clear Evidence: mouse NCITR* NCI-CG-TR-74,78. Community Right To Know List. Reported in EPA TSCA Inventory.

OSHA PEL: TWA 10 ppm (skin)
ACGIH TLV: TWA 10 ppm (skin)
DFG MAK: 10 ppm (55 mg/m³)

THR: Poison by ingestion, intravenous and subcutaneous routes. Moderately toxic by inhalation, skin contact, and intraperitoneal routes. An experimental carcinogen. Experimental reproductive effects. Mutagenic data. An eye and severe skin irritant. Has narcotic properties and acts as a local irritant to the eyes, nose and lungs. It may also be injurious to the liver and kidneys. Incompatible with potassium. When heated to decomposition it emits toxic fumes of Cl^-. A priority pollutant associated with EPA superfund sites. See also CHLORINATED HYDROCARBONS, ALIPHATIC and other trichloroethane entries. For further information, see Vol. 5, No. 3 of *DPIM Report*.

TIN500 *HR: 3*

TRICHLOROETHANOL

CAS: 115-20-8 NIOSH: KM 3850000
mf: $C_2H_3Cl_3O$ mw: 149.40

PROP: Liquid. Mp: 17.8°, bp: 150° @ 765 mm, d: 1.54 @ 25/4°, vap press: 1 mm @ 20°, vap d: 5.16.

SYNS:
TRICHLORETHANOL
2,2,2-TRICHLOROETHANOL
TRICHLOROETHYL ALCOHOL
2,2,2-TRICHLOROETHYL ALCOHOL

TOXICITY DATA:	CODEN:
mmo-asn 5 µL/plate/2H	CBINA8 30,9,80
sln-asn 10240 µmol/L	MUREAV 155,105,85
sce-hmn:lym 178 g/L	TOERD9 3,63,81
orl-rat LDLo:500 mg/kg	CRAA7 17,258,38
ipr-rat LDLo:300 mg/kg	JPETAB 63,453,38
orl-mus LDLo:500 mg/kg	CRAAA7 17,258,38
ivn-mus LD50:201 mg/kg	28ZPAK -,78,72
ivn-rbt LDLo:50 mg/kg	JPETAB 63,453,38
rec-rbt LDLo:500 mg/kg	CRAA7 17,258,38

EPA Genetic Toxicology Program. Reported in EPA TSCA Inventory.

THR: Poison by intravenous and intraperitoneal routes. Moderately toxic by ingestion and rectal routes. Human mutagenic data. Explosive reaction with concentrated sodium hydroxide solutions. When heated to decomposition it emits toxic fumes of Cl^-. Used as an hypnotic and anesthetic. See also CHLORINATED HYDROCARBONS, ALIPHATIC.

TIN750 *HR: 3*

TRICHLOROETHENYLSILANE

CAS: 75-94-5 NIOSH: VV 6125000
DOT: 1305
mf: $C_2H_3Cl_3Si$ mw: 161.49

PROP: Fuming liquid. Bp: 90.6°, d: 1.265 @ 25/25°, flash p: 16°F.

SYNS:
SILANE, VINYL TRICHLORO (1-150)
TRICHLORO(VINYL)SILANE
TRICHLOROVINYL SILICANE
UNION CARBIDE A-150
VINYLSILICON TRICHLORIDE
VINYL TRICHLOROSILANE (DOT)
VINYL TRICHLOROSILANE, INHIBITED (DOT)

ivn-rat LD50:24 mg/kg	YACHDS 12(Suppl 6),969,84
orl-mus LD50:325 mg/kg	YACHDS 12(Suppl 6),969,84
scu-mus LD50:284 mg/kg	YACHDS 12(Suppl 6),969,84
ivn-mus LD50:28 mg/kg	YACHDS 12(Suppl 6),969,84
orl-dog LD50:405 mg/kg	YACHDS 12(Suppl 6),969,84
ivn-dog LD50:9200 µg/kg	YACHDS 12(Suppl 6),969,84
orl-rbt LD50:425 mg/kg	YACHDS 12(Suppl 6),969,84

THR: Poison by ingestion, subcutaneous and intravenous routes. When heated to decomposition it emits toxic fumes of NO_x and HCl.

XGA725 ***HR: 3***

XILOBAM

CAS: 50528-97-7 NIOSH: YT 8850000

mf: $C_{14}H_{19}N_3O$ mw: 245.36

SYNS:

N-(2,6-DIMETHYLPHENYL)-N'-(1-METHYL-2-PYRROLIDINYLIDENE)UREA	MCN-3113
	1-(1-METHYL-2-PYRROLIDINYLIDENE)-3-(2,6-XYLYL)UREA

TOXICITY DATA:	CODEN:
orl-rat LD50:830 mg/kg	AIPTAK 233,326,78
ipr-rat LD50:128 mg/kg	AIPTAK 233,326,78
orl-mus LD50:320 mg/kg	JMCMAR 21,1044,78
ipr-mus LD50:110 mg/kg	AIPTAK 233,326,78

THR: Poison by ingestion and intraperitoneal routes. When heated to decomposition it emits toxic fumes of NO_x.

XGS000 ***HR: 2***

XYLENE

CAS: 1330-20-7 NIOSH: ZE 2100000

DOT: 1307

mf: C_8H_{10} mw: 106.18

PROP: A clear liquid. Bp: 138.5°, flash p: 100°F (TOC), d: 0.864 @ 20°/4°, vap press: 6.72 mm @ 21°. Composition: as nonaromatics 0.07%, toluene 14%, ethyl benzene 19.27%, p-xylene 7.84%, m-xylene 65.01%, o-xylene 7.63%, C9 and aromatics 0.04% (TXAPA9 33,543,75).

SYNS:

DIMETHYLBENZENE	VIOLET 3
KSYLEN (POLISH)	XILOLI (ITALIAN)
METHYL TOLUENE	XYLENEN (DUTCH)
NCI-C55232	XYLOL (DOT)
RCRA WASTE NUMBER U239	XYLOLE (GERMAN)

TOXICITY DATA:	CODEN:
eye-hmn 200 ppm	JIHTAB 25,282,43
skn-rbt 100% MOD	AMIHAB 14,387,56
skn-rbt 500 mg/24H MOD	28ZPAK -,24,72
eye-rbt 87 mg MLD	AMIHAB 14,387,56
eye-rbt 5 mg/24H SEV	28ZPAK -,24,72
cyt-smc 1 mmol/tube	HEREAY 33,457,47
ihl-rat TCLo:1000 mg/m³/24H (9-14D preg):TER	TXCYAC 11,55,78
orl-mus TDLo:31 mg/kg (6-15D preg):REP	JTEHD6 9,97,82
ihl-mus TCLo:2000 ppm/6H (6-12D preg):TER	TJADAB 28,22A,83
ihl-hmn TCLo:200 ppm:NOSE,EYE,PUL	JIHTAB 25,282,43
ihl-man LCLo:10000 ppm/6H	BMJOAE 3,442,70
orl-rat LD50:4300 mg/kg	AMIHAB 14,387,56
ihl-rat LC50:5000 ppm/4H	NPIRI* 1,123,74
scu-rat LD50:1700 mg/kg	NPIRI* 1,123,74
ipr-mus LD50:1548 mg/kg	AGGHAR 18,109,60
ipr-gpg LDLo:2000 mg/kg	AIHAAP 35,21,74
ipr-mam LDLo:2000 mg/kg	AJHYA2 7,276,27

Reported in EPA TSCA Inventory. EPA Genetic Toxicology Program. Community Right To Know List.

OSHA PEL: TWA 100 ppm

ACGIH TLV: TWA 100 ppm; STEL 150 ppm; BEI: methyl hippuric acids in urine end of shift 1.5 g/g creatinine

DFG MAK: (all isomers) 100 ppm (440 mg/m³); BAT: blood end of shift 150 µg/dl, urine 2 g/l

NIOSH REL: (Xylene) TWA 100 ppm; CL 200 ppm/10M

DOT Classification: Flammable Liquid; Label: Flammable Liquid; Flammable or Combustible Liquid; Label: Flammable Liquid

THR: Moderately toxic by intraperitoneal and subcutaneous routes. Mildly toxic by ingestion and inhalation. An experimental teratogen. Human systemic effects by inhalation: olfactory changes, conjunctiva irritation and pulmonary changes. Experimental reproductive effects. Mutagenic data. A human eye irritant. An experimental skin and severe eye irritant. Some temporary corneal effects are noted, as well as some conjunctival irritation by instillation (adding drops to the eyes one at a time). Irritation can start at 200 ppm. A very dangerous fire hazard when exposed to heat or flame; can react with oxidizing materials. To fight fire, use foam, CO_2, dry chemical. When heated to decomposition it emits acrid smoke and irritating fumes. See also other xylene entries. For further information, see Vol. 6, No. 4 of *DPIM Report*.

XHA000 ***HR: 3***

m-XYLENE

CAS: 108-38-3 NIOSH: ZE 2275000

DOT: 1307

mf: C_8H_{10} mw: 106.18

PROP: Colorless liquid. Mp: −47.9°, bp: 139°, lel: 1.1%, uel: 7.0%, flash p: 77°F, d: 0.864 @ 20/4°, vap press: 10 mm @ 28.3°, vap d: 3.66, autoign temp: 986°F. Insol in water; misc with alc, ether and some organic solvents.

Chemical name, structure/formula, CAS and RTECS Nos., and DOT ID and guide Nos.	Synonyms, trade names, and conversion factors	Exposure limits (TWA unless noted otherwise)	IDLH	Physical description	Chemical and physical properties		Incompatibilities and reactivities	Measurement method (See Table 1)
					MW, BP, SOL, FI.P, IP, Sp.Gr, flammability	VP, FRZ UEL, LEL		
Acetaldehyde CH_3CHO 75 07 0 AB1925000 1089 26	Acetic aldehyde, Ethanal, Ethyl aldehyde 1 ppm = 1 83 mg/m³	NIOSH Ca See Appendix A OSHA 100 ppm (180 mg·m⁻³) ST 150 ppm (270 mg/m³)	Ca [10,000 ppm]	Colorless liquid or gas (above 69°F) with a pungent, fruity odor	MW 44 1 BP 69 F Sol Miscible FI P -36 F IP 10 22 eV Sp Gr 0 79 Class IA Flammable Liquid	VP 740 mm FRZ -190°F UEL 60% LEL 4 0%	Strong oxidizers, acids, bases, alcohols, ammonia & amines, phenols, ketones HCN, H_2S [Note Prolonged contact with air may cause formation of peroxides that may explode and burst containers, easily undergoes polymerization]	XAD 2*, Toluene, GC/FID, III [#2538]
Acetic acid CH_3COOH 64 19 7 AF1225000 1842 29 (soln) 2790 60 (10-80% acid) 2789 29 (80% acid)	Acetic acid (aqueous), Ethanoic acid, Glacial acetic acid (pure compound), Methanecarboxlyic acid [Note Can be found in concentrations of 5 8% in vinegar] 1 ppm = 2 50 mg/m³	NIOSH 10 ppm (25 mg/m³) ST 15 ppm (37 mg/m³) OSHA 10 ppm (25 mg/m³)	1000 ppm	Colorless liquid or crystals with a sour, vinegar-like odor. [Note Pure compound is a solid below 62°F Often used in an aqueous solution]	MW 60 1 BP 244 F Sol Miscible FI P 102°F IP 10 66 eV Sp Gr 1 05 Class II Combustible Liquid	VP 11 mm FRZ 62°F UEL(200°F) 19 9% LEL 4 0%	Strong oxidizers (especially chromic acid, sodium peroxide & nitric acid), strong caustics [Note Corrosive to metals.]	Char, HCOOH, GC/FID, III [#1603]
Acetic anhydride $(CH_3CO)_2O$ 108 24 7 AK1925000 1715 39	Acetic acid anhydride, Acetic oxide, Acetyl oxide, Ethanoic anhydride 1 ppm = 4 24 mg/m³	NIOSH/OSHA C 5 ppm (20 mg/m³)	1000 ppm	Colorless liquid with a strong, pungent, vinegar like odor	MW 102 1 BP 282°F Sol 12% FI P 120 F IP 10 00 eV Sp Gr 1 08 Class II Combustible Liquid	VP 4 mm FRZ 99°F UEL 10 3% LEL 2 7%	Water, alcohols, strong oxidizers (especially chromic acid), amines, strong caustics [Note Corrosive to iron steel & other metals Reacts with water to form acetic acid]	Bub, Reagent, Vis, III [#3506]
Acetone CH_3COCH_3 67-64 1 AL3150000 1090 26	Dimethyl ketone, Ketone propane, 2-Propanone 1 ppm = 2 42 mg/m³	NIOSH 250 ppm (590 mg/m³) OSHA 750 ppm (1800 mg/m³) ST 1000 ppm (2400 mg/m³)	20,000 ppm [Note Enforcement of the OSHA TWA for "doffers" in the cellulose acetate fiber industry was stayed on 9/5/89 until 9/1/90, further, the OSHA STEL does NOT apply to that industry.]	Colorless liquid with a fragrant, mint like odor	MW 58 1 BP 133°F Sol Miscible FI P 0°F IP 9 69 eV Sp Gr 0 79 Class IB Flammable Liquid	VP 180 mm FRZ -140°F UEL 13% LEL 2 5%	Oxidizers, acids	Char, CS_2, GC/FID, III [#1300, Ketones I]

Personal protection and sanitation (See Table 3)		Recommendations for respirator selection — maximum concentration for use (MUC) (See Table 4)	Health hazards				
			Route	Symptoms (See Table 5)	First aid (See Table 6)		Target organs (See Table 5)
Clothing Goggles Wash Change Remove Provide	Repeat Any poss Prompt wet N R Immed wet (flamm) Eyewash	NIOSH ¥ SCBAF PD,PP/SAF PD,PP ASCBA Escape GMFOV/SCBAE	Inh Ing	Eye, nose, throat irrit, conj, cough, CNS depres, eye, skin burns, derm, delayed pulm edema, [carc]	Eye Skin Breath Swallow	Irr immed Water flush prompt Resp support Medical attention immed	Resp sys, skin, kidneys
Clothing Goggles Wash Change Remove Provide	Any poss >50%/Repeat 10 49% Any poss Immed contam >50% Prompt 10 49% N R Immed non imperv contam >50%/Prompt non imperv contam 10 49% Eyewash (>5%)/Quick drench (>50%)	NIOSH/OSHA 250 ppm SA:CF[1]/PAPROV[t] 500 ppm CCRFOV/SCBAF/SAF/GMFOV/PAPRTOV[t] 1000 ppm SAF,PD,PP § SCBAF PD,PP/SAF PD,PP ASCBA Escape GMFOV/SCBAE	Inh	Conj, lac, irrit nose throat, phar edema, chronic bron, burns eyes, skin; skin sens, dental erosion, black skin, hyperkeratosis	Eye Skin Breath Swallow	Irr immed Water flush immed Resp support Medical attention immed	Resp sys, skin, eyes, teeth
Clothing Goggles Wash Change Remove Provide	Reason prob Any poss Immed contam N R Immed non imperv contam Eyewash, quick drench	NIOSH/OSHA 125 ppm SA:CF[1]/PAPROV[t] 250 ppm CCRFOV/SCBAF/SAF/GMFOV/PAPRTOV[t] 1000 ppm SAF,PD,PP § SCBAF PD,PP/SAF PD,PP ASCBA Escape GMFOV/SCBAE	Inh Ing Con	Conj, lac, corneal edema, opac, photo, nasal, phar irrit, cough, dysp, bron, skin burns, vesic, sens derm	Eye Skin Breath Swallow	Irr immed Water flush immed Resp support Medical attention immed	Resp sys, eyes, skin
Clothing Goggles Wash Change Remove	Repeat Reason prob Prompt wet N R Immed wet (flamm)	NIOSH 1000 ppm CCROV*/PAPROV*/SA*/SCBA* 6250 ppm SA:CF* 12,500 ppm GMFOV/SCBAF/SAF 20,000 ppm SAF,PD,PP § SCBAF PD,PP/SAF PD,PP ASCBA Escape GMFOV/SCBAE	Inh Ing Con	Irrit eyes, nose, throat, head, dizz, derm	Eye Skin Breath Swallow	Irr immed Soap wash immed Resp support Medical attention immed	Resp sys, skin

