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OPERATIONS AND MAINTENANCE MANUAL FOR A FULL SCALE BIOSLURPER SYSTEM AT SOLID WASTE MANAGEMENT UNIT 7 NS MAYPORT FL

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BATTELLE

OPERATIONS AND MAINTENANCE MANUAL FOR A FULL-SCALE BIOSLURPER SYSTEM AT SWMU7 AT NAVAL STATION MAYPORT, FLORIDA

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ACRONYMS AND ABBREVIATIONS

BTEX	benzene, toluene, ethylbenzene, and xylenes
cfm	cubic foot (feet) per minute
CFR	*Code of Federal Regulations*
F.A.C.	Florida Administrative Code
FDEP	Florida Department of Environmental Protection
HASP	Health and Safety Plan
HAZWOPER	hazardous waste operations and emergency response
LNAPL	light, nonaqueous-phase liquid
LRP	liquid ring pump
LUFT	leaking underground fuel tank
MSDS	Material Safety Data Sheet
NAVSTA	Naval Station
OSHA	Occupational Safety and Health Act; Occupational Safety and Health Administration
OWTP	Oily Waste Treatment Plant
PAH	polycyclic aromatic hydrocarbon
PVC	polyvinyl chloride
SWMU	Solid Waste Management Unit
TLV	threshold limit value
TPH	total petroleum hydrocarbons
TWA	time-weighted average
U.S. EPA	United States Environmental Protection Agency
VOA	volatile organic analysis
VOC	volatile organic compound (or carbon)
WWTP	wastewater treatment plant

OPERATIONS AND MAINTENANCE MANUAL FOR A FULL-SCALE BIOSLURPER SYSTEM AT SWMU7 AT NAVAL STATION MAYPORT, FLORIDA

Section 1.0: INTRODUCTION

1.1 Background and Objectives. The purpose of this manual is to provide guidance in the operations and maintenance of a full-scale vacuum-enhanced free-product recovery system (i.e., a bioslurper) to remediate subsurface contamination identified in the area of Solid Waste Management Unit (SWMU) 7 of Naval Station (NAVSTA) Mayport. The primary objective of this technology is to recover free-floating product existing as light, nonaqueous-phase liquid (LNAPL). This manual describes the components of the bioslurper and the operation of each piece of equipment. Maintenance requirements of the system are detailed and a schedule is given, as are performance monitoring and sampling requirements. A section on troubleshooting is included to help NAVSTA personnel reduce system downtime. Health and safety issues as well as training requirements for all personnel involved in bioslurper system operation also are addressed.

This manual is based on the full-scale conceptual design developed by Battelle and may need to be modified if the full-scale system deviates from Battelle's design plans detailed in the document entitled *Full-Scale Conceptual Design of Bioslurper System for SWMU7 at Naval Station Mayport, Florida* (Battelle, 1996a). The conceptual design was based on an initial 2-week pilot-scale test performed at the site to determine if bioslurping would be effective in removing the free product at the SWMU7 area. Product recovery rates, soil-gas permeability test results, and in situ respiration data collected during pilot-scale testing were used to establish the bioslurper system configuration for this site. The bioslurper system was designed to recover free product from areas where it has been observed during previous site investigation activities. The system is designed to use an off-gas treatment unit; however, continued use will be dependent on regulatory requirements. A number of options are provided for treating the discharge water. Discharge regulatory requirements and contaminant loading will dictate which of these treatment options is required at the site.

1.2 Technology Description. Bioslurping is a technology application that teams vacuum-assisted free-product recovery with bioventing to simultaneously recover free product and remediate the vadose zone. Unlike other LNAPL recovery technologies, bioslurping systems treat two separate geologic media simultaneously. Bioslurping pumps are designed to extract free-phase fuel from the water table and to aerate vadose zone soils through soil-gas extraction. Bioslurper systems also can be designed to achieve hydraulic control as is done with the conventional pump-and-treat technology. The bioslurper system withdraws groundwater, free product, and soil gas in one process stream using a single aboveground pump. Groundwater is separated from the free product, treated (when required), and discharged. Free product is recovered and can be recycled. Soil-gas vapor is treated (when required) and discharged.

The bioslurping technology is unique because it uses elements of two separate remedial technologies, **free-product recovery** and **bioventing/soil vapor extraction**, to address two separate contaminant media.

1. **Free-product recovery** is the process of removing free-phase petroleum in liquid form from the capillary fringe. LNAPL recovery generally is accomplished by using either (a) a skimmer pump to pump out any fuel that passively enters a well, or (b) a dual-pump recovery system in which one pump lowers the water table and increases the fuel flow into the well (due to the gravity-induced gradient) and the second pump skims off the fuel.

2. **Bioventing and soil vapor extraction** are forced aeration processes that enhance the natural in situ biodegradation of petroleum contamination and the removal of volatile organic compounds (VOCs) from the vadose zone.

Both technologies, which are described in detail in Section 1.0 of the *Best Practices Manual for Bioslurping* (Battelle, 1996b), are widely used in some form. Bioslurping combines elements of each to simultaneously recover free product and aerate the vadose zone soils. Conventional LNAPL recovery skimmer systems generally are inefficient for LNAPL recovery because they have little effect on free product outside the recovery well, so efficiency relies on the passive movement of fuel into the recovery well. Dual-pump LNAPL recovery systems increase recovery efficiency by drawing the water table down several feet to create a hydraulic gradient into the well. Although higher recovery rates are achieved, creation and maintenance of the hydraulic gradient can require extraction of large volumes of groundwater that must be treated prior to discharge. In addition, lowering the water table may serve only to trap much of the free product in the newly exposed vadose zone so that it reappears when the water table returns to its normal level.

Bioslurping may improve free-product recovery efficiency without requiring the extraction of large quantities of groundwater. The bioslurper system pulls a vacuum of up to 20 inches of mercury on the recovery well to create a pressure gradient that promotes movement of fuel into the well. Bioslurping treats the vadose zone by increasing the oxygen levels in the unsaturated soils through soil-gas extraction. The slurping action of the bioslurper system cycles between recovering liquid (free product and/or groundwater) and recovering soil gas. When free-product removal activities are complete at a site, the bioslurper system is easily converted to a conventional bioventing system to complete remediation of the vadose zone soils.

Bioslurping systems are designed to minimize environmental discharges of groundwater and soil gas. As done in bioventing, bioslurper systems can be designed and operated to extract soil gas at a low rate to reduce volatilization of contaminants. In some instances, the volatile discharge from the bioslurper can be kept below treatment action levels without treatment. The slurping action of a bioslurping system greatly reduces the volume of groundwater that must be extracted compared to conventional LNAPL recovery systems, thus greatly reducing groundwater treatment costs. Figure 1 illustrates the differences between conventional dual-pump LNAPL recovery and bioslurping.

Nonaqueous-phase liquids that are less dense than water move downward through the vadose zone and accumulate at and above the water table. Generally, the vertical interval containing the accumulated LNAPL also contains some air and water. Near the top of the LNAPL zone, both water and LNAPL contents are low and most of the pore space is occupied by air. LNAPL contents usually are greatest toward the center of the LNAPL zone and decline to zero at the bottom where the pore space is fully occupied by water.

A significant feature of the slurping process is the induced air flow toward the well, which is believed to increase LNAPL flow to the well. The pressure gradient created in the air phase causes a driving force on the LNAPL that is similar to the hydraulic gradient created with the dual-pump recovery system. Also of importance is the fact that the air flow created by the vacuum actually enhances the LNAPL content around the well. That is, the LNAPL tends to accumulate around the well. For these reasons, bioslurping has the potential for removing more LNAPL and at greater rates than do other pumping technologies.

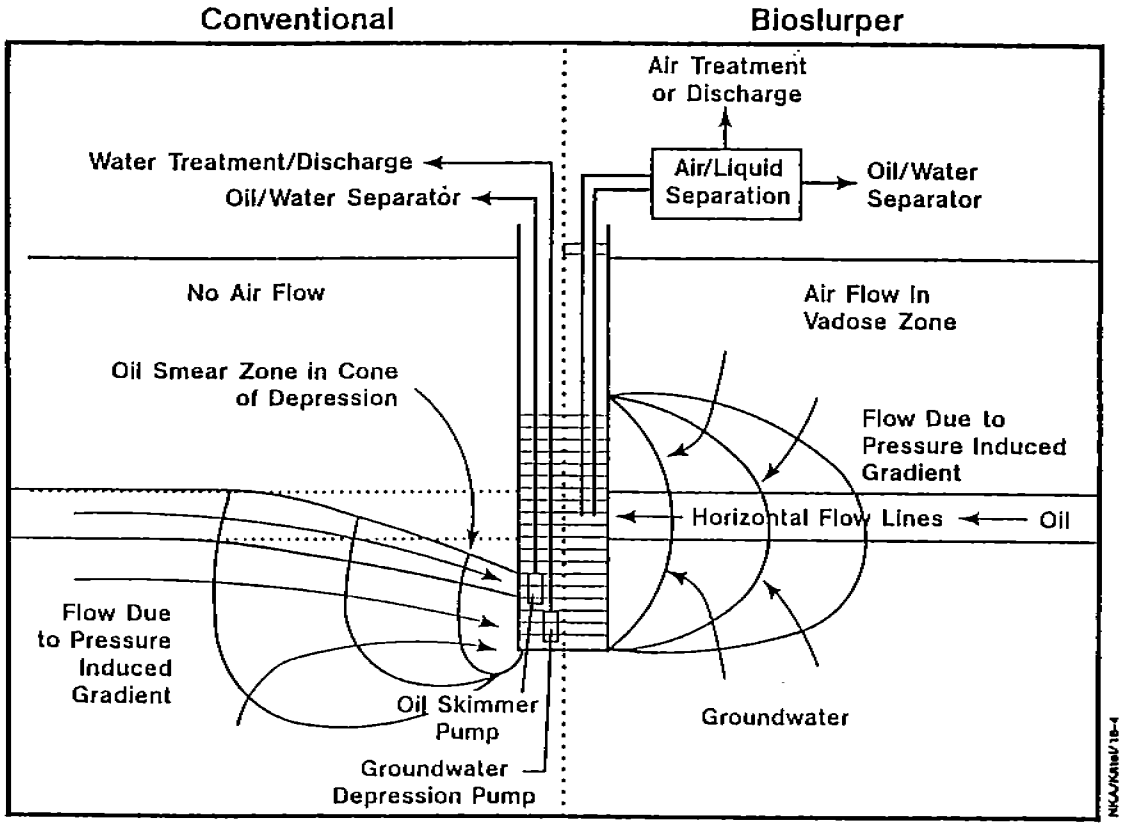


Figure 1. Comparison of Conventional LNAPL Recovery and Bioslurping

Section 2.0: COMPONENTS OF THE FULL-SCALE BIOSLURPER SYSTEM

This section describes the components of the bioslurper system at NAVSTA Mayport, including the extraction system, off-gas and oil/water treatment, and monitoring instruments. Manufacturer's data for a number of the system components can be found in Appendix A.

2.1 Extraction System. The full-scale bioslurping system designed for the area outside of the sludge drying beds at NAVSTA Mayport consists of extraction wells, monitoring points, and associated treatment and disposal equipment. Two bioslurping extraction systems are used. One extraction system is located north of Patrol Road behind Building 262; the other is located south of Patrol Road near SWMU7 next to the concrete pad that houses the tanks and controls for the existing treatment system.

The tanks and pumps for both extraction systems are installed on concrete pads. The major items of equipment on the pads are a manifold to link several extraction wells, an equalizing tank, a liquid ring pump, a heat exchanger, and a seal water reservoir. The equipment is explosion proof, meeting the requirements for Class I, Division I, Groups C and D, because of the possibility that flammable gases or vapors may be present in the air in quantities sufficient to produce explosive or ignitible mixtures under normal operating conditions.

The extraction equipment will generate both gas and liquid wastestreams. The treatment equipment for the resulting liquid discharge includes transfer pumps and an oil/water surge tank at each site location. This remedial design assumes that the discharged liquid (oil and water) will be pumped into the two existing 20,000-gallon double-walled storage tanks to be subsequently discharged to the NAVSTA Oily Waste Treatment Plant (OWTP). The 20,000-gallon tanks currently are being used to store oil/water generated by the existing treatment system. They are fixed units with subsurface plumbing to the NAVSTA OWTP.

The treatment equipment for the off-gas stream consists of a dehumidifier, two vapor-phase-activated carbon adsorbers placed in series, and an induced-draft blower. The condensate from the dehumidifier will be transported to the oil/water surge tank. The off-gas treatment equipment is placed with the system located behind Building 262; more contamination is anticipated in that region, compared with the area south of Patrol Road. The off-gas from the system located south of Patrol Road will be pumped through subsurface pipes to the off-gas treatment system on the northern pad next to Building 262. A conceptual drawing of the extraction and treatment equipment is shown in Figure 2.

2.1.1 Extraction Wells. Extraction wells are screened in the vadose zone and across the water table to remove free product, groundwater, and soil gas. The annular space corresponding to the screened interval is packed with a sand filter, and the space between the screened interval and the ground surface is sealed with hydrated bentonite. To accommodate the bioslurper system, the top of the well casing is fitted with a 2 × 1-inch sanitary seal. The bioslurper drop tube is inserted into the well through this seal. The drop tube is set so that its opening is at the free-product/water interface.

2.1.2 Manifold. The extraction wells are connected to the liquid ring pump by a manifold system. A short length of clear pipe allowing for visual observation of the well effluent should be placed in line between the drop tube and the manifold. The drop tube and clear pipe are connected to the manifold system by a section of vacuum-proof fuel-grade hose and camlock fittings. The manifold consists of lengths of pipe, the sizes of which are based on the number of wells connected to it. Control of the system may be increased by installing valves which make it possible to isolate legs of the manifold.