Acetone

Chemical name, structure/formula, CAS and RTECS Nos., and DOT ID and guide Nos.	Synonyms, trade names, and conversion factors	Exposure limits (TWA unless noted otherwise)	IDLH	Physical description	Chemical and physical properties MW, BP, SOL FI.P, IP, Sp.Gr, flammability	 VP, FRZ UEL, LEL	Incompatibilities and reactivities	Measurement method (See Table 1)
Barium (soluble compounds as Ba) 1: $Ba(NO_3)_2$ 2: $BaCl_2$ 1: 10022-31-8/ CQ9625000 2: 10361-37-2/ CQ8750000 1446-42 (Barium nitrate)	1: Barium nitrate, Barium dinitrate 2. Barium chloride, Barium dichloride Synonyms of other soluble compounds vary depending upon the specific compound.	NIOSH/OSHA 0.5 mg/m³	1100 mg/m³	Barium nitrate & Barium chloride are white odorless solids	MW: 261.4/ 208.3 BP: Decomposes /2840°F Sol: 9/38% FI.P: NA/? IP: ?/? Sp.Gr: 3.24/3.86 $Ba(NO_3)_2$: Noncombustible Solid $BaCl_2$: Combustible Solid	VP: Low/Low MLT: 1098/ 1765°F UEL: NA/? LEL: NA/?	Acids, oxidizers [Note: Contact of barium nitrate with combustible material may cause fire.]	Filter, Water, AA; III [#7056]
Benzene C_6H_6 71-43-2 CY1400000 1114; 27	Benzol, Phenyl hydride 1 ppm = 3.25 mg/m³	NIOSH Ca See Appendix A 0.1 ppm ST 1 ppm OSHA [1910.1028] 1 ppm ST 5 ppm	Ca [3000 ppm] ACGIH A2	Colorless to light-yellow liquid with an aromatic odor [Note: A solid below 42°F.]	MW: 78.1 BP: 176°F Sol: 0.07% FI.P: 12°F IP: 9.24 eV Sp.Gr: 0.88 Class IB Flammable Liquid	VP: 75 mm FRZ: 42°F UEL: 7.9% LEL: 1.3%	Strong oxidizers, many fluorides & perchlorates, nitric acid	Char, CS_2, GC/FID III [#1500 Hydrocarbons] [Note: Measurements may also be made with a portable GC using NIOSH #3700 (III).]
Benzidine $NH_2C_6H_4C_6H_4NH_2$ 92-87-5 DC9625[illegible] 1885; 53	4,4'-Bianiline, 4,4'-Biphenyldiamine, 1,1'-Biphenyl-4,4'-diamine, 4,4'-Diaminobiphenyl, p-Diaminodiphenyl	NIOSH Ca See Appendix A OSHA [1910.1010] See Appendix B ACGIH A1 [skin]	Ca	Grayish-yellow, reddish-gray, or white crystalline powder	MW: 184.3 BP: 752°F Sol(54°F): 0.04% FI.P: ? IP: ? Sp.Gr: 1.25 Combustible Solid, but difficult to burn	VP: Low MLT: 239°F UEL: ? LEL: ?	None reported	Filter, Si gel, Reagent, HPLC/UVD, III [#5509]
Benzoyl peroxide $(C_6H_5CO)_2O_2$ [illegible]-0 [illegible]675000 [illegible]5/2086/2087; 49 [illegible]/2089/2090; 49	Benzoperoxide, Dibenzoyl peroxide	NIOSH/OSHA 5 mg/m³	7000 mg/m³	Colorless to white crystals or a granular powder with a faint benzaldehyde like odor	MW: 242.2 BP: ? Sol: <1% FI.P: ? IP: ? Sp.Gr(77°F): 1.33 Combustible Solid (easily ignited and burns very rapidly)	VP: <1 mm MLT: 217°F UEL: ? LEL: ?	Combustible substances (wood, paper, etc.), acids, alkalis, alcohols, amines, ethers [Note: Containers may explode when heated. Extremely explosion-sensitive to shock, heat, and friction.]	Filter, Diethyl ether, HPLC/UVD, III [#5009]

Personal protection and sanitation (See Table 3)		Recommendations for respirator selection — maximum concentration for use (MUC) (See Table 4)	Health hazards					
			Route	Symptoms (See Table 5)	First aid (See Table 6)		Target organs (See Table 5)	
Recommendations vary depending upon the specific compound		NIOSH/OSHA 5 mg/m³ DMXSQ/SA/SCBA 12.5 mg/m³ PAPRDM/SA:CF 25 mg/m³ HiEF/PAPRTHiE/SAT:CF/SCBAF/SAF 250 mg/m³ SAF:PD,PP § SCBAF:PD,PP/SAF:PD,PP:ASCBA Escape: HiEF:SCBAE	Inh Ing Con	Upper resp irrit, gastroenteritis, musc spasm, slow pulse, extrasystoles, hypokalemia, irrit eyes, skin, skin burns	Eye Skin Breath Swallow	Irr immed Water flush immed Resp support Medical attention immed	Heart, CNS, skin, resp sys, eyes	
Clothing Goggles Wash Change Remove	Repeat Reason prob Prompt wash soap N.R. Immed wet (flamm)	NIOSH ¥ SCBAF:PD,PP/SAF:PD,PP:ASCBA Escape: GMFOV:SCBAE	Inh Abs Ing Con	Irrit eyes, nose, resp sys, gidd, head, nau staggered gait, ltg, anor, lass, derm, bone marrow depres, [carc]	Eye Skin Breath Swallow	Irr immed Soap wash prompt Resp support Medical attention immed	Blood, CNS, skin, bone marrow, eyes, resp sys	
Clothing Goggles Wash Change Remove Provide	Any poss Any poss Immed contam/daily After work if any poss contam Immed contam Eyewash, quick drench	NIOSH ¥ SCBAF:PD,PP/SAF:PD,PP:ASCBA Escape: HiEF/SCBAE	Inh Abs Ing Con	Hema, secondary anemia from hemolysis, acute cystitis, acute liver disorders, derm, painful and irregular urination, [carc]	Eye Skin Breath Swallow	Irr immed (15 min) Soap wash immed Resp support Medical attention immed	Bladder, kidneys, liver, skin, blood	
Clothing Goggles Wash Change Remove	Repeat Reason prob Prompt contam After work if reason prob contam Prompt non imperv contam	NIOSH/OSHA 50 mg/m³ DMXSO*/SA*/SCBA* 125 mg/m³ PAPRDM*/SA:CF* 250 mg/m³ HiEF/SCBAF/SAF/PAPRTHiE* 7000 mg/m³: SAF:PD,PP § SCBAF:PD,PP/SAF:PD,PP:ASCBA Escape: HiEF/SCBAE	Inh Ing Con	Irrit skin, eyes, muc memb, sens derm	Eye Skin Swallow	Irr immed Soap wash prompt Medical attention immed	Skin, resp sys, eyes	
Benzoyl peroxide								

Chemical name, structure/formula, CAS and RTECS Nos., and DOT ID and guide Nos.	Synonyms, trade names, and conversion factors	Exposure limits (TWA unless noted otherwise)	IDLH	Physical description	Chemical and physical properties MW, BP, SOL Fl.P, IP, Sp.Gr, flammability	 VP, FRZ UEL, LEL	Incompatibilities and reactivities	Measurement method (See Table 1)
Bromine Br_2 [illegible]	Molecular bromine	NIOSH OSHA 0.1 ppm (0.7 mg/m³) ST 0.3 ppm (2 mg/m³)	10 ppm	Dark reddish brown fuming liquid with suffocating, irritating fumes	MW 159.8 BP 139°F Sol 4% Fl.P NA IP 10.55 eV Sp.Gr 3.12 Noncombustible Liquid but accelerates the burning of combustibles	VP 172 mm FRZ 19°F UEL NA LEL NA	Combustible organics (sawdust, wood, cotton, straw, etc.) aluminum, readily oxidizable materials, ammonia, hydrogen, acetylene, phosphorus, potassium, sodium [Note: Corrodes iron, steel, stainless steel & copper.]	Bub. none. IC OSHA [#ID108]
Bromoform $CHBr_3$ 75-25-2 PB5600000 [illegible]58	[illegible]e, [illegible]ane 1 ppm = 10.51 mg/m³	NIOSH OSHA 0.5 ppm (5 mg/m³) [skin]	Unknown	Colorless to yellow liquid with a chloroform like odor [Note: A solid below 47°F.]	MW 252.8 BP 301°F Sol 0.1% Fl.P NA IP 10.48 eV Sp.Gr 2.89 Noncombustible Liquid	VP 5 mm FRZ 47°F UEL NA LEL NA	Lithium, sodium, potassium, calcium, aluminum, zinc, magnesium, strong caustics, acetone [Note: Gradually decomposes, acquiring yellow color; air & light accelerate decomposition.]	Char. CS_2 GC/FID. III [#1003, Halogenated Hydrocarbons]
1,3-Butadiene $CH_2=CHCH=CH_2$ 106-99-0 EI9275000 1010, 17 (inhibited)	Biethylene, Bivinyl, Butadiene Divinyl, Erythrene Vinylethylene [illegible]ppm = 2.25 mg/m³	NIOSH Ca See Appendix A Reduce exposure to lowest feasible concentration OSHA 1000 ppm (2200 mg/m³)	Ca [20,000 ppm] [LEL] ACGIH A2: 10 ppm (22 mg/m³)	Colorless gas with a mild aromatic or gasoline like odor [Note: A liquid below 24°F.]	MW 54.1 BP 24°F Sol Insoluble Fl.P NA (Gas) <0°F (Liquid) IP 9.07 eV Sp.Gr 0.65 (Liquid at 24°F) Flammable Gas Class IA Flammable Liquid	VP >1 atm FRZ 164°F UEL 12.0% LEL 2.0%	Phenol, chlorine dioxide, copper, crotonaldehyde [Note: May contain inhibitors (such as tri-butylcatechol) to prevent self polymerization. May form explosive peroxides upon exposure to air.]	Char(2). CH_2Cl_2 GC/FID. III [#1024]
2-Butanone $CH_3COCH_2CH_3$ 78-93-3 EL6475000 1193/1232, 26	[illegible]thyl methyl ketone, MEK, Methyl acetone, Methyl ethyl ketone 1 ppm = 3.00 mg/m³	NIOSH OSHA 200 ppm (590 mg/m³) ST 300 ppm (885 mg/m³)	3000 ppm	Colorless liquid with a moderately sharp, fragrant, *mint- or acetone* like odor	MW 72.1 BP 175°F Sol 28% Fl.P 16°F IP 9.54 eV Sp.Gr 0.81 Class IB Flammable Liquid	VP 71 mm FRZ 123°F UEL(200°F) 11.4% LEL(200°F) 1.4%	Strong oxidizers, amines, ammonia, inorganic acids, *caustics*, copper, isocyanates, pyridines	Ambersorb. CS_2 GC/FID. III [#2500]

Personal protection and sanitation (See Table 3)		Recommendations for respirator selection — maximum concentration for use (MUC) (See Table 4)	Health hazards				
			Route	Symptoms (See Table 5)	First aid (See Table 6)		Target organs (See Table 5)
Clothing	Repeat	NIOSH	Inh	Eye, nose, throat irrit,	Eye	Irr immed	Resp sys, skin,
Goggles	Any poss	¥ SCBAF PD,PP/SAF PD,PP ASCBA	Ing	conj, cough, CNS depres,	Skin	Water flush prompt	kidneys
Wash	Prompt wet	Escape GMFOV/SCBAE		eye, skin burns, derm,	Breath	Resp support	
Change	N R			delayed pulm edema, [carc]	Swallow	Medical attention immed	
Remove	Immed wet (flamm)						
Provide	Eyewash						
Clothing	Any poss >50%/Repeat 10 49%	NIOSH/OSHA	Inh	Conj, lac, irrit nose,	Eye	Irr immed	Resp sys, skin,
Goggles	Any poss	250 ppm SA CF[1]/PAPROV[1]		throat, phar edema, chronic	Skin	Water flush immed	eyes, teeth
Wash	Immed contam >50%	500 ppm CCRFOV/SCBAF/SAF/		bron, burns eyes, skin;	Breath	Resp support	
	Prompt 10 49%	GMFOV/PAPRTOV[1]		skin sens, dental erosion;	Swallow	Medical attention	
Change	N R	1000 ppm SAF PD,PP		black skin, hyperkeratosis		immed	
Remove	Immed non imperv contam >50%/Prompt non imperv contam 10 49%	§ SCBAF PD,PP/SAF PD,PP ASCBA Escape GMFOV/SCBAE					
Provide	Eyewash (>5%)/Quick drench (>50%)						
Clothing	Reason prob	NIOSH/OSHA	Inh	Conj, lac, corneal edema,	Eye	Irr immed	Resp sys,
Goggles	Any poss	125 ppm SA CF[1]/PAPROV[1]	Ing	opac, photo, nasal, phar	Skin	Water flush immed	eyes, skin
Wash	Immed contam	250 ppm CCRFOV/SCBAF/SAF/	Con	irrit; cough, dysp, bron,	Breath	Resp support	
Change	N R	GMFOV/PAPRTOV[1]		skin burns, vesic, sens	Swallow	Medical attention	
Remove	Immed non imperv contam	1000 ppm SAF,PD,PP		derm		immed	
Provide	Eyewash, quick drench	§ SCBAF PD,PP/SAF PD,PP ASCBA Escape GMFOV/SCBAE					
Clothing	Repeat	NIOSH	Inh	Irrit eyes, nose, throat,	Eye	Irr immed	Resp sys, skin
Goggles	Reason prob	1000 ppm CCROV*/PAPROV*/SA*/	Ing	head, dizz, derm	Skin	Soap wash immed	
Wash	Prompt wet	SCBA*	Con		Breath	Resp support	
Change	N R	6250 ppm SA CF*			Swallow	Medical attention	
Remove	Immed wet (flamm)	12,500 ppm GMFOV/SCBAF/SAF				immed	
		20,000 ppm SAF PD,PP					
		§ SCBAF PD,PP/SAF PD,PP ASCBA					
		Escape GMFOV/SCBAE					