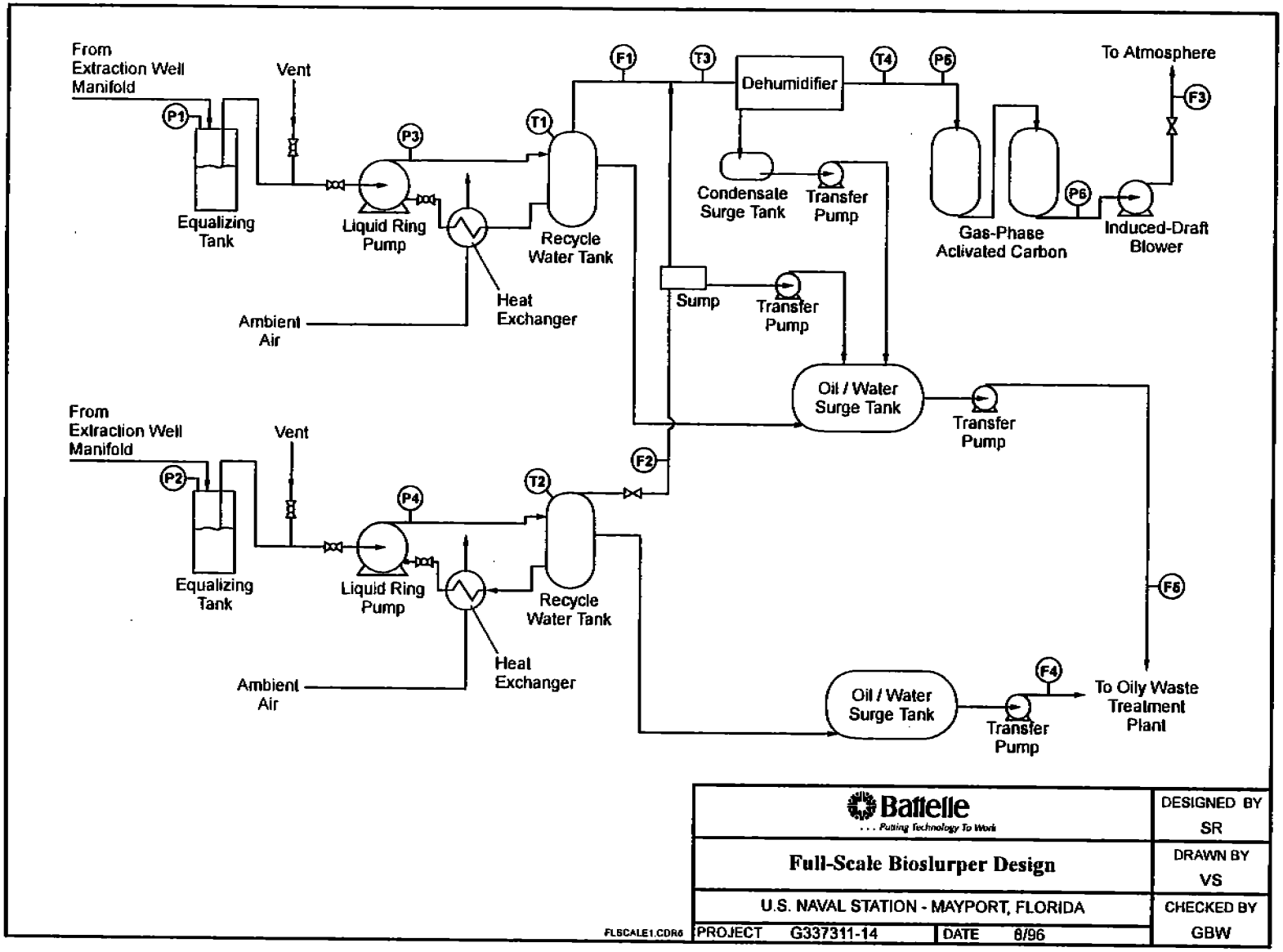


Figure 2. Full-Scale Bioslurper Design

2.1.3 Equalizing Tank. The equalizing tank is a heavy-gauge steel 55-gallon drum with a removable lid. The lid is equipped with fittings that allow for the attachment of an inlet line from the manifold and an outlet line to the liquid ring pump. A drop tube on the inside of the drum is attached to the outlet line. The purpose of the equalizing tank is to minimize the possibility of subjecting the liquid ring pump to large slugs of water, which tend to overload the pump.

2.1.4 Liquid Ring Pump. The liquid ring pump unit used for bioslurping consists of a pump, seal water tank, and explosion-proof motor starter box. At Mayport, a 15-hp ring pump is located north of Patrol Rd., and the unit to the south of the road has a 20-hp pump. High- and low-level float switches are installed inside the seal water tank. The switches will shut down the ring pump if the seal water level deviates above or below recommended limits. Circuitry is provided to shut down the ring pump motor if it begins to overheat or draws greater than 125% of its full-load amperage.

2.1.5 Heat Exchanger. A heat exchanger is installed between the seal water tank and the liquid ring pump to reduce the temperature of the recirculated groundwater/fuel mixture in the liquid ring pump. Cooling the recirculating liquid reduces the possibility of damaging the pump's wiring and also minimizes volatilization of hydrocarbons in the seal water tank.

2.1.6 Surge Tank. The surge tank is a double-walled steel storage tank connected to the outlet of the seal water tank. This tank will store the oily water effluent of the bioslurper until a sufficient quantity accumulates and can be pumped to the NAVSTA 20,000-gallon OWTP storage tanks.

2.1.7 Annunciator Panel. An annunciator panel is used to diagnose any off-normal condition that causes the liquid ring pump to shut down. The panel allows the operator to quickly determine the cause of a system shutdown. The panel includes indicator lights to determine a shutdown caused by loss of power, motor overcurrent, motor overtemperature, low liquid level in the seal water reservoir, high liquid level in the seal water reservoir, high liquid level in the oil/water surge tank, or high liquid level in the 20,000-gallon temporary storage tanks. A timer also is included to track the total hours of system operation.

2.2 Off-Gas Treatment System. Off-gas from the two bioslurper systems will be treated with one treatment system located north of Patrol Road. Vapor discharge from the southern bioslurper is piped subsurface to the treatment area. A sump is installed at the north system to capture any condensate which may collect in the subsurface pipe.

2.2.1 Dehumidifier. A dehumidifier is installed in the off-gas discharge line, prior to carbon treatment. The dehumidifier will remove excess moisture from the vapor effluent so that the activated carbon is not rendered ineffective due to the burden of a liquid coating. The relative humidity of the off-gas should be kept between 40 and 50%.

2.2.2 Granular Activated Carbon. Off-gas from the bioslurper system will be treated using vapor-phase granular activated carbon. The absorbers are constructed from carbon steel with epoxy internal coatings and PVC internals. Off-gas will pass from the dehumidifier into a pair of 2,000-lb carbon containers connected in series. An alternative off-gas treatment method would be to use a thermal oxidizer for which manufacturer's literature can be found in Appendix A.

2.2.3 Induced Air Blower. The blower is installed in the vapor discharge stream following the carbon containers. The blower pulls the vapor from the liquid ring pump seal water tanks through the dehumidifier and carbon treatment system. The blower motor and wiring should be explosion-proof.

2.3 Oil/Water Treatment. The oil/water mixture extracted by the liquid ring pump enters the seal water tank and gravity-flows out of the side of the tank to a double-walled surge tank. The oil and water accumulate in the surge tank to be pumped to the NAVSTA 20,000-gallon storage tanks. At NAVSTA Mayport, oil/water separation will be performed by the NAVSTA OWTP rather than at the site.

2.3.1 Transfer Pumps. Transfer pumps move liquid collected in the dehumidifier and in the sumps in the subsurface vapor line that transport the off-gas from the bioslurper system on the south side of Patrol Road. This collected water is pumped to the oil/water surge tank. Transfer pumps also are used to empty the oil/water surge tanks, pumping the liquid to the NAVSTA 20,000-gallon storage tanks. The transfer pumps are controlled by liquid level switches.

2.3.2 20,000-Gallon Storage Facility. Twin 20,000-gallon storage tanks are located south of Patrol Road across from Building 262. These tanks serve as a temporary storage facility for the liquid effluent from the bioslurper systems. The oil/water mixture accumulates in one of the two tanks. When one tank fills, the process flow is automatically transferred to the other tank. Contents in the tanks are manually discharged to the NAVSTA OWTP. Liquid level switches, which will shut down the bioslurper system in the event that both tanks fill completely must be installed inside these tanks.

2.4 Monitoring Instruments. This section describes the instruments that are necessary to monitor the bioslurper system and the calibration procedures for each instrument.

2.4.1 Oxygen/Carbon Dioxide Meter. Gaseous concentrations of oxygen and carbon dioxide in the soil gas and in the bioslurper vapor discharge will be analyzed using an O_2/CO_2 meter (GasTech model 3252OX or equivalent). The meter is coupled to a male quick-connect fitting, which allows ease of sampling from soil-gas monitoring points and off-gas sampling ports fitted with female quick-connects, or from Tedlar™ bags. A small pump in the meter pulls a sample through oxygen and carbon dioxide sensors. A switch on the instrument allows the user to alternate which reading is displayed on the analog gauge, showing concentrations in percentage of the sample volume. This meter has oxygen and carbon dioxide ranges from 0 to 25%.

The battery charge level should be checked prior to use to ensure proper operation, and the air filters should be checked to determine if they need to be cleaned or replaced. The instrument should be turned on and allowed to equilibrate for at least 30 minutes before conducting calibration or obtaining measurements. Check the sampling pump of the instrument to ensure that it is functioning. A low flow alarm can indicate that the battery level is low or that some fines are trapped in the pump or tubing.

The meters are calibrated against purchased carbon dioxide and oxygen calibration standards prior to each use. These standards should be in the concentration range of the soil gas to be sampled. Standard gases can be purchased from a specialty gas supplier. To calibrate the instrument with standard gases, a Tedlar™ bag (capacity ~1 L) is filled with the standard gas, and the valve on the bag is closed. The inlet nozzle of the instrument is connected to the Tedlar™ bag, and the valve on the bag is opened. The instrument is then calibrated against the standard gas according to the manufacturer's instructions. Next, the inlet nozzle of the instrument is disconnected from the Tedlar™ bag and the valve on the bag is shut off. The instrument is then rechecked against atmospheric concentration. If recalibration is required, the

above steps will be repeated. Detailed calibration procedures can be found in the manufacturer's literature presented in Appendix B.

2.4.2 Total Petroleum Hydrocarbon Meter. This meter measures TPH concentration in parts per million by volume (ppmv) in soil gas and bioslurper vapor discharge, and may also be used for the in situ respiration test. The TPH meter (GasTech TraceTechtor™ or equivalent) pulls a sample in the same way as the O_2/CO_2 meter. Results are displayed on an analog gauge with range settings of 100 ppmv, 1000 ppmv, and 10,000 ppmv. The analyzer is calibrated against hexane calibration gas. The oxygen concentration must be above 10% for the TraceTechtor™ analyzer to be accurate. When the oxygen drops below 10%, a dilution fitting must be added to provide adequate oxygen for analysis. The dilution fitting can also be used if hydrocarbon concentrations are greater than 10,000 ppmv. Detailed calibration procedures can be found in the manufacturer's literature presented in Appendix B.

2.4.3 Oil/Water Interface Probe. The interface probe is used to measure depth to free product and depth to groundwater in a well, thus allowing calculation of free-product thickness. It may also be used to measure free-product thickness in storage tanks. The hand-held instrument consists of a sensor connected to a lead marked in 0.01-inch increments. The instrument emits a solid tone when the downhole sensor encounters free product and sounds an intermittent tone when the sensor is immersed in water.

2.4.4 Temperature Meter. The digital thermometer is used to determine temperature in the subsurface, the seal water tank, the off-gas, or the ambient air. The thermometer has two ports for connection of male thermocouple plugs, and displays temperature in Celsius or Fahrenheit to 0.1 degree. The manufacturer's operation manual can be found in Appendix B.

Section 3.0 BIOSLURPER SYSTEM MANAGEMENT

3.1 Operating Requirements.

3.1.1 Training. All site personnel must be trained in accordance with the OSHA 29 CFR 1910.120 regulations covering hazardous waste operations and emergency response (HAZWOPER). Consistent with these regulations, each site team member must provide a document certifying the dates of his or her 40-hour HAZWOPER training (and the 8-hour annual refresher training, if applicable). Individuals designated as site supervisors must receive an additional 8 hours of supervisory training consistent with OSHA 29 CFR 1910.120. All team members must have a minimum of 3 days of actual field experience under the direction of a skilled supervisor.

3.1.2 System Startup and Shakedown. Operation of the bioslurper system should start with a shakedown test. All components are checked to ensure that they are operating properly and that there are no leaks in the system. Components that must be checked include valves, pressure/vacuum gauges, all extraction and process equipment, flowmeters, and emergency shutoff switches. A checklist for system shakedown is provided in Appendix C. Baseline measurements, as described in Section 3.3.1, should be taken prior to system startup. Procedures for startup should be followed in the order described below:

1. Prime the liquid ring pump (LRP), the seal water tank, and the equalizing drum with water. The water level in the liquid ring pump reservoir should be higher than the top of the liquid ring pump.

2. Open the bleed valve located on the LRP inlet.

3. Check to see if all the lights on the annunciator panel are on. If not, reset the relay (which turns on the light) by pressing the reset button beneath the light that is off.

4. Press the start button. If not already open, gradually open the flow-control valve. Gradually close the vent valve.

3.1.3 Shutdown. Procedures for shutdown of the bioslurper system should be followed in the order described below:

1. Slowly open the bleed valve located at the inlet of the LRP.

2. Close the flow-control valve.

3. Press the stop button on the LRP.

4. If shutdown is to be permanent and/or the system will be transported, drain and clean the LRP.

3.1.4 Restarting System After Unattended Shutdown. Several conditions may cause the bioslurper system to automatically shut down. These problems include (1) overheated or excessive workload on the bioslurper pump, or (2) a malfunction that activates the liquid level alarm. In the event of an automatic shutdown, it is necessary to determine the cause of the shutdown before restarting the system.

1. Check the visible light alarm on the annunciator panel to diagnose potential problem areas.

2. Open the inlet bypass valve to the LRP.

3. Depress the start button and observe the results.

4. (a) If the bioslurper pump does not start at all, it is probable that the pump was being overworked and pulled too many amps of current. In addition, it is possible that the problem could be attributed to low line voltage to the pump. To prevent damage to the pump, the specific problem causing the shutdown must be determined. This determination should include checking the internal mechanisms of the pump housing to ensure that there are no broken parts. Once the problem has been identified and corrected, the pump motor starter needs to be reset by depressing the reset button on the control panel. Refer to Section 5.0 for additional troubleshooting recommendations.

   (b) If the bioslurper pump starts but operates only while the start button is depressed, a liquid level problem is likely the cause. Check the liquid level at all locations to ensure proper fluid levels. Take the appropriate action to correct the problem (i.e., draining full tanks, repairing transfer pumps, and/or filling the seal water tank). Refer to Section 5.0 for additional troubleshooting recommendations.

5. After correcting the cause of the automatic shutdown, the bioslurper system can be restarted according to the procedure described in Section 3.1.2.

3.1.5 Priming the Bioslurper System. The LRP, the seal water tank, and the vacuum drum should be primed according to the following procedures:

1. Prime the LRP and seal water tank by pouring clean water into the pumphead via the inlet bypass valve at the inlet of the LRP. Fill the pump until the liquid level indicator mounted on the side of the seal water tank reaches approximately ½ to ¾ of the sight glass on the seal water tank.

2. Prime the equalizing drum by removing the flexible hose to the LRP and fill with approximately 30 gallons of clean water.

3.2 Routine Maintenance. Regular maintenance of the bioslurper system at NAVSTA Mayport will eliminate unnecessary system downtime. Generally, routine maintenance is performed on the extraction system, oil/water separation equipment, and off-gas treatment equipment. The majority of the maintenance involves the oil/water separation equipment. At NAVSTA Mayport, oil/water separation will be performed by the NAVSTA OWTP rather than at the site; therefore, routine maintenance will be minimal. As part of a routine maintenance schedule, process parameters such as system temperatures, flowrates, and pressures/vacuums should be measured regularly. If values deviate from normal recorded values, a potential equipment problem may exist. The cause for the deviation must be determined and corrected if related to an equipment problem. Refer to Section 3.3 for monitoring requirements.