Acetone

Chemical name, structure/formula, CAS and RTECS Nos., and DOT ID and guide Nos.	Synonyms, trade names, and conversion factors	Exposure limits (TWA unless noted otherwise)	IDLH	Physical description	Chemical and physical properties		Incompatibilities and reactivities	Measurement method (See Table 1)
					MW, BP, SOL Fl.P, IP, Sp.Gr, flammability	VP, FRZ UEL, LEL		
Barium (soluble compounds as Ba) 1: $Ba(NO_3)_2$ 2: $BaCl_2$ 1: 10022-31-8/ CQ9625000 2. 10361-37-2/ CQ8750000 1446 42 (Barium nitrate)	1: Barium nitrate, Barium dinitrate 2: Barium chloride, Barium dichloride Synonyms of other soluble compounds vary depending upon the specific compound.	NIOSH/OSHA 0 5 mg/m³	1100 mg/m³	Barium nitrate & Barium chloride are white odorless solids	MW: 261 4/ 208 3 BP: Decomposes /2840 F Sol 9/38% Fl P NA/? IP ?/? Sp Gr: 3 24-3 86 $Ba(NO_3)_2$: Noncombustible Solid $BaCl_2$: Combustible Solid	VP: Low/Low MLT: 1098/ 1765°F UEL NA/? LEL NA ?	Acids, oxidizers [Note Contact of barium nitrate with combustible material may cause fire]	Filter, Water, AA; III [#7056]
Benzene C_6H_6 71-43-2 CY1400000 1114 27	Benzol, Phenyl hydride 1 ppm = 3 25 mg/m³	NIOSH Ca See Appendix A 0 1 ppm ST 1 ppm OSHA [1910 1028] 1 ppm ST 5 ppm	Ca [3000 ppm] ACGIH A2	Colorless to light-yellow liquid with an aromatic odor [Note: A solid below 42°F]	MW 78 1 BP 176 F Sol 0 07% Fl P 12°F IP 9 24 eV Sp Gr. 0 88 Class IB Flammable Liquid	VP 75 mm FRZ 42 F UEL 7 9% LEL 1 3%	Strong oxidizers, many fluorides & perchlorates, nitric acid [Note Measurements may also be made with a portable GC using NIOSH #3700 (III)]	Char, CS_2, GC/FID, III [#1500, Hydrocarbons]
Benzidine $NH_2C_6H_4C_6H_4NH_2$ 92-87-5 DC9625000 1885 53	4,4'-Bianiline; 4,4'-Biphenyldiamine, 1,1'-Biphenyl-4,4'-diamine, 4,4'-Diaminobiphenyl, p Diaminodiphenyl	NIOSH Ca See Appendix A OSHA [1910 1010] See Appendix B ACGIH A1 [skin]	Ca	Grayish-yellow, reddish-gray, or white crystalline powder	MW 184 3 BP 752°F Sol(54°F) 0 04% Fl P ? IP ? Sp Gr 1 25 Combustible Solid, but difficult to burn	VP Low MLT 239 F UEL ? LEL ?	None reported	Filter/ Si gel, Reagent, HPLC/UVD, III [#5509]
Benzoyl peroxide $(C_6H_5CO)_2O_2$ 94-36-0 DM8575000 2085/2086/2087 49 2088/2089/2090 49	Benzoperoxide, Dibenzoyl peroxide	NIOSH/OSHA 5 mg/m³	7000 mg/m³	Colorless to white crystals or a granular powder with a faint benzaldehyde-like odor.	MW: 242 2 BP: ? Sol <1% Fl P ? IP ? Sp Gr(77°F) 1 33 Combustible Solid (easily ignited and burns very rapidly)	VP <1 mm MLT 217 F UEL ? LEL ?	Combustible substances (wood, paper, etc), acids, alkalis, alcohols, amines, ethers [Note Containers may explode when heated Extremely explosion-sensitive to shock, heat, and friction]	Filter, Diethyl ether, HPLC/UVD, III [#5009]

Personal protection and sanitation (See Table 3)		Recommendations for respirator selection — maximum concentration for use (MUC) (See Table 4)	Health hazards					
			Route	Symptoms (See Table 5)	First aid (See Table 6)		Target organs (See Table 5)	
Recommendations vary depending upon the specific compound		NIOSH/OSHA 5 mg/m³: DMXSQ/SA/SCBA 12.5 mg/m³: PAPRDM/SA:CF 25 mg/m³: HiEF/PAPRTHiE/SAT:CF/SCBAF/SAF 250 mg/m³: SAF:PD,PP § SCBAF:PD,PP/SAF:PD,PP:ASCBA Escape: HiEF/SCBAE	Inh Ing Con	Upper resp irrit, gastroenteritis, musc spasm; slow pulse, extrasystoles; hypokalemia; irrit eyes, skin; skin burns	Eye: Skin: Breath Swallow	Irr immed Water flush immed Resp support Medical attention immed	Heart, CNS, skin, resp sys, eyes	
Clothing Goggles Wash Change Remove	Repeat Reason prob Prompt wash soap N R Immed wet (flamm)	NIOSH ¥ SCBAF:PD,PP/SAF:PD,PP:ASCBA Escape: GMFOV:SCBAE	Inh Abs Ing Con	Irrit eyes, nose, resp sys; gidd, head; nau; staggered gait; fig, anor; lass; derm; bone marrow depres; [carc]	Eye: Skin Breath Swallow	Irr immed Soap wash prompt Resp support Medical attention immed	Blood, CNS, skin, bone marrow, eyes, resp sys	
Clothing Goggles Wash Change Remove Provide	Any poss Any poss Immed contam/daily After work if any poss contam Immed contam Eyewash, quick drench	NIOSH ¥ SCBAF:PD,PP/SAF:PD,PP:ASCBA Escape: HiEF/SCBAE	Inh Abs Ing Con	Hema; secondary anemia from hemolysis; acute cystitis; acute liver disorders; derm; painful and irregular urination; [carc]	Eye: Skin Breath: Swallow	Irr immed (15 min) Soap wash immed Resp support Medical attention immed	Bladder, kidneys, liver, skin, blood	
Clothing Goggles Wash: Change Remove	Repeat Reason prob Prompt contam After work if reason prob contam Prompt non-imperv contam	NIOSH/OSHA 50 mg/m³: DMXSQ*/SA*/SCBA* 125 mg/m³: PAPRDM*/SA:CF* 250 mg/m³: HiEF/SCBAF/SAF/[illegible]:PAPRTHiE* 7000 mg/m³: SAF:PD,PP § SCBAF:PD,PP/SAF:PD,PP:ASCBA Escape: HiEF/SCBAE	Inh Ing Con	Irrit skin, eyes, muc memb; sens derm	Eye: Skin: Swallow	Irr immed Soap wash prompt Medical attention immed	Skin, resp sys, eyes	
Benzoyl peroxide								

Chemical name, structure/formula, CAS and RTECS Nos., and DOT ID and guide Nos.	Synonyms, trade names, and conversion factors	Exposure limits (TWA unless noted otherwise)	IDLH	Physical description	Chemical and physical properties MW, BP, SOL Fl.P, IP, Sp.Gr, flammability VP, FRZ UEL, LEL	Incompatibilities and reactivities	Measurement method (See Table 1)
Bromine Br_2 7726 95 6 EF9100000 1744 59	Molecular bromine 1 ppm = 6 64 mg/m³	NIOSH OSHA 0 1 ppm (0 7 mg m³) ST 0 3 ppm (2 mg m³)	10 ppm	Dark reddish brown fuming liquid with suffocating, irritating fumes	MW 159 8 BP 139°F Sol 4% Fl P NA IP 10 55 eV VP 172 mm FRZ 19 F UEL NA LEL NA Sp Gr 3 12 Noncombustible Liquid but accelerates the burning of combustibles	Combustible organics (sawdust, wood, cotton, straw, etc) aluminum readily oxidizable materials ammonia, hydrogen, acetylene phosphorus, potassium sodium [Note Corrodes iron, steel stainless steel & copper]	Bub, none, IC OSHA [#ID108]
Bromoform $CHBr_3$ 75 25 2 PB5600000 2515 58	Methyl tribromide, Tribromomethane 1 ppm = 10 51 mg/m³	NIOSH OSHA 0 5 ppm (5 mg m³) [skin]	Unknown	Colorless to yellow liquid with a chloroform like odor [Note A solid below 47 F]	MW 252 8 BP 301°F Sol 0 1% Fl P NA IP 10 48 eV VP 5 mm FRZ 47 °F UEL NA LEL NA Sp Gr 2 89 Noncombustible Liquid	Lithium, sodium, potassium, calcium, aluminum, zinc, magnesium, strong caustics acetone [Note Gradually decomposes, acquiring yellow color, air & light accelerate decomposition]	Char, CS_2, GC/FID, III [#1003, Halogenated Hydrocarbons]
1,3 Butadiene CH_2=CHCH=CH_2 106 99 0 EI9275000 1010 17 (inhibited)	Biethylene, Bivinyl, Butadiene Divinyl, Erythrene Vinylethylene 1 ppm = 2 25 mg/m³	NIOSH Ca See Appendix A Reduce exposure to lowest feasible concentration OSHA 1000 ppm (2200 mg m³)	Ca [20,000 ppm] [LEL] ACGIH A2, 10 ppm (22 mg/m³)	Colorless gas with a mild aromatic or gasoline like odor [Note A liquid below 24 °F]	MW 54 1 BP 24°F Sol Insoluble Fl P NA (Gas) <0°F (Liquid) IP 9 07 eV VP >1 atm FRZ 164 F UEL 12 0% LEL 2 0% Sp Gr 0 65(Liquid at 24 F) Flammable Gas Class IA Flammable Liquid	Phenol, chlorine dioxide, copper, crotonaldehyde [Note May contain inhibitors (such as tri butylcatechol) to prevent self polymerization May form explosive peroxides upon exposure to air]	Char(2), CH_2Cl_2, GC/FID, III [#1024]
2 Butanone $CH_3COCH_2CH_3$ 78 93 3 EL6475000 1193/1232 26	Ethyl methyl ketone, MEK, Methyl acetone, Methyl ethyl ketone 1 ppm = 3 00 mg/m³	NIOSH OSHA 200 ppm (590 mg m³) ST 300 ppm (885 mg m³)	3000 ppm	Colorless liquid with a moderately sharp, fragrant, mint- or acetone-like odor	MW 72 1 BP 175 F Sol 28% Fl P 16°F IP 9 54 eV VP 71 mm FRZ 123 °F UEL(200°F) 11 4% LEL(200 F) 1 4% Sp Gr 0 81 Class IB Flammable Liquid	Strong oxidizers, amines, ammonia inorganic acids, caustics, copper, isocyanates, pyridines	Ambersorb, CS_2, GC/FID, III [#2500]

Personal protection and sanitation (See Table 3)		Recommendations for respirator selection — maximum concentration for use (MUC) (See Table 4)	Health hazards				
			Route	Symptoms (See Table 5)	First aid (See Table 6)		Target organs (See Table 5)
Clothing:	Any poss	NIOSH/OSHA	Inh	Dizz, head lac, epis,	Eye	Irr immed	Resp sys, eyes,
Goggles:	Any poss	2 5 ppm SA:CF[c]/PAPRS[c]	Ing	cough, feeling of	Skin	Soap wash immed	CNS
Wash:	Immed contam	5 ppm CCRFS[c]/GMFS[c]/SCBAF/SAF PAPRTS[c]	Con	oppression pulm edema, pneu, abdom pain, diarr; measle like eruptions; severe burns eyes, skin	Breath	Resp support	
Change	N R	10 ppm SAF PD,PP			Swallow	Medical attention immed	
Remove	Immed contam	§ SCBAF:PD,PP/SAF PD,PP ASCBA					
Provide	Eyewash, quick drench	Escape GMFS/SCBAE					
Clothing	Repeat	NIOSH/OSHA	Inh	Irrit eyes, resp sys,	Eye	Irr immed	Skin, liver,
Goggles	Reason prob	12 5 ppm SA:CF[c]:PAPROV[c]	Abs	CNS depression, liver	Skin	Soap wash prompt	kidneys, resp
Wash	Prompt contam	25 ppm CCRFOV/GMFOV/SCBAF/SAF/ PAPR1OV[c]	Ing	damage	Breath	Resp support	sys, CNS
Change	N R	1000 ppm SAF PD,PP			Swallow	Medical attention immed	
Remove	Prompt non imperv contam	§ SCBAF PD,PP:SAF PD,PP ASCBA					
		Escape GMFOV SCBAE					
Clothing	Prevent skin freezing	NIOSH	Inh	Irrit eyes, nose, throat,	Eye	Irr immed	Eyes, resp sys,
Goggles	Reason prob	¥ SCBAF PD,PP/SAF PD,PP ASCBA	Con	drow, h head	Skin	Water flush immed	CNS
Wash	Immed wet	Escape GMFS,SCBAE		frostbite (carc)	Breath	Resp support	
Change	N R						
Remove	Immed wet (flamm)						
Clothing	Repeat	NIOSH/OSHA	Inh	Irrit eyes, nose, head,	Eye	Irr immed	CNS, lungs
Goggles	Reason prob	1000 ppm PAPROV[c]/CCRFOV	Ing	dizz, vomit	Skin	Water wash immed	
Wash	N R	3000 ppm: GMFOV/SA:CF[c]/SCBAF/SAF	Con		Breath	Fresh air	
Change	N R	§ SCBAF:PD,PP/SAF:PD,PP:ASCBA			Swallow	Medical attention immed	
Remove	Prompt non impery contam	Escape GMFOV/SCBAE					
Provide	Eyewash						

2 Butanone

Chemical name, structure/formula, CAS and RTECS Nos., and DOT ID and guide Nos.	Synonyms, trade names, and conversion factors	Exposure limits (TWA unless noted otherwise)	IDLH	Physical description	Chemical and physical properties MW, BP, SOL Fl.P, IP, Sp.Gr, flammability	 VP, FRZ UEL, LEL	Incompatibilities and reactivities	Measurement method (See Table 1)
Dibutyl phosphate $(C_4H_9O)_2(OH)PO$ 107-66-4 TB9605000	Dibutyl acid o-phosphate, di-n-Butyl hydrogen phosphate, Dibutyl phosphoric acid	NIOSH/OSHA 1 ppm (5 mg/m³) ST 2 ppm (10 mg/m³)	125 ppm	Pale amber, odorless liquid.	MW: 210.2 BP: 212°F (Decomposes) Sol: Insoluble Fl.P: ? IP: ?	VP: 1 mm (approx) FRZ: ? UEL: ? LEL: ?	Strong oxidizers	Filter, CH_3CN, GC/FPD, III [#5017]
	1 ppm = 8.74 mg/m³				Sp Gr: 1.06 Combustible Liquid			
Dibutylphthalate $C_6H_4(COOC_4H_9)_2$ 84-74-2 TI0875000	DBP; Dibutyl 1,2-benzene-dicarboxylate; Di-n-butyl phthalate	NIOSH/OSHA 5 mg/m³	9300 mg/m³	Colorless to faint yellow, oily liquid with a slight, aromatic odor	MW: 278.3 BP: 644°F Sol(77°F): 0.5% Fl.P: 315 F IP: ?	VP: <0.01 mm FRZ: 31°F UEL: ? LEL(456 F): 0.5%	Nitrates, strong oxidizers, alkalis & acids, liquid chlorine	Filter, CS_2, GC/FID, III [#5020]
	1 ppm = 11.57 mg/m³				Sp Gr: 1.05 Class IIIB Combustible Liquid			
o-Dichlorobenzene $C_6H_4Cl_2$ 95-50-1 CZ4500000 1591 58	o-DCB; 1,2-Dichlorobenzene; ortho-Dichlorobenzene; o-Dichlorobenzol	NIOSH/OSHA C 50 ppm (300 mg/m³)	1000 ppm	Colorless to pale-yellow liquid with a pleasant, aromatic odor [herbicide]	MW: 147.0 BP: 357°F Sol: 0.01% Fl.P: 151°F IP: 9.06 eV	VP: 1 mm FRZ: 1°F UEL: 9.2% LEL: 2.2%	Strong oxidizers, aluminum, acids, acid fumes, chlorides	Char, CS_2, GC/FID, III [#1003, Halogenated Hydrocarbons]
	1 ppm = 6.11 mg/m³				Sp Gr: 1.30 Class IIIA Combustible Liquid			
p-Dichlorobenzene $C_6H_4Cl_2$ 106-46-7 CZ4550000 1592 58	p-DCB; 1,4-Dichlorobenzene; para-Dichlorobenzene; Dichlorocide	NIOSH Ca See Appendix A OSHA 75 ppm (450 mg/m³) ST 110 ppm (675 mg/m³)	Ca [1000 ppm]	Colorless or white crystalline solid with a mothball-like odor [insecticide]	MW: 147.0 BP: 345°F Sol: 0.008% Fl.P: 150°F IP: 8.98 eV	VP(77°F): 0.4 mm M.P: 128°F UEL: ? LEL: ?	Oxidizers	Char, CS_2, GC/FID, III [#1003, Halogenated Hydrocarbons]
					Sp Gr: 1.25 Combustible Solid, but may take some effort to ignite.			