3.2.1 Extraction System. The LRP is the only piece of extraction equipment requiring routine maintenance. Two activities that should be performed at regular intervals include (1) cleaning the pump strainers and (2) descaling the pump rotor and housing. There are two strainers installed on the ring pump:

one located at the pump inlet and the other located in the recirculation line between the ring pump and seal water tank. Initially, the strainers should be cleaned on a weekly basis. If they are found to be relatively clean, the interval between cleanings may be increased. Additional information is included in the manufacturer's literature for the LRP in Appendix A.

Minerals in the process water eventually may form a scale on the LRP rotor and on the inside of the housing causing the LRP to seize. Routine descaling will prevent excessive scale formation. The LRP can be descaled by adding muriatic acid to the seal water tank. The inlet control valve should be closed so that the muriatic acid will recycle through the pump head. Step-by-step procedures for descaling the LRP are included in the manufacturer's literature in Appendix A. The frequency of descaling should be determined by visually inspecting the pump housing and rotor for scale. It is recommended that a visual inspection be performed 1 to 2 weeks after beginning operation. If scale is not present, the housing and rotor should be inspected after an additional 1 to 2 weeks of operation. It has been found that descaling is not necessary at the majority of bioslurping sites.

3.2.2 **Off-Gas Treatment System.** Routine maintenance of the off-gas treatment system consists of rotating and replacing spent batches of activated carbon. Off-gas samples must be collected at regular intervals to determine the frequency of carbon replacement (Section 3.3.4). Two carbon adsorbers are connected in series. When the carbon in the first absorber has been spent, it must be recharged or disposed. The spent carbon is replaced with a fresh batch. The adsorbers are then replumbed so that the adsorber that was in the second position is now in the first position and the adsorber containing the fresh carbon is in the second position. The adsorbers also should be checked weekly for the presence of water. If water is present, it should be drained from the bottom of the adsorber. The presence of water indicates that the relative humidity of the vapor stream is too high. Keeping the relative humidity between 40 and 50% should eliminate this problem.

3.3 **Performance Monitoring and Sampling Requirements.** During operation of the full-scale bioslurper system, it is recommended that the bioslurper process be monitored on a regular basis. Monitoring consists of reading and recording the values of the various temperature, pressure, and flow gauges as well as collecting and analyzing samples for hydrocarbon constituents. Table 1 lists the bioslurper operational parameters and the recommended frequency at which they should be monitored. The frequency of the measurement or analysis is determined on the basis of data needs. In some cases, as in the case of vapor discharge, the monitoring requirements are established based on the requirements of the Florida Department of Environmental Protection (FDEP). In other cases, the requirements are recommended based on Battelle's prior experience in operating full-scale bioslurper systems. The system must be monitored closely for the first 2 to 4 weeks of operation to determine the most effective operating configuration. This section describes the frequency of various bioslurper monitoring and sampling parameters. Additional information on specific monitoring, sampling, and analytical procedures can be found in Section 4.0.

3.3.1 **Baseline.** Following system shakedown, the baseline data for the site should be collected. LNAPL thickness and depth to groundwater at each bioslurper well should be measured with an oil/water interface probe. Measurements should be recorded on the initial oil/water level data sheet in Appendix C. Oxygen, carbon dioxide, and total petroleum hydrocarbon (TPH) concentrations should be measured at each soil-gas monitoring point according to the method described in Section 4.3. Measurements should be recorded on the soil-gas survey data sheet in Appendix C.

Table 1. Full-Scale Bioslurper Monitoring Parameters and Frequency

Activity	Recommended Frequency
Baseline oil/water level data and soil-gas concentrations	Prior to startup
Routine system monitoring and site inspection (process vacuums, flowrates, temperatures, etc.)	A minimum of 2 to 3 times a week during the first month of operation; weekly thereafter
Vapor discharge flowrate	Weekly
Vapor discharge sampling for laboratory analysis of TPH and BTEX	Weekly for first 4 weeks; monthly thereafter at discretion of FDEP
Vapor discharge monitoring with field instrumentation	Weekly
Aqueous and LNAPL discharge volumes and rates	Weekly
Aqueous discharge stream sampling for laboratory analysis of TPH and BTEX	Monitor weekly during first month of operation to determine if it is more economical to discharge water to OWTP without treatment or to treat water and discharge to WWTP; quarterly thereafter at discretion of FDEP
LNAPL levels and recovery rates in wells[a]	Monthly for 3 to 6 months; quarterly thereafter
Aeration monitoring[b]	Monthly
Respiration monitoring[c]	Quarterly first year and semiannually thereafter

(a) LNAPL levels and recovery rates into the wells are used to indicate the degree of removal of LNAPL. As more LNAPL is removed, the resulting levels are less and the recovery rate is slower. This monitoring test must be performed with the system off. It may be performed more or less frequently based on the observed change in the LNAPL recovery rate during bioslurper operation.

(b) Aeration monitoring is performed with the bioslurper system on. Soil-gas concentrations in the monitoring points are measured to determine if the subsurface process is being aerated by the bioslurper process.

(C) Respiration monitoring is performed with the bioslurper system off to determine the change in the biodegradation rate over time.

3.3.2 Routine System Monitoring. Routine system monitoring should be conducted approximately 2 to 3 times per week during the first month of operation and weekly thereafter. It is important to make sure that all equipment is operating properly and that the entire system is operating according to specifications. Data to be recorded include process vacuums, flowrates, and temperatures. These operational data should be recorded on data sheets similar to those found in Appendix C.

Visual observations also should be made during routine system monitoring. Items to take notice of include liquid levels in process tanks, slurping action of the wells, and visual characteristics of extracted groundwater. Any unusual circumstances should be noted in a field logbook.

3.3.3 Vacuum/Pressure Monitoring. Vacuum/pressure monitoring should take place at the time of routine system monitoring. Changes in vacuum/pressure are measured using Magnehelic™ or equivalent gauges. Tygon™ or equivalent tubing is used to connect the pressure/vacuum gauge to the quick-disconnect fitting. Gauges should be positioned as shown in Figure 2. A gauge may also be placed at the head of each bioslurper well. A portable magnehelic gauge board may be used to measure the vacuums at the wells. Pressure/vacuum gauges are available in a variety of pressure/vacuum ranges, and the same gauge can be used to measure either vacuum or pressure simply by switching inlet ports. Gauges are sealed and calibrated at the factory and will be rezeroed before each test. The following pressure ranges (in inches H_2O) typically will be available for this field test:

0-1″, 0-5″, 0-10″, 0-20″, 0-50″, 0-100″, and 0-200″

Process vacuums/pressures to monitor during routine system monitoring include pump head vacuum, equalizing tank pressure, extraction well vacuum, and pressure at the inlet and outlet port of the carbon canister. Data should be recorded on the appropriate data sheets in Appendix C.

3.3.4 Vapor Discharge. The vapor discharge flowrate should be measured weekly at each bioslurper stack and recorded on the off-gas analysis record sheet in Appendix C. The volume of vapor discharge may be quantified using a pitot tube (Annubar Flow Characteristics Model #HCR-15 or equivalent) flow indicator. The pitot tube is connected to a differential pressure gauge calibrated in inches of H_2O. The flowrate in cubic feet per minute (cfm) is determined by referencing the differential pressure to a flow calibration curve (Appendix D). The volume of hydrocarbon loadings will be calculated based on the average flowrate and hydrocarbon concentrations in the off-gas.