Personal protection and sanitation (See Table 3)	Recommendations for respirator selection — maximum concentration for use (MUC) (See Table 4)	Health hazards				
		Route	Symptoms (See Table 5)	First aid (See Table 6)		Target organs (See Table 5)
Clothing: Reason prob Goggles: Reason prob Wash: Prompt contam Change: N R Remove: Prompt non-imperv contam Provide: Quick drench	NIOSH/OSHA 10 ppm: SA/SCBA 25 ppm: SA:CF 50 ppm: SCBAF/SAF/SAT:CF 125 ppm: SA:PD,PP § SCBAF:PD,PP/SAF:PD,PP:ASCBA Escape: GMFOVHiE/SCBAE	Inh Ing Con	Irrit resp sys, skin; head	Eye: Skin: Breath: Swallow:	Irr immed Soap wash prompt Resp support Medical attention immed	Resp sys, skin
Clothing: N R Goggles: Reason prob Wash: N R Change: N R Remove: N R	NIOSH/OSHA 50 mg/m³: DMF 125 mg/m³: PAPRDM[f]/SA:CF[t] 250 mg/m³: HiEF/SCBAF/SAF 9300 mg/m³: SAF:PD,PP § SCBAF:PD,PP/SAF:PD,PP:ASCBA Escape: HiEF/SCBAE	Inh Ing Con	Irrit upper resp tract, stomach	Eye Skin Breath: Swallow:	Irr immed Wash regularly Resp support Medical attention immed	Resp sys, GI tract
Clothing: Repeat Goggles: Reason prob Wash: Prompt contam Change: N R Remove: Prompt non-imperv contam	NIOSH/OSHA 1000 ppm: PAPROV[t]/CCRFOV § SCBAF:PD,PP/SAF:PD,PP:ASCBA Escape: GMFOV/SCBAE	Inh Abs Ing Con	Irrit nose, eyes; liver, kidney damage, skin blister	Eye Skin Breath Swallow	Irr immed Soap wash prompt Resp support Medical attention immed	Liver, kidneys, skin, eyes
Clothing: Repeat Goggles: Reason prob Wash: Daily (reason prob) Change: N R Remove: N R	NIOSH ¥ SCBAF:PD,PP/SAF:PD,PP:ASCBA Escape: GMFOV/SCBAE	Inh Ing Con	Head, eye irrit, swell periorb, profuse rhinitis, anor, nau, vomit, low wgt, jaun, cirr, [carc] in animals: liver, kidney damage	Eye Skin Breath Swallow	Irr immed Soap wash Resp support Medical attention immed	Liver, resp sys, eyes, kidneys, skin

p-Dichlorobenzene

Chemical name, structure/formula, CAS and RTECS Nos., and DOT ID and guide Nos.	Synonyms, trade names, and conversion factors	Exposure limits (TWA unless noted otherwise)	IDLH	Physical description	Chemical and physical properties MW, BP, SOL Fl.P, IP, Sp.Gr, flammability	 VP, FRZ UEL, LEL	Incompatibilities and reactivities	Measurement method (See Table 1)
3,3'-Dichlorobenzidine (and its salts) $C_6H_3ClNH_2C_6H_3ClNH_2$ 91-94-1 DD0525000	4,4'-Diamino-3,3'-dichlorobiphenyl; Dichlorobenzidine base; o,o'-Dichlorobenzidine; 3,3'-Dichlorobiphenyl-4,4'-diamine; 3,3'-Dichloro-4,4'-biphenyldiamine; 3,3'-Dichloro-4,4'-diaminobiphenyl	NIOSH Ca See Appendix A OSHA [1910.1007] See Appendix B ACGIH A2 [skin]	Ca	Gray to purple crystalline solid.	MW: 253.1 BP: 788°F Sol: Almost insoluble Fl.P: ? IP: ?	VP: ? MLT: 271°F UEL: ? LEL: ?	None reported	Filter/Si gel, Reagent, HPLC/UVD, III [#5509]
Dichlorodifluoromethane CCl_2F_2 75-71-8 PA8200000 1028 12	Difluorodichloromethane; Fluorocarbon 12; Freon® 12; Halon® 122; Propellant 12; Refrigerant 12 1 ppm = 5.03 mg/m³	NIOSH/OSHA 1000 ppm (4950 mg/m³)	50,000 ppm	Colorless gas with an ether-like odor at extremely high concentrations. [Note: Shipped as a liquefied compressed gas.]	MW: 120.9 BP: -22°F Sol(77°F): 0.03% Fl.P: NA IP: 11.75 eV Nonflammable Gas	VP: >1 atm FRZ: -252°F UEL: NA LEL: NA	Chemically active metals such as sodium, potassium, calcium, powdered aluminum, zinc & magnesium	Char(2), CH_2Cl_2, GC/FID, III [#1018]
1,3-Dichloro-5,5-dimethylhydantoin $C_5H_6Cl_2N_2O_2$ 118-52-5 MU0700000	Dactin; DDH; Halane	NIOSH/OSHA 0.2 mg/m³ ST 0.4 mg/m³	Unknown	White powder with a chlorine-like odor.	MW: 197.0 BP: ? Sol: 0.2% Fl.P: 346°F IP: ? Sp.Gr: 1.5 Combustible Solid	VP: ? MLT: 270°F UEL: ? LEL: ?	Water, strong acids, easily oxidized materials such as ammonia salts & sulfides	None available
1,1-Dichloroethane $CHCl_2CH_3$ 75-34-3 KI0175000 2362 27	Asymmetrical dichloroethane; Ethylidene chloride; 1,1-Ethylidene dichloride 1 ppm = 4.12 mg/m³	NIOSH/OSHA 100 ppm (400 mg/m³)	4000 ppm	Colorless, oily liquid with a chloroform-like odor.	MW: 99.0 BP: 135°F Sol: 0.6% Fl.P(oc): 22°F IP: 11.06 eV Sp.Gr: 1.18 Class IB Flammable Liquid	VP(77°F): 230 mm FRZ: -143°F UEL: ? LEL: 5.6%	Strong oxidizers, strong caustics	Char, CS_2, GC/FID, III [#1003, Halogenated Hydrocarbons]

Personal protection and sanitation (See Table 3)		Recommendations for respirator selection — maximum concentration for use (MUC) (See Table 4)	Health hazards				
			Route	Symptoms (See Table 5)	First aid (See Table 6)		Target organs (See Table 5)
Clothing: Goggles: Wash: Change: Remove: Provide:	Any poss Any poss Immed contam/daily After work if any poss contam Immed contam Eyewash, quick drench	NIOSH V: SCBAF:PD,PP/SAF:PD,PP:ASCBA Escape: HiEF/SCBAE	Inh Abs Ing Con	Allergic skin reaction, sens, derm; head, dizz; caustic burns; frequent urination, dysuria; hema; GI upsets; upper resp infection; [carc]	Eye: Skin: Breath: Swallow:	Irr immed (15 min) Soap wash immed Resp support Medical attention immed	Bladder, liver, lung, skin, GI tract
Clothing: Goggles: Wash: Change: Remove:	Prevent wet or freezing Reason prob N.R. N.R. Immed wet (flamm)	NIOSH/OSHA 10,000 ppm: SA/SCBA 25,000 ppm: SA:CF 50,000 ppm: SCBAF/SAF §: SCBAF:PD,PP/SAF:PD,PP:ASCBA Escape: GMFOV/SCBAE	Inh Con	Dizz, tremors, unconsciousness, card arrhy, card arrest	Eye: Skin: Breath:	Irr immed Water flush immed Resp support	CVS, PNS
Clothing: Goggles: Wash: Change: Remove: Provide:	Repeat Any poss Prompt contam After work if reason prob contam Prompt non-imperv contam Eyewash	NIOSH/OSHA 2 mg/m³: SA/SCBA 5 mg/m³: SA:CF/SCBAF/SAF §: SCBAF:PD,PP/SAF:PD,PP:ASCBA Escape: GMFSHIE/SCBAE	Inh Ing Con	Irrit eyes, muc memb, resp sys	Eye: Skin: Breath: Swallow:	Irr immed Soap wash prompt Resp support Medical attention immed	Resp sys, eyes
Clothing: Goggles: Wash: Change: Remove:	Repeat Reason prob Immed wet N.R. Immed wet (flamm)	NIOSH/OSHA 1000 ppm: SA/SCBA 2500 ppm: SA:CF 4000 ppm: SCBAF/SAF §: SCBAF:PD,PP/SAF:PD,PP:ASCBA Escape: GMFOV/SCBAE	Inh Ing Con	CNS depres; skin irrit; liver, kidney damage	Eye: Skin: Breath: Swallow:	Irr immed Soap flush prompt Resp support Medical attention immed	Skin, liver, kidneys

1,1-Dichloroethane

Chemical name, structure/formula, CAS and RTECS Nos., and DOT ID and guide Nos.	Synonyms, trade names, and conversion factors	Exposure limits (TWA unless noted otherwise)	IDLH	Physical description	Chemical and physical properties		Incompatibilities and reactivities	Measurement method (See Table 1)
					MW, BP, SOL Fl.P, IP, Sp.Gr, flammability	VP, FRZ UEL, LEL		
Ethyl acrylate CH_2=$CHCOOC_2H_5$ 140 88 5 AT0700000 1917 27	Ethyl acrylate (inhibited), Ethyl ester of acrylic acid, Ethyl propenoate 1 ppm = 4 16 mg/m³	NIOSH Ca See Appendix A OSHA 5 ppm (20 mg m³) ST 25 ppm (100 mg/m³) [skin]	Ca [2000 ppm]	Colorless liquid with an acrid odor	MW 100 1 BP 211°F Sol 2% Fl P 48 F IP ? Sp Gr 0 92 Class IB Flammable Liquid	VP 29 mm FRZ -96 °F UEL 14% LEL 1 4%	Oxidizers, peroxides, polymerizers, strong alkalis, moisture, chlorosulfonic acid [Note Polymerizes readily unless an inhibitor such as hydroquinone is added]	Char, CS_2, GC/FID III [#1450 Esters I]
Ethylamine $CH_3CH_2NH_2$ 75 04 7 KH2100000 1036 68	Aminoethane, Ethylamine (anhydrous), Monoethylamine 1 ppm = 1 87 mg/m³	NIOSH OSHA 10 ppm (18 mg/m³)	4000 ppm	Colorless gas or water-white liquid (below 62°F) with an ammonia like odor [Note Shipped as a liquefied compressed gas]	MW 45 1 BP 62°F Sol Miscible Fl P 1°F IP 8 86 eV Sp Gr 0 69 (Liquid) Flammable Gas Class IA Flammable Liquid	VP >1 atm FRZ 114°F UEL 14 0% LEL 3 5%	Strong acids, strong oxidizers, copper, tin & zinc in presence of moisture, cellulose nitrate	Si gel H_2SO_4 GC/FID II(3) [#S144]
Ethyl benzene $CH_3CH_2C_6H_5$ 100 41 4 DA0700000 1175 26	Ethylbenzol, Phenylethane 1 ppm = 4 41 mg/m³	NIOSH/OSHA 100 ppm (435 mg/m³) ST 125 ppm (545 mg/m³)	2000 ppm	Colorless liquid with an aromatic odor	MW 106 2 BP 277 F Sol 0 01% Fl P 55°F IP 8 76 eV Sp Gr 0 87 Class IB Flammable Liquid	VP(79°F) 10 mm FRZ 139 F UEL 6 7% LEL 1 0%	Strong oxidizers	Char, CS_2, GC/FID III [#1501, Aromatic Hydro carbons]
Ethyl bromide CH_3CH_2Br 74 96 4 KH6475000 1891 58	Bromoethane 1 ppm = 4 53 mg/m³	NIOSH See Appendix D OSHA 200 ppm (890 mg/m³) ST 250 ppm (1110 mg/m³)	3500 ppm	Colorless to yellow liquid with an ether-like odor [Note A gas above 101 F]	MW 109 0 BP 101°F Sol 0 9% Fl P <4°F IP 10 29 eV Sp Gr 1 46 Class IB Flammable Liquid	VP(70°F) 400 mm FRZ -182°F UEL 8 0% LEL 6 8%	Chemically active metals such as sodium, potassium, calcium, powdered aluminum, zinc & magnesium	Char, 2 Propanol, GC/FID, III [#1011]

Personal protection and sanitation (See Table 3)		Recommendations for respirator selection — maximum concentration for use (MUC) (See Table 4)	Health hazards				
			Route	Symptoms (See Table 5)	First aid (See Table 6)		Target organs (See Table 6)
Clothing: Goggles: Wash: Change: Remove:	Repeat Reason prob Prompt wet N R Immed wet (flamm)	NIOSH V: SCBAF:PD,PP/SAF:PD,PP:ASCBA Escape: GMFOV/SCBAE	Inh Abs Ing Con	Irrit eyes, resp sys, skin, [carc]	Eye: Skin: Breath: Swallow:	Irr immed Water flush immed Resp support Medical attention immed	Resp sys, eyes, skin
Clothing: Goggles: Wash: Change: Remove: Provide:	Reason prob Any poss Immed contam N R Immed wet/immed non imperv contam Eyewash, quick drench	NIOSH/OSHA 250 ppm: SA:CF[f]/PAPRS[f] 500 ppm: CCRFS/GMFS/SCBAF/SAF 4000 ppm: SAF:PD,PP §: SCBAF:PD,PP/SAF:PD,PP:ASCBA Escape: GMFS/SCBAE	Inh Abs Ing Con	Irrit eyes, burns skin, resp irrit, derm	Eye: Skin: Breath: Swallow:	Irr immed Water flush immed Resp support Medical attention immed	Resp sys, eyes, skin
Clothing: Goggles: Wash: Change: Remove:	Repeat Reason prob Prompt contam N R Immed wet (flamm)	NIOSH/OSHA 1000 ppm: PAPROV*/SA*/SCBA*/CCROV* 2000 ppm: GMFOV/SCBAF/SAF §: SCBAF:PD,PP/SAF:PD,PP:ASCBA Escape: GMFOV/SCBAE	Inh Ing Con	Irrit eyes, muc memb; head; derm; narco; coma	Eye: Skin: Breath: Swallow:	Irr immed Water flush prompt Resp support Medical attention immed	Eyes, upper resp sys, skin, CNS
Clothing: Goggles: Wash: Change: Remove:	Repeat Reason prob Prompt wet N R Immed wet (flamm)	OSHA 2000 ppm: SA/SCBA 3500 ppm: SA:CF/SCBAF/SAF §: SCBAF:PD,PP/SAF:PD,PP:ASCBA Escape: GMFOV/SCBAE	Inh Ing Con	Irrit eyes, resp sys, skin, CNS depres; pulm edema, liver, kidney disease; card arrhy; card arrest	Eye: Skin: Breath: Swallow:	Irr immed Soap flush prompt Resp support Medical attention immed	Skin, liver, kidneys, resp sys, CVS, CNS