Off-gas samples for laboratory analysis should be collected weekly for the first 4 weeks and monthly thereafter at the discretion of the FDEP. Each sampling event should consist of a total of three samples collected from the following locations: one sample from the bioslurper seal water tank on the north side of Patrol Rd., one sample from the bioslurper seal water tank on the south side of Patrol Rd., and one sample following treatment with the first carbon drum. Samples are to be collected in evacuated stainless steel canisters and analyzed for TPH and benzene, toluene, ethylbenzene, and xylenes (BTEX). Detailed procedures for off-gas sampling and analysis are found in Section 4.1.2. Off-gas can be analyzed in the field more frequently during the routine system checks. Procedures for off-gas analysis with field instrumentation are found in Section 4.1.1.

Off-gas temperatures should be monitored 2 to 3 times per week during the first month of operation and weekly thereafter. Temperatures should be recorded on the off-gas analysis record sheet in Appendix C. Temperature at the off-gas sample locations should be measured with a Type K thermocouple (or equivalent) using a Fluke Model 52 thermocouple thermometer (or equivalent). In addition, the

temperature of the dehumidifier inlet and outlet airstream should be measured and recorded on the operational data sheet provided in Appendix C.

3.3.5 Aqueous and LNAPL Discharge. The volume of extracted LNAPL/groundwater resulting from bioslurper operation can be quantified using the existing in-line flow totalizer meter installed at the NAVSTA 20,000-gallon-capacity temporary storage tank. The volume of aqueous discharge along with bioslurper operational time will be used to calculate the aqueous discharge rate. Recovery volumes and operational periods should be recorded on a groundwater recovery data sheet like that provided in Appendix C.

Hydrocarbon concentrations in the aqueous discharge stream should be monitored weekly during the first month of operation and quarterly thereafter at the discretion of the FDEP. Each sampling event should consist of one sample collected from the bottom of one of the 20,000-gallon-capacity storage tanks. Samples should be analyzed for TPH and BTEX concentrations. Results should be used to determine if it would be more economical to discharge the water to the OWTP without treatment or to first treat the water and then discharge it to the WWTP. Until this determination is made, it is recommended that the aqueous wastestream be discharged into the two base-supplied 20,000-gallon-capacity temporary storage tanks to subsequently undergo treatment by the NAVSTA Mayport OWTP. Detailed procedures for collection and analysis of aqueous samples can be found in Section 4.2.

LNAPL volume should be monitored weekly by measuring the thickness of free product that accumulates on the surface of the aqueous discharge collected in the 20,000-gallon tank. The LNAPL thickness should be measured both prior to and after emptying the tank, because a thin layer of liquid will remain at the bottom of the tank after emptying. The product thickness measured each time prior to emptying the tank is adjusted by subtracting the amount which remained in the tank the previous week. The resulting thickness may be converted to a volume by multiplying it by the cross-sectional area of the tank. The volume of LNAPL discharged along with bioslurper operational time between measurements can be used to determine the LNAPL discharge rate. Product thickness can be measured using an oil/water interface probe (ORS model #1068013 or equivalent). Data should be recorded on a fuel recovery data sheet similar to the one found in Appendix C.

3.3.6 LNAPL Levels and Recovery Rates in Wells. Important parameters that must be monitored closely are the LNAPL levels and recovery rates in wells. This type of monitoring should be conducted monthly for 3 to 6 months and then quarterly thereafter, however, it may be performed more or less frequently based on observed change in the LNAPL extraction rate during bioslurper operation. To determine the rate of LNAPL recovery in the bioslurper wells, the system must be shut down. The recovery testing should be conducted using an oil/water interface probe to periodically monitor the change in free-product thickness in wells immediately following system shutdown. Free-product thicknesses should be recorded on oil/water level record sheets similar to those found in Appendix C. Measurements should be taken every hour for 2 hours, then every 2 to 4 hours. The time between measurements can be more frequent if LNAPL recovery is rapid, or less frequent if recovery is very slow. Monitoring may be discontinued when free-product recovery into the well is minimal. As the quantity of recoverable LNAPL in the subsurface decreases, the rate of recovery into the wells also will decrease. The change in product thickness over time may be plotted to determine recovery rates. LNAPL thicknesses and recovery rates can be used to evaluate how the bioslurper system operation should be modified. For example, bioslurper treatment should be continued at wells with high recovery rates and/or comparatively high LNAPL thickness, whereas treatment at wells with no LNAPL may be discontinued. Wells in which LNAPL as free-floating product was not observed should still be monitored periodically to verify that LNAPL

continues to be absent. If LNAPL is detected at a later date, the well should again be incorporated into the bioslurper extraction system.

3.3.7 Aeration Monitoring. Soil-gas monitoring is performed to determine if vadose zone soils are being aerated by the bioslurper process and to what extent. This monitoring is conducted with the bioslurper system in operation and should be performed once a month. Aeration monitoring is performed by measuring oxygen, carbon dioxide, and TPH concentrations in soil gas collected from the soil-gas monitoring points. Concentrations should be recorded on the soil-gas survey information sheet in Appendix C. Procedures for soil-gas monitoring are detailed in Section 4.3.

3.3.8 Respiration Monitoring. Respiration monitoring is performed with the bioslurper system shut down to determine the change in biodegradation rate over time. It is recommended that the respiration test be performed quarterly during the first year of operation and semianually thereafter (during different seasons). Respiration monitoring should be conducted simultaneously with monitoring of LNAPL levels and recovery rates in wells in order to minimize the amount of bioslurper shutdown time. Procedures for respiration testing are described in detail in Section 4.4. An explanation of respiration test data calculations along with a worksheet is found in Appendix E.

3.4 Closeout Requirements. Cleanup criteria at the site, according to Florida State regulatory requirements, mandate that free product in excess of 0.1 inch thickness be removed from the water table. It is, however, stated in the Petroleum Contamination Site Cleanup Criteria that free-product recovery shall be deemed complete when free product has been removed to the maximum extent practicable (FDEP, 1994). Free product should be removed until LNAPL thickness at a well is reduced to less than 0.1 inch for a prolonged period. At this time, such a well may be eliminated from the bioslurper extraction system. If free product is not present or has a thickness of less than 0.1 inch in an extraction well, the well should be monitored to ensure that the product thickness does not increase. If at some time the free-product thickness in a well increases beyond 0.1 inch, it should be reincorporated into the extraction system. When product thicknesses are measured, the system should be shut down and the wells allowed to fully recover before taking readings. The LNAPL thickness and recovery data collected during the operation of the system should be evaluated frequently to decide what areas served by the bioslurper wells have been effectively remediated, so that some wells can be closed and the extraction can be limited to those wells with residual LNAPL.

As with any situ remedial technology, clean up times are difficult to accurately estimate; however, it is expected that removal of the recoverable free product at SWMU7 can be achieved within 6 to 12 months. If necessary, remediation can be expedited by installing additional extraction wells. After removing the free product, additional time may be required to biodegrade hydrocarbon contamination present in the vadose zone. The bioslurper extraction wells have been designed so that they can be easily urilized for bioventing.

Biodegradation of hydrocarbons in the vadose zone can be monitored by performing in situ respiration testing. When in situ respiration testing indicates that the site is clean, final soil samples may be taken. The extent and methodology of soil sampling necessary for site closure should be determined by the FDEP. Rule 17-77.200(2) of the Florida Administrative code defines excessively contaminated soils as soil which causes a total hydrocarbon reading of 50 ppm for Kerosene Analytical Group. This reading should be obtained with an organic vapor analysis on the headspace of a jar of contaminated soil. FDEP may additionally require laboratory analysis of soil samples to verify that the site has been successfully remediated. Sampling activities to meet closure requirements should be coordinated with the FDEP.