Ethyl bromide

Chemical name, structure/formula, CAS and RTECS Nos., and DOT ID and guide Nos.	Synonyms, trade names, and conversion factors	Exposure limits (TWA unless noted otherwise)	IDLH	Physical description	Chemical and physical properties: MW, BP, SOL, FI.P, IP, Sp.Gr, flammability	Chemical and physical properties: VP, FRZ, UEL, LEL	Incompatibilities and reactivities	Measurement method (See Table 1)
Ethyl butyl ketone $CH_3CH_2CO[CH_2]_3CH_3$ 106 35 4 MJ5250000	Butyl ethyl ketone, 3-Heptanone	NIOSH/OSHA 50 ppm (230 mg/m³)	3000 ppm	Colorless liquid with a powerful, fruity odor	MW 114 2 BP 298°F Sol 1% FI P(oc) 115 F IP 9 02 eV	VP 4 mm FRZ 38°F UEL ? LEL ?	Oxidizers, acetaldehyde, perchloric acid	Char, Methanol/ CS_2, GC/FID, III [#1301, Ketones II]
	1 ppm = 4 75 mg/m³				Sp Gr 0 82 Class II Combustible Liquid			
Ethyl chloride CH_3CH_2Cl 75-00 3 KH7525000	Chloroethane, Hydrochloric ether, Monochloroethane, Muriatic ether	NIOSH See Appendix D Handle with caution in the workplace OSHA 1000 ppm (2600 mg/m³)	20,000 ppm	Colorless gas or liquid (below 54°F) with a pungent, ether like odor [Note Shipped as a liquefied compressed gas]	MW 64 5 BP 54°F Sol 0 6% FI P NA (Gas) IP 10 97 eV	VP >1 atm FRZ 218°F UEL 15 4% LEL 3 8%	Chemically active metals such as sodium, potassium, calcium, powdered aluminum, zinc & magnesium, oxidizers, water or steam [Note Reacts with water to form hydrochloric acid]	Char(2), CS_2, GC/FID, III [#2519]
1037 27	1 ppm = 2 68 mg/m³				Sp Gr 0 92 (Liquid at 32 F) Flammable Gas Class IA Flammable Liquid			
Ethylene chlorohydrin CH_2ClCH_2OH 107 07 3 KK0875000	2-Chloroethanol, 2 Chloroethyl alcohol, Ethylene chlorhydrin	NIOSH OSHA C 1 ppm (3 mg/m³) [skin]	10 ppm	Colorless liquid with a faint, ether like odor	MW 80 5 BP 262 F Sol Miscible FI P 140 F IP 10 90 eV	VP 5 mm FRZ 90°F UEL 15 9% LEL 4 9%	Strong oxidizers, strong caustics, water or steam	Char(pet), 2 Propanol/ CS_2, GC/FID, III [#2513]
1135 55	1 ppm = 3 35 mg/m³				Sp Gr 1 20 Class IIIA Combustible Liquid			
Ethylenediamine $NH_2CH_2CH_2NH_2$ 107-15 3 KH8575000	1,2-Diaminoethane, 1,2-Ethanediamine, Ethylenediamine (anhydrous)	NIOSH/OSHA 10 ppm (25 mg/m³)	2000 ppm	Colorless, viscous liquid with an ammonia like odor [Note A solid below 47°F] [fungicide]	MW 60 1 BP 241°F Sol Miscible FI P 93°F IP 8 60 eV	VP 11 mm FRZ 47°F UEL 14 4% LEL 4 2%	Strong acids & oxidizers, carbon tetrachloride & other chlorinated organic compounds, carbon disulfide [Note Corrosive to metals]	XAD 2*, DMF, HPLC/UVD, III [#2540]
1604 29	1 ppm = 2 50 mg/m³				Sp Gr 0 91 Class IC Flammable Liquid			

Personal protection and sanitation (See Table 3)		Recommendations for respirator selection — maximum concentration for use (MUC) (See Table 4)	Health hazards				
			Route	Symptoms (See Table 5)	First aid (See Table 6)		Target organs (See Table 8)
Clothing Goggles Wash Change Remove	Repeat Reason prob Prompt contam N R Prompt non imperv contam	NIOSH/OSHA 500 ppm: CCROV*/SA*/SCBA* 1000 ppm: PAPROV*/CCRFOV 1250 ppm: SA:CF* 2500 ppm: GMFOV/SCBAF/SAF 3000 ppm: SAF:PD,PP §: SCBAF:PD,PP/SAF:PD,PP ASCBA Escape: GMFOV/SCBAE	Inh Ing Con	Irrit eyes, muc memb; head, narco, coma, derm	Eye Skin Breath Swallow	Irr immed Water flush Resp support Medical attention immed	Eyes, skin, resp sys
Clothing Goggles Wash Change Remove	Repeat Reason prob N R N R Immed wet (flamm)	OSHA 10,000 ppm: SA*/SCBA* 20,000 ppm: SA:CF*/SCBAF/SAF §: SCBAF:PD,PP/SAF:PD,PP ASCBA Escape: GMFOV/SCBAE	Inh Abs Ing Con	Inco, inebriate, abdom cramps, card arrhy, card arrest, liver, kidney damage	Eye Skin Breath Swallow	Irr immed Water flush prompt Resp support Medical attention immed	Liver, kidneys, resp sys, CVS
Clothing Goggles Wash Change Remove Provide	Any poss Any poss Immed contam N R Immed non imperv contam Eyewash, quick drench	NIOSH/OSHA 10 ppm: SCBA*/SA* §: SCBAF:PD,PP/SAF:PD,PP ASCBA Escape: GMFOV/SCBAE	Inh Abs Ing Con	Irrit muc memb, nau, vomit; verti, inco; numb, vis dist; head, thirst, delirium, low BP, collapse, shock, coma	Eye Skin Breath Swallow	Irr immed Water flush immed Resp support Medical attention immed	Resp sys, liver, kidneys, CNS, skin, CVS
Clothing Goggles Wash Change Remove Provide	Any poss Any poss Immed contam/daily After work if any poss contam Immed wet/immed non-imperv contam Eyewash (>6%), quick drench	NIOSH/OSHA 250 ppm: SA:CF[c]/PAPRS[c] 500 ppm: CCRFS/GMFS/SCBAF/SAF 2000 ppm: SAF:PD,PP §: SCBAF:PD,PP/SAF:PD,PP ASCBA Escape: GMFS/SCBAE	Inh Abs Ing Con	Nasal irrit, primary irrit; sens derm, irrit resp sys, asthma; liver, kidney damage	Eye Skin Breath Swallow	Irr immed Water flush immed Resp support Medical attention immed	Resp sys, liver, kidneys, skin
Ethylenediamine							

Chemical name, structure/formula, CAS and RTECS Nos., and DOT ID and guide #no.	Synonyms, trade names, and conversion factors	Exposure limits (TWA unless noted otherwise)	IDLH	Physical description	Chemical and physical properties		Incompatibilities and reactivities	Measurement method (See Table 1)
					MW, BP, SOL, FI.P, Sp.Gr., flammability	VP, FRZ UEL, LEL		
Hexachloroethane Cl_3CCCl_3 67-72-1 KI4025000 9037 53	Carbon hexachloride, Perchloroethane	NIOSH Ca See Appendix A 1 ppm (10 mg/m³) [skin] OSHA 1 ppm (10 mg/m³) [skin]	Ca [300 ppm]	Colorless crystals with a camphor-like odor	MW: 236.7 BP: Sublimes Sol(72°F) 0.005% FI.P: NA IP: 11.22 eV Sp.Gr: 2.09 Noncombustible Solid	VP: 0.2 mm MLT: 368°F (Sublimes) UEL: NA LEL: NA	Alkalis, metals such as zinc, cadmium, aluminum, hot iron & mercury	Char. CS_2, GC/FID, III [#1003 Halogenated Hydrocarbons]
Hexachloronaphthalene $C_{10}H_2Cl_6$ 1335-87-1 QJ7350000	Halowax® 1014	NIOSH/OSHA 0.2 mg/m³ [skin]	2 mg/m³	White to light-yellow solid with an aromatic odor	MW: 334.9 BP: 650-730°F Sol: Insoluble FI.P: NA IP: ? Sp.Gr: 1.78 Noncombustible Solid	VP: <1 mm MLT: 279°F UEL: NA LEL: NA	Strong oxidizers	Filter, Hexane, GC/ECD, II(2) [#S100]
n-Hexane $CH_3(CH_2)_4CH_3$ 110-54-3 MN9275000 1208 27 1 ppm = 3.58 mg/m³	Hexane, Hexyl hydride, Normal-hexane	NIOSH/OSHA 50 ppm (180 mg/m³)	5000 ppm	Colorless liquid with a gasoline-like odor.	MW: 86.2 BP: 156°F Sol: 0.002% FI.P: -7°F IP: 10.18 eV Sp.Gr: 0.66 Class IB Flammable Liquid	VP(77°F) 150 mm FRZ: -219°F UEL: 7.5% LEL: 1.1%	Strong oxidizers	Char. CS_2, GC/FID, III [#1500 Hydrocarbons]
2-Hexanone $CH_3CO(CH_2)_3CH_3$ 591-78-6 MP1400000 1 ppm = 4.17 mg/m³	Butyl methyl ketone, MBK, Methyl butyl ketone, Methyl n-butyl ketone	NIOSH 1 ppm (4 mg/m³) OSHA 5 ppm (20 mg/m³)	5000 ppm	Colorless liquid with an acetone-like odor.	MW: 100.2 BP: 262°F Sol: 2% FI.P: 77°F IP: 9.34 eV Sp.Gr: 0.81 Class IC Flammable Liquid	VP(77°F) 4 mm FRZ: -71°F UEL: 8% LEL: ?	Strong oxidizers	Char. CS_2, GC/FID, III [#1300 Ketones II]

Personal protection and sanitation (See Table 3)		Recommendations for respirator selection — maximum concentration for use (MUC) (See Table 4)	Health hazards				
			Route	Symptoms (See Table 5)	First aid (See Table 6)		Target organs (See Table 5)
Clothing Goggles Wash Change Remove	Repeat N R Prompt contam daily After work if reason prob contam Prompt non imperv contam	NIOSH ¥ SCBAF PD,PP/SAF PD,PP ASCBA Escape GMFOV/SCBAE	Inh Abs Ing Con	Irrit eyes, [carc]	Eye Skin Breath Swallow	Irr immed Soap wash immed Resp support Medical attention immed	Eyes
Clothing Goggles Wash Change Remove	Any poss molt Repeat liq sol Reason prob fumes Any poss molt Reason prob liq Prompt contam daily After work if reason prob contam Immed wet molt Prompt non imperv contam liq	NIOSH;OSHA 2 mg/m³ SA* SCBA* § SCBAF PD,PP/SAF PD,PP ASCBA Escape GMFOV SCBAE	Inh Abs Ing Con	Acne form derm, nau, cont, jaun, coma	Eye Skin Breath Swallow	Irr immed Soap wash prompt Resp support Medical attention immed	Liver, skin
Clothing Goggles Wash Change Remove	Repeat Reason prob Prompt contam N R Immed wet (flamm)	NIOSH;OSHA 500 ppm SA*;SCBA* 1250 ppm SA:CF* 2500 ppm SAT CF*/SCBAF/SAF 5000 ppm SAF PD,PP § SCBAF PD,PP SAF PD,PP ASCBA Escape GMFOV SCBAE	Inh Ing Con	Cyan head, nau, head, numb extremities, musc weak, irrit eyes, nose, derm, chemical pneu, gidd	Eye Skin Breath Swallow	Irr immed Soap wash immed Resp support Medical attention immed	Skin, eyes, resp sys
Clothing Goggles Wash Change Remove	Reason prob Reason prob Prompt contam N R Immed wet (flamm)	NIOSH 10 ppm SA:SCBA 25 ppm SA:CF 50 ppm SCBAF/SAF/SAT CF 2000 ppm SAF PD,PP § SCBAF PD,PP/SAF PD,PP ASCBA Escape GMFOV,SCBAE	Inh Abs Ing Con	Irrit eyes, nose, peripheral neur weak, pares, derm, head, drow	Eye Skin Breath Swallow	Irr immed Soap wash immed Resp support Medical attention immed	CNS, skin, resp sys

2 Hexanone

Chemical name, structure/formula, CAS and RTECS Nos., and DOT ID and guide Nos.	Synonyms, trade names, and conversion factors	Exposure limits (TWA unless noted otherwise)	IDLH	Physical description	Chemical and physical properties MW, BP, SOL Fl.P, IP, Sp.Gr, flammability	 VP, FRZ UEL, LEL	Incompatibilities and reactivities	Measurement method (See Table 1)
Methyl chloroform CH_3CCl_3 71-55-6 KJ6300000 2831 74	Chlorothene; 1,1,1-Trichloroethane; 1,1,1-Trichloroethane 1 ppm = 5.55 mg/m³	NIOSH C 350 ppm (1900 mg/m³) [15-min] OSHA 350 ppm (1900 mg/m³) ST 450 ppm (2450 mg/m³)	1000 ppm	Colorless liquid with a mild, chloroform-like odor	MW: 133.4 BP: 165°F Sol: 0.4% Fl.P: None IP: 11.00 eV Sp.Gr: 1.34 Noncombustible Liquid, however the vapor will burn	VP: 100 mm FRZ: 23°F UEL: 12.5% LEL: 7.5%	Strong caustics, strong oxidizers, chemically-active metals such as zinc, aluminum, magnesium powders, sodium & potassium, water [Note: Reacts slowly with water to form hydrochloric acid.]	Char. CS_2, GC/FID, III [#1003, Halogenated Hydrocarbons]
Methylcyclohexane $CH_3C_6H_{11}$ 108-87-2 GV6125000 2296 27	Cyclohexylmethane, Hexahydrotoluene 1 ppm = 4.08 mg/m³	NIOSH/OSHA 400 ppm (1600 mg/m³)	10,000 ppm	Colorless liquid with a faint, benzene-like odor	MW: 98.2 BP: 214°F Sol: Insoluble Fl.P: 25°F IP: 9.85 eV Sp.Gr: 0.77 Class IB Flammable Liquid	VP(72°F) 43 mm FRZ: 196°F UEL: 6.7% LEL: 1.2%	Strong oxidizers	Char. CS_2, GC/FID, III [#1500, Hydrocarbons]
Methylcyclohexanol $CH_3C_6H_{10}OH$ 25639-42-3 GV6300000 2617 26	Hexahydrocresol, Hexahydromethylphenol 75 mg/m³	NIOSH/OSHA 50 ppm (235 mg/m³)	10,000 ppm	Straw-colored liquid with a weak odor like coconut oil	MW: 114.2 BP: 311-356°F Sol: 4% Fl.P: 154°F IP: ? Sp.Gr: 0.92 Class IIIA Combustible Liquid	VP(86°F) 2 mm FRZ: 58°F UEL: ? LEL: ?	Strong oxidizers	Char. CH_2Cl_2, GC/FID, II(4) [#S374]
o-Methylcyclohexanone $CH_3C_6H_9O$ 583-60-8 GW1750000 ppm = 4.66 mg/m³	ne	NIOSH/OSHA 50 ppm (230 mg/m³) ppm	2500 ppm	Colorless liquid with a weak peppermint-like odor	MW: 112.2 BP: 325°F Sol: Insoluble Fl.P: 118°F IP: ? Sp.Gr: 0.93 Class II Combustible Liquid	VP: 1 mm (approx) FRZ: 7°F UEL: ? LEL: ?	Strong oxidizers	Porapak, Acetone, GC/FID, III [#2521]

Personal protection and sanitation (See Table 3)		Recommendations for respirator selection — maximum concentration for use (MUC) (See Table 4)	Health hazards					
			Route	Symptoms (See Table 5)	First aid (See Table 6)		Target organs (See Table 5)	
Clothing:	Repeat	NIOSH/OSHA	Inh	Head; lass; CNS depres;	Eye	Irr immed	Skin, CNS, CVS,	
Goggles:	Reason prob	1000 ppm: SA*/SCBA*	Ing	poor equi; irrit eyes;	Skin:	Soap wash prompt	eyes	
Wash:	Prompt wet	◊: SCBAF:PD,PP/SAF:PD,PP:ASCBA	Con	derm; card arrhy	Breath:	Resp support		
Change:	N.R	Escape: GMFOV/SCBAE			Swallow:	Medical attention immed		
Remove:	Prompt non-imperv wet							
Clothing:	Repeat	NIOSH/OSHA	Inh	Li head, drow; skin,	Eye:	Irr immed	Resp sys, skin	
Goggles:	Reason prob	4000 ppm: SA/SCBA	Ing	nose, throat irrit	Skin:	Soap wash prompt		
Wash:	Prompt wet	10,000 ppm: SA:CF/SCBAF/SAF	Con		Breath:	Resp support		
Change:	N.R	◊: SCBAF:PD,PP/SAF:PD,PP:ASCBA			Swallow	Medical attention immed		
Remove:	Immed wet (flamm)	Escape: GMFOV/SCBAE						
Clothing:	Repeat	NIOSH/OSHA	Inh	Head; irrit eyes, upper	Eye:	Irr immed	Resp sys, skin,	
Goggles:	Reason prob	500 ppm: SA*/SCBA*	Abs	resp sys;	Skin:	Soap wash prompt	eyes;	
Wash:	Prompt contam	1250 ppm: SA:CF*	Ing	in animals: narco; liver,	Breath:	Resp support	in animals: CNS,	
Change:	N.R	2500 ppm: SCBAF:SAF	Con	kidney damage	Swallow	Medical attention immed	liver, kidneys	
Remove:	Prompt non-imperv contam	10,000 ppm: SAF:PD,PP ◊: SCBAF:PD,PP/SAF:PD,PP:ASCBA Escape: GMFOV/SCBAE						
Clothing:	Repeat	NIOSH/OSHA	Inh	In animals: narco; irrit	Eye:	Irr immed	In animals;	
Goggles:	Reason prob	500 ppm: SA*/SCBA*	Abs	eyes, muc memb; derm	Skin:	Soap wash prompt	resp sys, liver,	
Wash:	Prompt contam	1250 ppm: SA:CF*	Ing		Breath:	Resp support	kidneys, skin	
Change:	N.R	2500 ppm: SCBAF:SAF	Con		Swallow:	Medical attention immed		
Remove:	Prompt non-imperv contam	◊: SCBAF:PD,PP/SAF:PD,PP:ASCBA Escape: GMFOV/SCBAE						

o-Methylcyclohexanone

Chemical name, structure/formula, CAS and RTECS Nos., and DOT ID and guide Nos.	Synonyms, trade names, and conversion factors	Exposure limits (TWA unless noted otherwise)	IDLH	Physical description	Chemical and physical properties		Incompatibilities and reactivities	Measurement method (See Table 1)
					MW, BP, SOL Fl.P, IP, Sp.Gr, flammability	VP, FRZ UEL, LEL		
Methylene bisphenyl isocyanate $CH_2(C_6H_4NCO)_2$ 101-68-8 NQ9350000 2489 53	4,4'-Diphenylmethane diisocyanate; MDI; Methylene bis(4-phenyl isocyanate); Methylene di-p-phenylene ester of isocyanic acid	NIOSH 0.05 mg/m³ (0.005 ppm) C 0.2 mg/m³ (0.020 ppm) [10-min] OSHA C 0.2 mg/m³) (0.02 ppm)	100 mg/m³	White to light-yellow, odorless flakes [Note: A liquid above 99°F.]	MW: 250.3 BP: 342°F Sol: 0.2% Fl P(oc): 396°F IP: ? Sp Gr(122 F): 1.19 Combustible Solid	VP(104 F) 0.001 mm MLT: 99°F UEL: ? LEL: ?	Strong alkalis, acids, alcohol	Bub, Acetylate, HPLC/UVD, III [#5521]
Methylene chloride CH_2Cl_2 75-09-2 PA8050000 1593 74	Dichloromethane, Methylene dichloride 1 ppm = 3.53 mg/m³	NIOSH Ca See Appendix A Reduce exposure to lowest feasible concentration. OSHA 500 ppm C 1000 ppm 2000 ppm (5 min max peak in any 2 hrs) ACGIH A2: 50 ppm (175 mg/m³)	Ca [5000 ppm]	Colorless liquid with a chloroform-like odor. [Note: A gas above 104°F.]	MW: 84.9 BP: 104°F Sol: 2% Fl P: ? IP: 11.32 eV Sp Gr: 1.33 Combustible Liquid	VP: 350 mm FRZ: 139°F UEL: 22% LEL: 14%	Strong oxidizers, caustics, chemically active metals such as aluminum, magnesium powders, potassium & sodium; concentrated nitric acid	Char(2), CS_2, GC/FID, III [#1005]
Methyl formate $HCOOCH_3$ 107-31-3 LQ8925000 1243 26	Meth... ...mic acid, Meth... 1 ppm = 2.50 mg/m³	NIOSH/OSHA 100 ppm (250 mg/m³) ST 150 ppm (375 mg/m³)	5000 ppm	Colorless liquid with a pleasant odor [Note: A gas above 89°F.]	MW: 60.1 BP: 89°F Sol: 30% Fl P: -2°F IP: 10.82 eV Sp Gr: 0.98 Class IA Flammable Liquid	VP: 476 mm FRZ: -148°F UEL: 23% LEL: 4.5%	Strong oxidizers [Note: Reacts slowly with water to form methanol & formic acid.]	Carbo B(2), Ethyl acetate, GC/FID, II(5) [#S291]
5-Methyl-3-heptanone $CH_3CH_2CO[CH_2]_4CH_3$ 541-85-5 MJ7350000 2271 26	Amyl ethyl ketone, Ethyl amyl ketone 1 ppm = 5.33 mg/m³	NIOSH/OSHA 25 ppm (130 mg/m³)	3000 ppm	Colorless liquid with a pungent odor.	MW: 128.2 BP: 315°F Sol: Insoluble Fl P: 138°F IP: ? Sp Gr: 0.82 Class II Combustible Liquid	VP: 2 mm FRZ: 70°F UEL: ? LEL: ?	Strong oxidizers	Char, Methanol/ CS_2, GC/FID, III, [#1301, Ketones II]

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Personal protection and sanitation (See Table 3)		Recommendations for respirator selection — maximum concentration for use (MUC) (See Table 4)	Health hazards				
			Route	Symptoms (See Table 5)	First aid (See Table 6)		Target organs (See Table 5)
Clothing:	Reason prob	NIOSH	Inh	Irrit eyes, nose, throat;	Eye:	Irr immed	Resp sys, eyes
Goggles:	Any poss	2 mg/m³: SA*/SCBA*	Ing	cough, pulm secretions,	Skin:	Soap wash immed	
Wash:	Prompt contam	5 mg/m³: SA:CF*	Con	chest pain; dysp, asthma	Breath:	Resp support	
Change:	After work if reason prob contam	10 mg/m³: SCBAF/SAF			Swallow:	Medical attention immed	
Remove:	Prompt non-imperv contam	100 mg/m³: SCBAF:PD,PP					
		&: SCBAF:PD,PP/SAF:PD,PP:ASCBA					
		Escape: GMFOVHiE/SCBAE					
Clothing:	Repeat	NIOSH	Inh	Fig, weak, sleepiness,	Eye:	Irr immed	Skin, CVS, eyes, CNS
Goggles:	Reason prob	¥: SCBAF:PD,PP/SAF:PD,PP:ASCBA	Ing	li-head; limbs numb,	Skin:	Soap wash prompt	
Wash:	Prompt wet	Escape: GMFOV/SCBAE	Con	tingle; nau; irrit eyes,	Breath:	Resp support	
Change:	N R			skin, [carc]	Swallow:	Medical attention immed	
Remove:	Prompt non-imperv wet						
Clothing:	Repeat	NIOSH/OSHA	Inh	Eye, nose irrit; chest	Eye:	Irr immed	Eyes, resp sys, CNS
Goggles:	Reason prob	1000 ppm: SA*/SCBA*	Abs	oppression, dysp; vis	Skin:	Soap wash immed	
Wash:	Prompt wet	2500 ppm: SA:CF*	Ing	dist; CNS depres;	Breath:	Resp support	
Change:	N R	5000 ppm: SCBAF/SAF	Con	in animals: pulm edema	Swallow:	Medical attention immed	
Remove:	Immed wet (flamm)	&: SCBAF:PD,PP/SAF:PD,PP:ASCBA					
		Escape: GMFOV/SCBAE					
Clothing:	Any poss	NIOSH/OSHA	Inh	Irrit eyes, muc memb;	Eye:	Irr immed	Eyes, skin, resp sys, CNS
Goggles:	Reason prob	250 ppm: SA*/SCBA*	Ing	head, narco, coma; derm	Skin:	Water flush	
Wash:	Prompt wet	625 ppm: SA:CF*/PAPROV*	Con		Breath:	Resp support	
Change:	N R	1000 ppm: CCRFOV			Swallow:	Medical attention immed	
Remove:	Prompt non-imperv wet	1250 ppm: GMFOV/SCBAF/SAF					
		3000 ppm: SAF:PD,PP					
		&: SCBAF:PD,PP/SAF:PD,PP:ASCBA					
		Escape: GMFOV/SCBAE					

5-Methyl-3-heptanone

Chemical name, structure/formula, CAS and RTECS Nos., and DOT ID and guide Nos.	Synonyms, trade names, and conversion factors	Exposure limits (TWA unless noted otherwise)	IDLH	Physical description	Chemical and physical properties: MW, BP, SOL, FI.P, IP, Sp.Gr, flammability	Chemical and physical properties: VP, FRZ, UEL, LEL	Incompatibilities and reactivities	Measurement method (See Table 1)
Styrene $C_6H_5CH{=}CH_2$ 100 42 5 WL3675000 2055 27 (inhibited)	Ethenyl benzene, Phenylethylene, Styrene monomer, Styrol, Vinyl benzene 1 ppm = 4.33 mg/m³	NIOSH/OSHA 50 ppm (215 mg/m³) ST 100 ppm (425 mg/m³)	5000 ppm	Colorless to yellow, oily liquid with a sweet, floral odor.	MW: 104.2 BP: 293°F Sol: Slight FI.P: 88°F IP: 8.40 eV Sp.Gr: 0.91 Class IC Flammable Liquid	VP: 5 mm FRZ: 23°F UEL: 7.0% LEL: 1.1%	Oxidizers, catalysts for vinyl polymers, peroxides, strong acids, aluminum chloride [Note: May polymerize if contaminated or subjected to heat. Usually contains an inhibitor such as tert-butylcatechol.]	Char; CS_2; GC/FID; III [#1501, Aromatic Hydrocarbons]
Sulfur dioxide SO_2 7446 09 5 WS4550000 10/9 16	Sulfurous acid anhydride, Sulfurous oxide, Sulfur oxide 1 ppm = 2.66 mg/m³	NIOSH/OSHA 2 ppm (5 mg/m³) ST 5 ppm (10 mg/m³)	100 ppm	Colorless gas with a characteristic, irritating, pungent odor [Note: A liquid below 14°F. Shipped as a liquefied compressed gas.]	MW: 64.1 BP: 14°F Sol: 10% FI.P: NA IP: 12.30 eV Nonflammable Gas	VP: >1 atm FRZ: -104°F UEL: NA LEL: NA	Powdered and alkali metals such as sodium & potassium, water, ammonia, aluminum [Note: Reacts with water to form sulfuric acid.]	Filters(2); $NaHCO_3$/ Na_2CO_3; IC; III [#6004]
Sulfuric acid H_2SO_4 7664 93 9 WS5600000 1830 39 (51.95% acid) 1831 39 (fuming) 1832 39 (spent)	Battery acid, Hydrogen sulfate, Oil of vitriol, Sulfuric acid (aqueous) 1 ppm = 4.08 mg/m³	NIOSH/OSHA 1 mg/m³	80 mg/m³	Colorless to dark brown, oily odorless liquid [Note: Pure compound is a solid below 51°F. Often used in an aqueous solution.]	MW: 98.1 BP: 554°F Sol: Miscible FI.P: NA IP: ? Sp.Gr: 1.84 (96.98% acid) Noncombustible Liquid, but capable of igniting finely divided combustible materials	VP(295°F): 1 mm FRZ: 51°F UEL: NA LEL: NA	Organic materials, chlorates, carbides, fulminates, water, powdered metals [Note: Reacts violently with water with evolution of heat. Corrosive to metals.]	Si gel; $NaHCO_3$/ Na_2CO_3; IC; III [#7903, Inorganic Acids]
Sulfur monochloride S_2Cl_2 10025 67 9 WS4[illegible] 1828 39	Sulfur chloride, Sulfur subchloride, Thiosulfurous dichloride 1 ppm = 5.61 mg/m³	NIOSH/OSHA C 1 ppm (6 mg/m³)	10 ppm	Light amber to yellow red, oily liquid with a pungent, nauseating, irritating odor.	MW: 135.0 BP: 280°F Sol: Decomposes FI.P: 245°F IP: 9.40 eV Sp.Gr: 1.68 Class IIIB Combustible Liquid	VP: 7 mm FRZ: 107°F UEL: ? LEL: ?	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.]	None available

Personal protection and sanitation (See Table 3)		Recommendations for respirator selection — maximum concentration for use (MUC) (See Table 4)	Health hazards				
			Route	Symptoms (See Table 5)	First aid (See Table 6)		Target organs (See Table 5)
Clothing: Goggles: Wash: Change: Remove:	Repeat Reason prob Prompt contam N R Immed wet (flamm)	NIOSH/OSHA 500 ppm: CCROV*/SA*/SCBA* 1000 ppm: CCRFOV/PAPROV* 1250 ppm: SA:CF* 2500 ppm: GMFOV/SCBAF/SAF 5000 ppm: SAF:PD,PP §: SCBAF:PD,PP/SAF:PD,PP ASCBA Escape: GMFOV/SCBAE	Inh Ing Con	Irrit eyes, nose, drow, weak, unsteady gait; narco; defatting derm	Eye: Skin: Breath: Swallow:	Irr immed Water flush Resp support Medical attention immed	Irrit resp sys, eyes; skin
Clothing: Goggles: Wash: Change: Remove: Provide:	Prevent skin freezing Any poss N R N R Immed wet Eyewash	NIOSH/OSHA 20 ppm: CCRS*/SA*/SCBA* 50 ppm: PAPRS*/SA:CF* 100 ppm: CCRFS/GMFS/PAPRTS*/SCBAF/SAF/SAT:CF* §: SCBAF:PD,PP/SAF:PD,PP ASCBA Escape: GMFS/SCBAE	Inh Con	Irrit eyes, nose, throat, rhin, choking, cough; reflex bronchoconstriction; eye, skin burns	Eye: Skin: Breath:	Irr immed Water flush immed Resp support	Resp sys, skin, eyes
Clothing: Goggles: Wash: Change: Remove: Provide:	Any poss >1%:Repeat <1% Any poss Immed contam N R Immed non-imperv contam >1%: Eyewash, quick drench	NIOSH/OSHA 25 mg/m³: PAPRAGHiE[f]/SA:CF[f] 50 mg/m³: CCRFAGHiE/SCBAF/SAF/GMFAGHiE 80 mg/m³: SAF:PD,PP §: SCBAF:PD,PP/SAF:PD,PP:ASCBA Escape: GMFAGHiE/SCBAE	Inh Ing Con	Eye, nose, throat irrit; pulm edema, bron; emphy; conj; stomatis; dental erosion; trachbronc; skin, eye burns; derm	Eye: Skin: Breath: Swallow:	Irr immed Water flush immed Resp support Medical attention immed	Resp sys, eyes, skin, teeth
Clothing: Goggles: Wash: Change: Remove: Provide:	Any poss Any poss Immed contam N R Immed non-imperv contam Eyewash, quick drench	NIOSH/OSHA 10 ppm: PAPRS[f]/CCRFS/GMFS/SCBAF/SAF §: SCBAF:PD,PP/SAF:PD,PP ASCBA Escape: GMFS/SCBAE	Inh Con Ing	Lac; cough; burn eyes, skin; pulm edema	Eye: Skin: Breath: Swallow:	Irr immed Water flush immed Resp support Medical attention immed	Resp sys, eyes, skin