3.5 Disposal Requirements. Vapor-phase activated carbon canisters will need to be disposed of in an acceptable manner. This usually involves laboratory analysis to determine the type of contaminant, the loading, and possibly the flashpoint associated with the contaminant. Many manufacturers have disposal programs and will accept and recharge or otherwise dispose of used carbon canisters. Other generated waste may include fuel-contaminated sorbent pads and rags. These items should be disposed of in accordance with NAVSTA Mayport regulations.

Section 4.0: MONITORING, SAMPLING, AND ANALYTICAL PROCEDURES

4.1 Off-Gas Monitoring and Sampling.

4.1.1 Field Monitoring. This section describes procedures for monitoring O_2, CO_2, and TPH concentrations in the vapor stream using hand-held meters. It should be noted that field monitoring instruments are available from several manufacturers and distributors. The procedures described here are meant to serve as a general guideline; however, the operator should always refer to the operating instruction manual supplied by the manufacturer for detailed operational and calibration procedures. The off-gas stack emissions are monitored in the field according to the following method:

Step 1. Calibrate the O_2/CO_2 detector and the TPH detector according to the operator's manual provided with each meter (Appendix B).

Step 2. Install a female quick-connect fitting into the vapor discharge stack. Install a male quick-connect fitting onto a diaphragm pump.

Step 3. Use the diaphragm pump to draw an off-gas sample from the vapor discharge stack into the Tedlar™ bag.

Step 4. Connect the O_2/CO_2 detector to the Tedlar™ bag and draw off-gas through the detector until the reading stabilizes.

Step 5. Record the O_2 and CO_2 readings.

Step 6. Repeat steps 4 and 5 using the TPH meter.

4.1.2 Sample Collection for Laboratory Analysis. An evacuated stainless steel canister is required to collect off-gas to be sent in for laboratory analysis. A vapor sample is collected with a canister according to the following method:

Step 1. Install a female quick-connect fitting into the vapor discharge stack. Install a male quick-connect fitting on the evacuated stainless steel canister.

Step 2. Check the vacuum on the canister using a 0- to 10-inch (0- to 30.5-cm) mercury (Hg) vacuum gauge. Typically, the vacuum prior to sampling is ~30 inches (91.5 cm) Hg gauge pressure.

Step 3. Connect the canister to the vapor discharge stack via the quick-connect fittings and open the valve on the canister to collect the sample.

Step 4. Close the valve on the canister and disconnect it from the stack. Recheck the vacuum in the canister. It should now be at 0 inch (0 cm) Hg gauge pressure.

Step 5. Fill out the chain-of-custody form (Appendix C), package the form and the sample canister, and ship to the laboratory via air express for analysis.

4.2 Aqueous Sampling and Analysis. Aqueous samples should be collected from the locations and at the frequencies described in Section 3.3.6. Headspace-free samples should be collected in 40-mL

borosilicate glass volatile organic analysis (VOA) vials. The pH of the aqueous effluent samples should be adjusted with hydrochloric acid to a value of <2 to stabilize the organic species. The vials should be labeled, stored at 4°C, and shipped with the proper chain-of-custody forms for analysis. Recommended analytical methods are EPA Method 624/8400 for BTEX and modified 8015/LUFT Manual/BLS-191 for TPH. If regulatory requirements mandate that polycyclic aromatic hydrocarbon (PAH) testing be performed, U.S. Environmental Protection Agency (EPA) Method 8310 may be used.

4.3 Soil-Gas Sample and Soil Temperature Data Collection.

4.3.1 Tedlar™ Sampling Bag Method. A Tedlar™ gas sampling bag is generally used to collect soil-gas samples for field measurements. Soil-gas sampling is conducted as part of routine monitoring and also during respiration testing. The soil-gas samples are obtained from the soil-gas monitoring points by pumping soil gas into the sampling bag using a vacuum pump (Figure 3). The soil-gas samples can be analyzed using hand-held analytical meters for O_2, CO_2, and TPH. The O_2 data are most important for ensuring sufficient aeration of vadose zone soils by the bioslurper system and for determining representative biodegradation rates. Sample collection using the Tedlar™ sampling bag is relatively simple, but care must be taken not to cross-contaminate samples through improper cleaning of the bags between samples. Before the Tedlar™ bag is reused, it should be flushed with ambient air. Sample the soil gas in the monitoring point according to the following procedure:

Step 1. Calibrate the O_2/CO_2 detector and the TPH detector using the appropriate span gases (Appendix B).

Step 2. Connect the vacuum pump to the quick-connect coupling at the monitoring point. A liquid trap should be placed between the pump and the monitoring probe to collect any water that might be pulled from the monitoring probe (Figure 3).

Step 3. Turn on the pump and fill the Tedlar™ bag with soil gas, making sure the valve on the bag is in the open position.

Step 4. Flush the bag with soil gas once and then collect the final soil-gas sample.

Step 5. Disconnect the bag from the pump and close the valve on the bag.

Step 6. Analyze the soil gas in the bag for O_2, CO_2, and TPH using portable gas analyzers. Record the readings on the appropriate data sheet in Appendix C. If the oxygen concentrations are below 10%, a 1:1 diluter must be used when the TPH concentrations are being analyzed.

It should be noted that there is a risk of pulling in atmospheric air during purging and sampling at shallow monitoring points. Also, excessive purging and sampling may result in erroneous readings. There is no benefit in oversampling, and when sampling shallow points, care should be taken to minimize the volume of air extracted.