Sulfur monochloride

Chemical name, structure/formula, CAS and RTECS Nos., and DOT ID and guide Nos.	Synonyms, trade names, and conversion factors	Exposure limits (TWA unless noted otherwise)	IDLH	Physical description	Chemical and physical properties: MW, BP, SOL, FI.P, IP, Sp.Gr, flammability	Chemical and physical properties: VP, FRZ, UEL, LEL	Incompatibilities and reactivities	Measurement method (See Table 1)
1,1,2,2-Tetrachloroethane $CHCl_2CHCl_2$ 79-34-5 KI8575000 1702 55	Acetylene tetrachloride, Symmetrical tetrachloroethane 1 ppm = 7.00 mg/m³	NIOSH Ca See Appendix A 1 ppm (7 mg/m³) [skin] OSHA 1 ppm (7 mg/m³) [skin]	Ca [150 ppm]	Colorless to pale-yellow liquid with a pungent, chloroform-like odor	MW: 167.9 BP: 296°F Sol: 0.3% FI.P: NA IP: 11.10 eV Sp.Gr(77°F): 1.59 Noncombustible Liquid	VP(86°F): 9 mm FRZ: 33 F UEL: NA LEL: NA	Chemically active metals, strong caustics, fuming sulfuric acid [Note: Degrades slowly when exposed to air.]	Char(pet), CS_2, GC/FID, III [#1019]
Tetrachloroethylene $Cl_2C=CCl_2$ 127-18-4 KX3850000 1897 74	Perchlorethylene, Perchloroethylene, Perk, Tetrachlorethylene 1 ppm = 6.89 mg/m³	NIOSH Ca See Appendix A Minimize workplace exposure concentrations; limit number of workers exposed OSHA 25 ppm (170 mg/m³)	Ca [500 ppm]	Colorless liquid with a mild, chloroform-like odor	MW: 165.8 BP: 250°F Sol(77°F): 0.02% FI.P: NA IP: 9.32 eV Sp.Gr: 1.62 Noncombustible Liquid	VP: 14 mm FRZ: 2°F UEL: NA LEL: NA	Strong oxidizers, chemically active metals such as lithium, beryllium & barium, caustic soda, sodium hydroxide, potash	Char, CS_2, GC/FID, III [#1003, Halogenated Hydrocarbons]
Tetrachloronaphthalene $C_{10}H_4Cl_4$ 1335-88-2	Halowax®, Nibren wax, Seekay wax	NIOSH/OSHA 2 mg/m³ [skin]	Unknown	Colorless to pale-yellow solid with an aromatic odor.	MW: 265.9 BP: 593-680°F Sol: Insoluble FI.P(oc): 410°F IP: ? Sp.Gr: 1.59-1.65 Combustible Solid	VP: <1 mm FRZ: 360°F UEL: ? LEL: ?	Strong oxidizers	Filter/Bub; none, GC/FID, II(2) [#S130]
Tetraethyl lead (as Pb) $Pb(C_2H_5)_4$ [illegible]	Lead tetraethyl, TEL [illegible] ppm = 13.45 mg/m³	NIOSH/OSHA 0.075 mg/m³ [skin]	40 mg/m³	Colorless liquid (unless dyed red, orange, or blue) with a pleasant, sweet odor [Note: Main usage is in anti-knock additives for gasoline.]	MW: 323.5 BP: 228°F (Decomposes) Sol: Insoluble FI.P: 200°F IP: 11.10 eV Sp.Gr: 1.65 Class IIIB Combustible Liquid	VP: 0.2 mm FRZ: -202°F UEL: ? LEL: 1.8%	Strong oxidizers, sulfuryl chloride, rust, potassium permanganate [Note: Decomposes slowly at room temperature and more rapidly at higher temperatures.]	XAD 2, Pentane; GC/PID; III [#2533]

Personal protection and sanitation (See Table 3)		Recommendations for respirator selection — maximum concentration for use (MUC) (See Table 4)	Health hazards				
			Route	Symptoms (See Table 5)	First aid (See Table 6)		Target organs (See Table 5)
Clothing: Goggles: Wash: Change: Remove: Provide:	Any poss Any poss Immed contam N R Immed non-imperv contam Eyewash, quick drench	NIOSH ¥: SCBAF:PD,PP/SAF:PD,PP:ASCBA Escape: GMFOV/SCBAE	Inh Abs Ing Con	Nau, vomit, abdom pain; tremor fingers; jaun, enlarged tend liver; derm; monocy, kidney damage	Eye: Skin: Breath: Swallow:	Irr immed Soap wash prompt Resp support Medical attention immed	Liver, kidneys, CNS
Clothing: Goggles: Wash: Change: Remove:	Repeat Reason prob Prompt contam N R Prompt non-imperv contam	NIOSH ¥: SCBAF:PD,PP/SAF:PD,PP:ASCBA Escape: GMFOV/SCBAE	Inh Ing Con	Irrit eyes, nose, throat; nau; flush face, neck; verti, dizz, inco; head, som; skin eryt; liver damage; [carc]	Eye: Skin: Breath: Swallow:	Irr immed Soap wash prompt Resp support Medical attention immed	Liver, kidneys, eyes, upper resp sys, CNS
Clothing: Goggles: Wash: Change: Remove:	Any poss molt/Repeat liq sol Any poss molt/Reason prob liq-sol Prompt contam After work if any poss contam Immed non-imperv contam molt/ Prompt non-imperv contam sol	NIOSH/OSHA 20 mg/m³: SCBAF/SAF ¢: SCBAF:PD,PP/SAF:PD,PP:ASCBA Escape: GMFOVHiE/SCBAE	Inh Abs Ing Con	Acne-form derm; head, fig, anor, verti; jaun, liver inj	Eye: Skin: Breath: Swallow:	Irr immed Soap wash immed Resp support Medical attention immed	Liver, skin
Clothing: Goggles: Wash: Change: Remove: Provide:	Any poss >0.1% Reason prob N R After work if any poss contam >0.1% Immed non-imperv contam (>0.1%) Quick drench (>0.1%)	NIOSH/OSHA 0.75 mg/m³: SA/SCBA 1.875 mg/m³: SA:CF 3.75 mg/m³: SCBAF/SAF/SAT:CF 40 mg/m³: SA:PD,PP ¢: SCBAF:PD,PP/SAF:PD,PP:ASCBA Escape: GMFOV/SCBAE	Inh Abs Ing Con	Insom, lass, anxiety; tremor, hyper reflexia, spastic, bradycardia, hypotension, hypothermia, pallor, nau, anor, low-wgt; disorientation, haiu, psychosis, mania, convuls, coma; eye irrit	Eye: Skin: Breath: Swallow:	Irr immed Soap wash immed Resp support Medical attention immed	CNS, CVS, kidneys, eyes

Tetraethyl lead (as Pb)

Chemical name, structure/formula, CAS and RTECS Nos., and DOT ID and guide Nos.	Synonyms, trade names, and conversion factors	Exposure limits (TWA unless noted otherwise)	IDLH	Physical description	Chemical and physical properties MW, BP, SOL Fl.P, IP, Sp.Gr, flammability	 VP, FRZ UEL, LEL	Incompatibilities and reactivities	Measurement method (See Table 1)
Tin (organic compounds as Sn)	Synonyms vary depending upon the specific organic compound.	NIOSH/OSHA 0.1 mg/m³ [skin]	Unknown	Appearance and odor vary depending upon the specific organic compound.	Properties vary depending upon the specific organic compound		Strong oxidizers	Filter/ XAD-2; HPLC, AA; III [#5504]
Titanium dioxide TiO_2 13463-67-7 XR2975000	Rutile, Titanium oxide, Titanium peroxide	NIOSH Ca See Appendix A OSHA 10 mg/m³	Ca [N.E.]	White, odorless powder.	MW: 79.9 BP: 4532 to 5432°F Sol: Insoluble Fl.P: NA IP: NA Sp.Gr: 4.26 Noncombustible Solid	VP: 0 mm (approx) MLT: 3326 to 3362°F UEL: NA LEL: NA	None reported	Filter, Acid; AA, II(3) [#S385]
Toluene $C_6H_5CH_3$ 108-88-3 XS5250000	Methyl benzene, Methyl benzol, Phenyl methane, Toluol	NIOSH/OSHA 100 ppm (375 mg/m³) ST 150 ppm (560 mg/m³)	2000 ppm	Colorless liquid with a sweet, pungent, benzene-like odor	MW: 92.1 BP: 232°F Sol(61°F): 0.05% Fl.P: 40°F IP: 8.82 eV Sp.Gr: 0.87 Class IB Flammable Liquid	VP(65°F): 20 mm FRZ: 139°F UEL: 7.1% LEL: 1.2%	Strong oxidizers	Char; CS_2; GC/FID; III [#1500, Hydrocarbons]
[illegible] $C_6H_3(NCO)_2$	[illegible] diisocyanate 1 ppm = 7.24 mg/m³	NIOSH Ca See Appendix A 0.005 ppm (0.04 mg/m³) ST 0.02 ppm (0.15 mg/m³) OSHA 0.005 ppm (0.04 mg/m³) ST 0.02 ppm (0.15 mg/m³)	Ca [10 ppm]	Colorless to pale-yellow solid or liquid (above 71°F) with a sharp, pungent odor.	MW: 174.2 BP: 484°F Sol: Insoluble Fl.P: 260°F IP: ? Sp.Gr: 1.22 Class IIIB Combustible Liquid	VP(77°F): 0.01 mm MLT: 71°F UEL: 9.5% LEL: 0.9%	Strong oxidizers, water, acids, bases & amines may cause foam and spatter; alcohols [Note: Reacts slowly with water to form carbon dioxide and polyureas.]	Coated glass wool; Methanol, HPLC/UVD III [#2535]

Personal protection and sanitation (See Table 3)	Recommendations for respirator selection — maximum concentration for use (MUC) (See Table 4)	Health hazards				
		Route	Symptoms (See Table 5)	First aid (See Table 6)		Target organs (See Table 5)
Recommendations vary depending upon the specific compound.	NIOSH/OSHA 1 mg/m³: CCROVDM/SA/SCBA 2.5 mg/m³: SA:CF/PAPROVDM 5 mg/m³: CCRFOVHiE/SCBAF/SAF/GMFOVHiE/PAPRTOVHiE/SAT:CF 200 mg/m³: SAF:PD,PP &: SCBAF:PD,PP/SAF:PD,PP:ASCBA Escape: GMFOVHiE/SCBAE	Inh Abs Ing Con	Head, vertl, irrit eyes; psycho-neurologic dist; sore throat, cough, abdom pain, vomit; urine retention; paresis, focal anes; skin burns; pruritus, in animals: hemolysis, hepatic nec	Eye: Skin: Breath: Swallow:	Irr immed Water flush immed Resp support Medical attention immed	CNS, eyes, liver, urinary tract, skin, blood
Clothing: N.R. Goggles: N.R. Wash: N.R. Change: N.R. Remove: N.R.	NIOSH ¥: SCBAF:PD/PP/SAF:PD,PP:ASCBA Escape: HiEF/SCBAE	Inh	Slight lung fib. [carc]	Breath:	Resp support	Lungs
Clothing: Repeat Goggles: Reason prob Wash: Prompt wet Change: N.R. Remove: Immed wet (flamm)	NIOSH/OSHA 1000 ppm: CCROV*/SA*/PAPROV*/SCBA* 2000 ppm: SA:CF*/SCBAF/SAF/GMFOV &: SCBAF:PD,PP/SAF:PD,PP:ASCBA Escape: GMFOV/SCBAE	Inh Abs Ing Con	Ftg, weak; conf, euph, dizz, head; dilated pupils, lac; ner, musc ftg, insom; pares; derm	Eye: Skin: Breath: Swallow:	Irr immed Soap wash prompt Resp support Medical attention immed	CNS, liver, kidneys, skin
Clothing: Repeat Goggles: Any poss Wash: Prompt contam Change: After work if reason prob contam Remove: Prompt non-impery contam Provide: Eyewash, quick drench	NIOSH ¥: SCBAF:PD,PP/SAF:PD,PP:ASCBA Escape: GMFOV/SCBAE	Inh Ing Con	Irrit nose, throat; choke, paroxysmal cough; chest pain, retster soreness; nau, vomit, abdom pain; bron spasm, pulm edema; dysp, asthma, conj, lac, derm, skin sens; [carc]	Eye: Skin: Breath: Swallow:	Irr immed Soap wash immed Resp support Medical attention immed	Resp sys, skin

Toluene-2,4-diisocyanate

Chemical name, structure/formula, CAS and RTECS Nos., and DOT ID and guide Nos.	Synonyms, trade names, and conversion factors	Exposure limits (TWA unless noted otherwise)	IDLH	Physical description	Chemical and physical properties		Incompatibilities and reactivities	Measurement method (See Table 1)
					MW, BP, SOL Fl.P, IP, Sp.Gr, flammability	VP, FRZ UEL, LEL		
o-Toluidine $CH_3C_6H_4NH_2$ 95-53-4 XU2975000 1708 55	o-Aminotoluene, 2-Aminotoluene, 1-Methyl-2-aminobenzene, o-Methylaniline, 2 Methylaniline, ortho-Toluidine 1 ppm = 4.46 mg/m³	NIOSH Ca See Appendix A 2 ppm (9 mg/m³) [skin] OSHA 5 ppm (22 mg/m³) [skin]	Ca [100 ppm] ACGIH A2	Colorless to pale-yellow liquid with an aromatic, aniline-like odor	MW: 107.2 BP: 392°F Sol: 2% Fl.P: 185°F IP: 7.44 eV Sp.Gr: 1.01 Class IIIA Combustible Liquid	VP: 0.3 mm FRZ: 6°F UEL: ? LEL: ?	Strong oxidizers, nitric acid	Si gel, Ethanol; GC/FID, III [#2002, Aromatic Amines]
Tributyl phosphate $(CH_3(CH_2)_3O)_3PO$ 126-73-8 TC7700000 1 ppm = 11.07 mg/m³	Butyl phosphate, TBP, Tributyl ester of phosphoric acid, tri-n-Butyl phosphate	NIOSH/OSHA 0.2 ppm (2.5 mg/m³)	125 ppm	Colorless to pale-yellow, odorless liquid	MW: 266.3 BP: 552°F (Decomposes) Sol: 0.6% Fl.P(oc): 295°F IP: ? Sp.Gr: 0.98 Class IIIB Combustible Liquid	VP(351°F) 127 mm FRZ: 112°F UEL: ? LEL: ?	None reported	Filter, Diethyl ether, GC/FPD, II(3) [#S208]
1,1,2-Trichloroethane $CHCl_2CH_2Cl$ 79-00-5 KJ3[redacted] 2831 74 1 ppm = 5.55 mg/m³	beta-Trichloroethane, Vinyl trichloride	NIOSH Ca See Appendix A 10 ppm (45 mg/m³) [skin] OSHA 10 ppm (45 mg/m³) [skin]	Ca [500 ppm]	Colorless liquid with a sweet, chloroform-like odor	MW: 133.4 BP: 237°F Sol: 0.4% Fl.P: NA IP: 11.00 eV Sp.Gr: 1.44 Noncombustible Liquid	VP: 19 mm FRZ: -34°F UEL: NA LEL: NA	Strong oxidizers & caustics; chemically active metals such as aluminum, magnesium powders, sodium & potassium	Char, CS_2; GC/FID, III [#1003, Halogenated Hydrocarbons]
Trichloroethylene $ClCH{=}CCl_2$ 79-01-6 KX[redacted] 1710 74 1 ppm = 5.46 mg/m³	Ethylene trichloride, Trilene, Trichloroethene	NIOSH Ca See Appendix A 25 ppm OSHA 50 ppm (270 mg/m³) ST 200 ppm (1080 mg/m³)	Ca [1000 ppm]	Colorless liquid (unless dyed blue) with a chloroform-like odor	MW: 131.4 BP: 189°F Sol(77°F): 0.1% Fl.P: 90°F IP: 9.45 eV Sp.Gr: 1.46 Class IC Flammable Liquid, but burns with difficulty	VP: 58 mm FRZ: -99°F UEL(77°F): 10.5% LEL(77°F): 8%	Strong caustics & alkalis, chemically-active metals such as barium, lithium, sodium, magnesium, titanium & beryllium	Char, CS_2; GC/FID, III [#1022]

Personal protection and sanitation (See Table 3)	Recommendations for respirator selection — maximum concentration for use (MUC) (See Table 4)	Health hazards			
		Route	Symptoms (See Table 5)	First aid (See Table 6)	Target organs (See Table 5)
Clothing: Any poss Goggles: Any poss Wash: Immed contam Change: N.R. Remove: Immed non imperv contam Provide: Eyewash, quick drench	NIOSH ¥: SCBAF:PD,PP/SAF:PD,PP:ASCBA Escape: GMFOV/SCBAE	Inh Abs Ing Con	Anoxia, head, cyan; weak, dizz, drow; micro hematuria, eye burns; derm; [carc]	Eye: Skin: Breath: Swallow:	Irr immed Soap wash immed Resp support Medical attention immed	Blood, kidneys, liver, CVS, skin, eyes
Clothing: Repeat Goggles: Reason prob Wash: Prompt wet Change: N.R. Remove: Prompt non imperv wet	NIOSH/OSHA 2 ppm: SA/SCBA 5 ppm: SA:CF 10 ppm: SCBAF/SAF 125 ppm: SAF:PD,PP §: SCBAF:PD,PP/SAF:PD,PP:ASCBA Escape: GMFOVH/E/SCBAE	Inh Con Ing	Eyes, resp, skin irrit; head, nau	Eye: Skin: Breath: Swallow:	Irr immed Soap wash prompt Resp support Medical attention immed	Resp sys, skin, eyes
Clothing: Repeat Goggles: Reason prob Wash: Prompt contam Change: N.R. Remove: Prompt non-imperv contam	NIOSH ¥: SCBAF:PD,PP/SAF:PD,PP:ASCBA Escape: GMFOV/SCBAE	Inh Abs Ing Con	Irrit nose, eyes; CNS depres; liver, kidney damage; [carc]	Eye: Skin: Breath: Swallow:	Irr immed Soap wash prompt Resp support Medical attention immed	CNS, eyes, nose, liver, kidneys
Clothing: Repeat Goggles: Reason prob Wash: Prompt wet Change: N.R. Remove: Prompt non-imperv wet	NIOSH ¥: SCBAF:PD,PP/SAF:PD,PP:ASCBA Escape: GMFOV/SCBAE	Inh Ing Con	Head, verti; vis dist, tremors, som, nau, vomit; irrit eyes; derm; card arrhy, pares; [carc]	Eye: Skin: Breath: Swallow:	Irr immed Soap wash prompt Resp support Medical attention immed	Resp sys, heart, liver, kidneys, CNS, skin

Trichloroethylene

Chemical name, structure/formula, CAS and RTECS Nos., and DOT ID and guide Nos.	Synonyms, trade names, and conversion factors	Exposure limits (TWA unless noted otherwise)	IDLH	Physical description	Chemical and physical properties		Incompatibilities and reactivities	Measurement method (See Table 1)
					MW, BP, SOL Fl.P, IP, Sp.Gr, flammability	VP, FRZ UEL, LEL		
Xylenes (o-, m-, p-isomers) $C_6H_4(CH_3)_2$ 1330-20-7 ZE2100000 1307 27	o: 1,2-Dimethylbenzene, o-Xylol, m: 1,3-Dimethylbenzene, m-Xylol, p: 1,4-Dimethylbenzene, p-Xylol	NIOSH/OSHA 100 ppm (435 mg/m³) ST 150 ppm (655 mg/m³)	1000 ppm	Colorless liquids with an aromatic odor (Note: Pure p-xylene is a solid below 56°F.)	MW: 106.2 BP: 292/269/ 281°F Sol: Insoluble Fl.P: 63/84/ 81°F IP: 8.56/8.56/8.44 eV Sp.Gr: 0.88/0.86/0.86 Class IB Flammable Liquid (o) Class IC Flammable Liquids (m,p)	VP: 7/9/9 mm FRZ: 13/ 54.5/ 5 UEL: 7.0/7.0/ 7.0% LEL: 1.1/1.0/1.1%	Strong oxidizers	Char, CS_2, GC/FID, III [#1501, Aromatic Hydro carbons]
1300-73-8 ZE8575000 1711 55	Dimethylaniline, Xylidine isomers, Xylidine (mixed o-, m-, p-)	(skin)		Yellow to brown liquid with a weak, aromatic, amine-like odor	MW: 121.2 BP: 415/439°F Sol: Slight Fl.P: 200°F IP: ? Class IIIB Combustible Liquid	VP: <1 mm FRZ: ? UEL: ? LEL: 1.0%	Strong oxidizers, hypochlorite bleaches	Si gel, Ethanol, GC/FID, III [#2002]
(Metal) ZG2500000 (Metal)	See the specific compound.	mg/m³	N.D.	Metal. Dark gray to black solid.	MW: 88.9 BP: 5301°F Sol: ? Fl.P: NA IP: NA Sp.Gr: 4.47 Noncombustible Solid in bulk form	VP: 0 mm (approx) MLT: 2732°F UEL: NA LEL: NA	Oxidizers	Filter, Acid, ICP; III [#7300 Elements]
	None	NIOSH/OSHA 1 mg/m³ ST 2 mg/m³	4800 mg/m³	White particulate dispersed in air.	MW: 136.3 BP: 1350°F Sol(77°F): 432% Fl.P: NA IP: NA Sp.Gr(77°F): 2.91 Noncombustible Solid	VP: 0 mm (approx) MLT: 554°F UEL: NA LEL: NA	Potassium	None available

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Personal protection and sanitation (See Table 3)		Recommendations for respirator selection — maximum concentration for use (MUC) (See Table 4)	Health hazards				
			Route	Symptoms (See Table 5)	First aid (See Table 6)		Target organs (See Table 5)
Clothing Goggles Wash Change Remove	Repeat Reason prob Prompt contam N R Limited wet (flamm)	NIOSH/OSHA 1000 ppm CCROV*/PAPROV*/SA*/SCBA* § SCBAF PD PP/SAF PD PP ASCBA Escape GMFOV/SCBAE	Inh Abs Ing Con	Dizz, excitement, drow, inco, staggering gait; irrit eyes, nose, throat, corneal vacuolization; anor, nau, vomit, abdom pain, derm	Eye Skin Breath Swallow	Irr immed Soap wash prompt Resp support Medical attention immed	CNS, eyes, GI tract, blood, liver, kidneys, skin
Clothing Goggles Wash Change Remove Provide	Any poss Any poss Immed contam N R Immed non imperv contam Eyewash, quick drench	NIOSH/OSHA 20 ppm CCROV/SA/SCBA 50 ppm SA CF/PAPROV 100 ppm CCRFOV/PAPRTOV/GMFOV/SCBAF/SAF 150 ppm SA PD,PP § SCBAF PD,PP/SAF PD PP ASCBA Escape GMFOV/SCBAE	Inh Abs Ing Con	Anoxia, cyan, lung, liver, kidney damage	Eye Skin Breath Swallow	Irr immed Soap wash immed Resp support Medical attention immed	Blood, lungs, liver, kidneys, CVS
Clothing Goggles Wash Change Remove Provide	N R Any poss N R N R N R Eyewash	NIOSH/OSHA 5 mg/m³ DM 10 mg/m³ DMXSQ/SA/SCBA 25 mg/m³ PAPRDM/SA CF 50 mg/m³ HiEF/PAPRTHiE/SAT CF/SCBAF/SAF 500 mg/m³ SA PD,PP § SCBAF PD,PP/SAF PD PP ASCBA Escape HiEF/SCBAE	Inh Ing Con	Irrit eyes; in animals: pulm irrit, eye inj; possible liver damage	Eye Skin Breath Swallow	Irr immed Soap wash prompt Resp support Medical attention immed	Eyes, lungs
Clothing Goggles Wash Change Remove	N R N R N R N R N R	NIOSH/OSHA 10 mg/m³ DMFu*/SA*/SCBA* 25 mg/m³ PAPRDMFu*/SA CF* 50 mg/m³ HiEF/PAPRTHiE*/SCBAF/SAF 2000 mg/m³ SAF PD,PP § SCBAF PD,PP/SAF PD PP ASCBA Escape HiEF/SCBAE	Inh Con	Conj irrit nose, throat, cough, copious sputum, dysp, chest pain, pulm edema, broncopneu, pulm fib, cor pulmonale, fever, cyan, tachypnea, burn skin, irrit skin, eyes	Breath	Resp support	Resp sys, skin, eyes

Zinc chloride fume

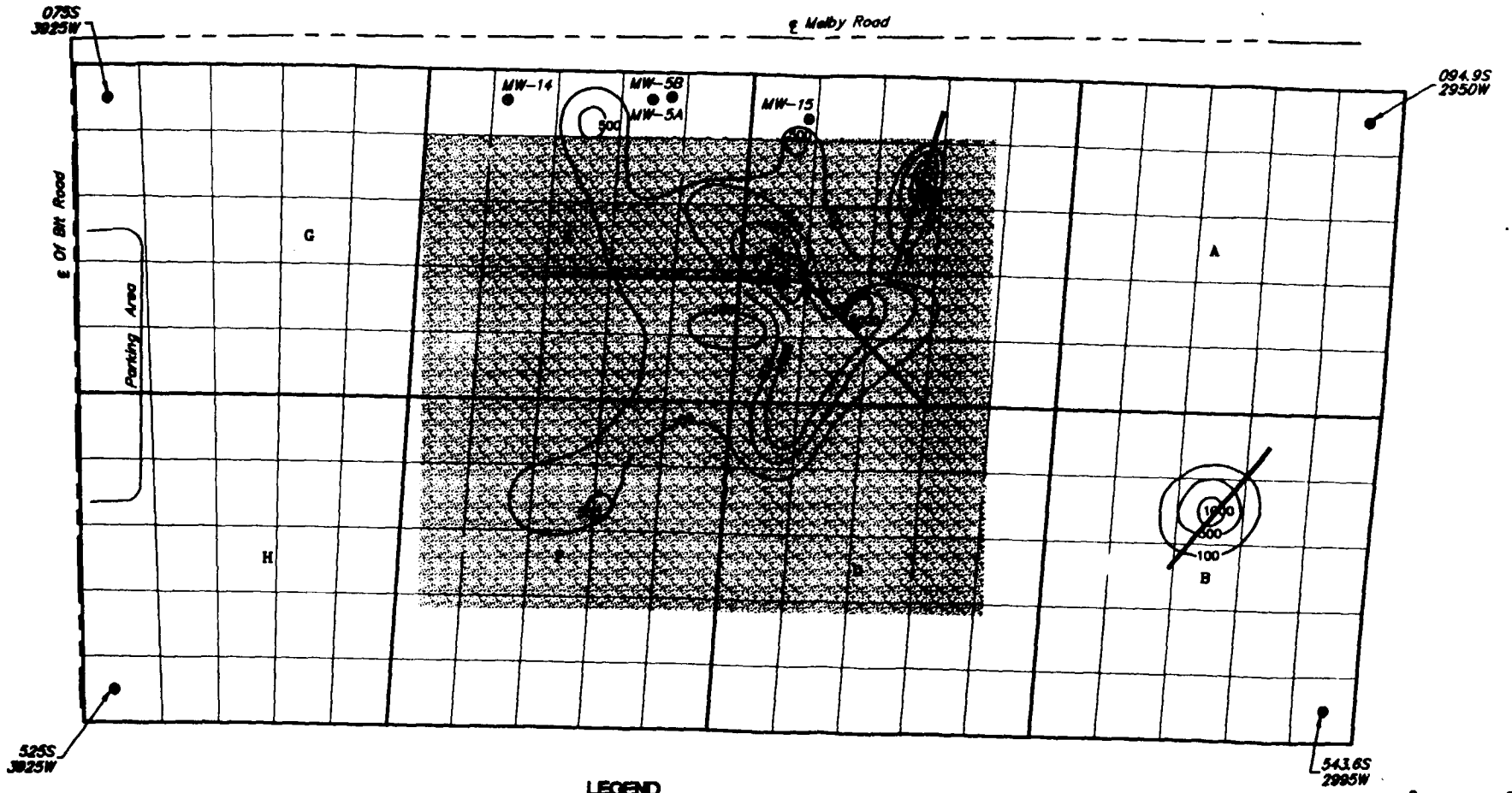
ATTACHMENT E

SITE MAPS

(TO BE USED AS EVACUATION ROUTE MAPS AND POSTED IN COMMAND POST)

eder associates consulting engineers, p.c.

FIGURE 1



GRID NUMBERING SYSTEM KEY

G-1	A-21	A-16	A-11	A-6	A-1
G-2	A-22	A-17	A-12	A-7	A-2
G-3	A-23	A-18	A-13	A-8	A-3
G-4	A-24	A-19	A-14	A-9	A-4
G-5	A-25	A-20	A-15	A-10	A-5
B-1	B-21	B-16	B-11	B-6	B-1

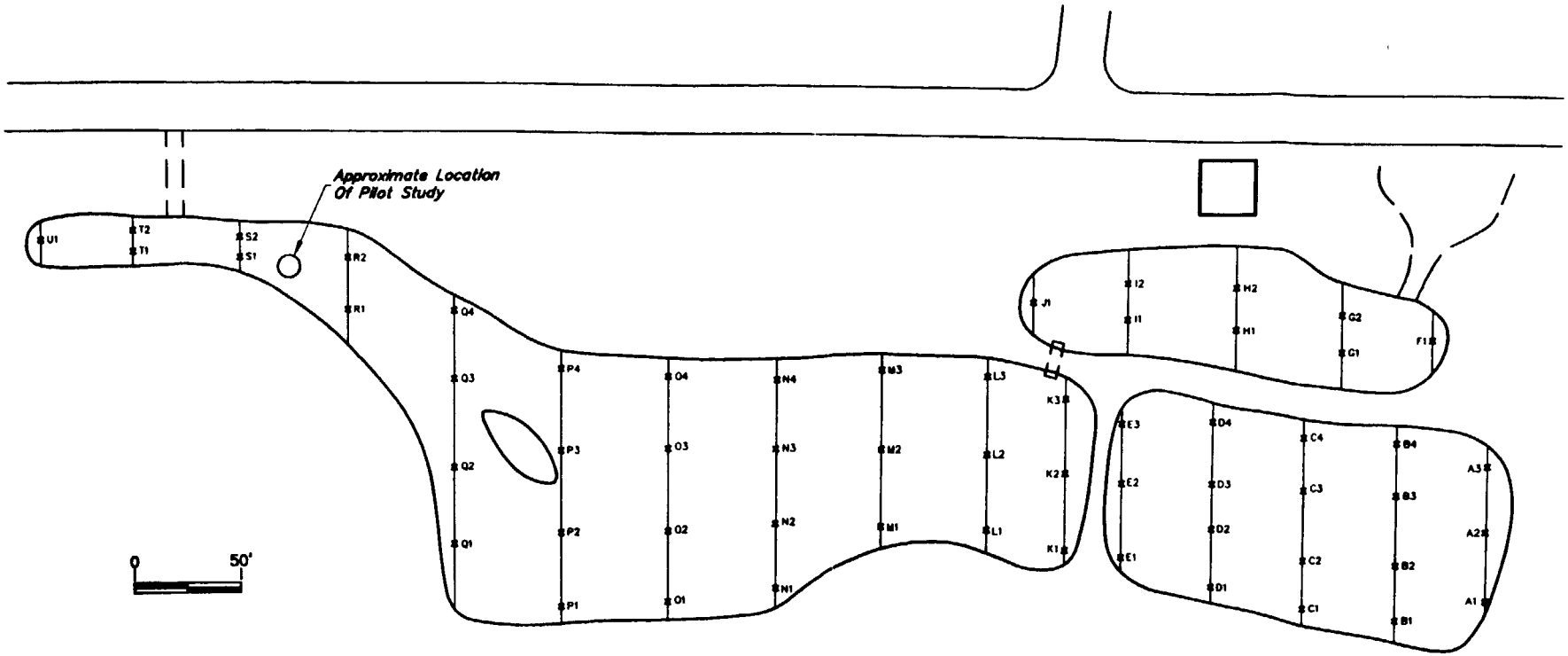
LEGEND

- Test Trench Location
- Existing Monitoring Well
- —1000— Contours Of 1,1,1-Trichloroethane Concentration In Soil Vapor Samples (PPB)
- Area Of Buried Waste Forge Compound Trenches (Approximate)
- Grid Coordinate Reference Point (Staked)

0 80'

SCALE IN FEET

MELBY ROAD DISPOSAL SITE
PRE-DESIGN PILOT STUDY
NATIONAL PRESTO INDUSTRIES, INC. SITE
EAU CLAIRE, WISCONSIN



LEGEND

× *Approximate Sampling Reference Points*

LAGOON No. 1
PRE-DESIGN PILOT STUDY
NATIONAL PRESTO INDUSTRIES, INC. SITE
EAU CLAIRE, WISCONSIN

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