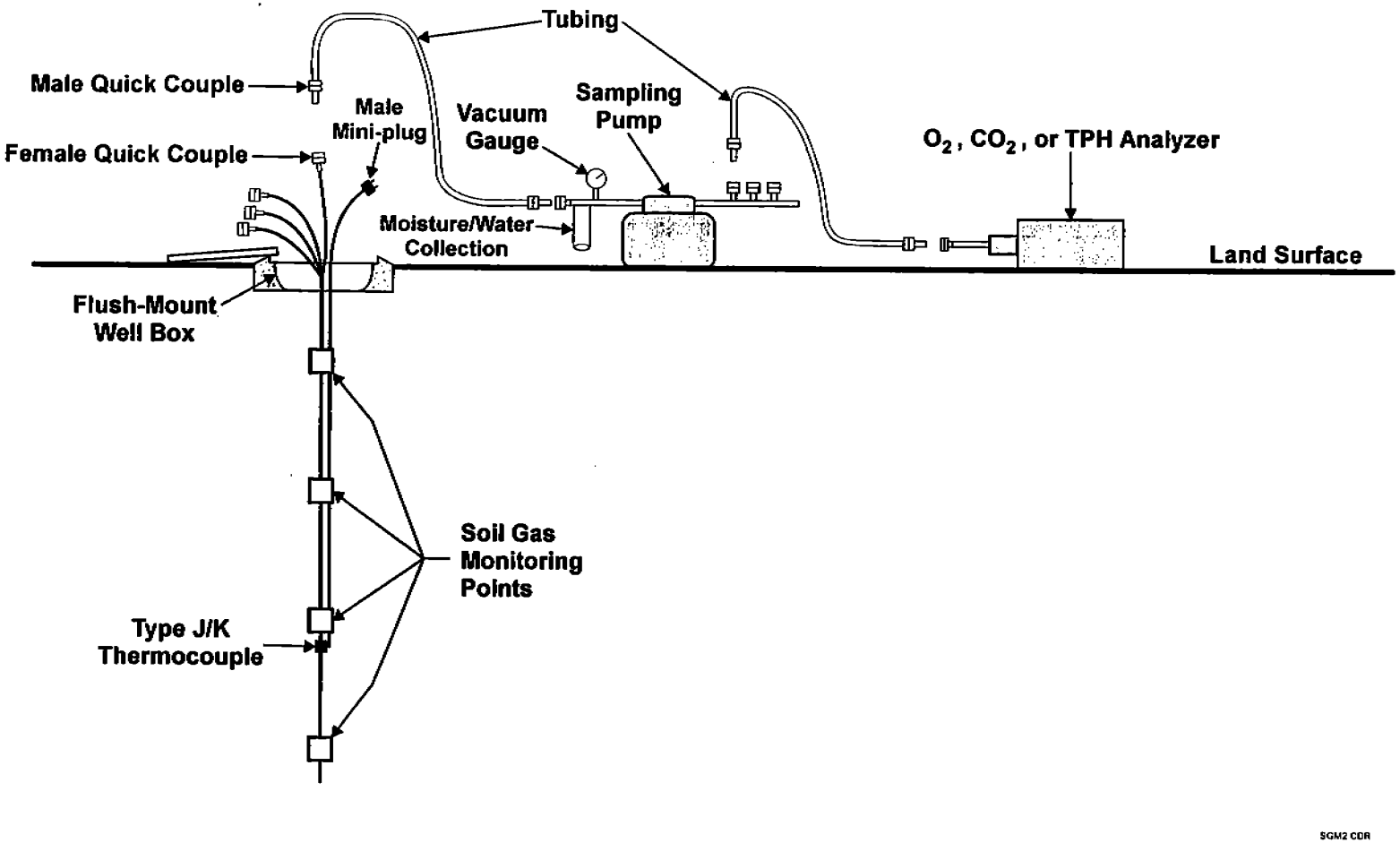


Figure 3. Typical Setup for Monitoring Soil Gas

4.3.2 Direct Soil-Gas Sampling Method. A convenient alternative to the Tedlar™ bag sampling method is to directly attach the gas detector to the monitoring point lines via the quick-connect couplings and proceed as described in steps 1 through 4 below:

Step 1. Calibrate the O_2/CO_2 detector and the TPH detector using the appropriate span gases (Appendix B).

Step 2. Attach the O_2/CO_2 detector to the monitoring point and draw soil gas through the detector until the reading stabilizes. Do not record the initial reading, because enough soil gas must clear through the detector to equal the amount originally in the monitoring point sampling line.

Step 3. Record the O_2 and CO_2 readings on the appropriate data sheet in Appendix C.

Step 4. Repeat steps 1 through 3 using the TPH meter.

This method should not be performed if water is expected to be present in the monitoring points. Pulling water through the meters will plug the filters inside the meter and potentially damage other internal components. For TPH readings, the direct soil-gas sampling method can be used only when the soil gas oxygen concentrations are >10%. If the O_2 levels drop below 10%, the 1:1 diluter must be used to collect accurate TPH concentrations. If soil-gas samples are directly collected with the 1:1 diluter attached to the TPH meter, back pressure created by the soil formation will alter the dilution ratio and generate incorrect data.

4.3.3 Soil Temperature Measurement. Soil temperature data are collected by means of soil temperature thermocouples (Type K or equivalent) placed in predetermined locations and depths during monitoring point construction. The data are collected through the thermocouple lead located at ground surface. Temperature readouts are obtained by connecting a Fluke Model 52 or equivalent thermocouple thermometer to the thermocouple lead and recording the data. Temperature data should be recorded along with soil-gas data on an appropriate data sheet (Appendix C). At the time of soil temperature measurement, changes in the ambient temperature also should be recorded.

4.4 Respiration Testing. Results from the respiration test will be used to determine the rate of microbial activity. To begin the shut-down respiration test, the bioslurper system is turned off. After shutdown of the system, the soil gas will be measured for O_2, CO_2, and TPH. To measure these parameters, soil gas will be extracted from soil-gas monitoring points using the soil-gas sampling method described in Section 4.3. Suggested frequencies and instrumentation to be used for the various parameters are shown in Table 2. Typically, soil-gas samples are collected at 2, 4, 6, and 8 hours and then every 4 to 12 hours, depending on the rate at which O_2 is being utilized. If O_2 uptake is rapid, more frequent monitoring will be required. If it is slower, less frequent readings will be acceptable. Standard respiration testing samples will be collected for 2 days; however, low O_2-use rates will require longer test periods. If the O_2 concentrations have not decreased below 5% after 5 days, the test should be terminated. Record concentrations and times of readings on a record sheet for in situ respiration testing similar to that found in Appendix C. The biodegradation rate can be calculated from the rate of oxygen utilization. The method for calculating the oxygen utilization and biodegradation rates is presented in Appendix E.

Table 2. Soil-Gas Parameters to be Measured for the Shutdown Respiration Test

Parameter	Suggested Instruments	Suggested Frequencies	Instrument Sensitivity
CO_2	Infrared adsorption method, GasTech Model 32520X (0 to 25% CO_2)	Immediately after bioslurper shutdown, every 2 hours for the first 8 hours, and then every 4 to 12 hours for the next 2 to 5 days	±0.2%
O_2	Electrochemical cell method, GasTech Model 32520X (0 to 25% oxygen)	Same as above	±0.5%
TPH	GasTech hydrocarbon detector	Same as above	±1 ppm

Section 5.0 TROUBLESHOOTING

Problems that may occur while operating the bioslurper system are described in Table 3. The table outlines the problem, the most likely causes for each problem, and the corrective action which should be taken. In the case of electrical difficulties, a certified electrician should be called to diagnose the problem and perform the repairs. In general, pumps and blowers should not be disassembled in the field as this may void the manufacturer's warranty and compromise the explosion-proof rating of the unit. Repair of these units should be performed by the manufacturer or a licensed repair shop.

Table 3. Troubleshooting Guidelines for Operating a Bioslurper System

Problem	Probable Cause	Solution
Liquid ring pump shut off	Kill switch is activated	Determine which switch has been activated. Check the annunciator panel to determine which lamp is off. High- and low-level switches are located in the liquid ring pump seal water tank. Also, high-level switches are placed in the surge tank and the 20,000-gallon storage tanks. Determine why the switch has tripped and correct the problem. Restart the liquid ring pump.
	Pump shuts down due to overcurrent	The reset button must be pressed before restarting the system if overcurrent has caused the pump to shut down. If the system can be started by pressing the start button (without pressing the reset button), the failure is not caused by overcurrent. An overcurrent condition could occur as a result of an improper ampere setting on the motor starter, an unbalanced power supply, an attempt by the pump to pull large slugs of water, a large backpressure, improper seal water flowrate, or scale buildup in the pump. The following instructions detail the procedure to determine the cause of the overload. *Ampere Setting*: Turn power off at disconnect. Open the panel on the liquid ring pump. The overload protector is located on the motor starter. It should be set at 125% of the current required at maximum load (the current required at maximum load is printed on the motor identification plate). Adjust if necessary. Close panel. Turn on power.

Problem	Probable Cause	Solution
Liquid ring pump shuts off (Continued)	Pump shuts down due to overcurrent (Continued)	*Unbalanced Power Supply*: Measure the current drawn by the motor as it is operating. First, shut off the power at the disconnect. Open the round junction box above the control panel. The wires from the right side of the box are the supply wires. Situate the wires so that they can be reached easily with a clamp-on ammeter. Turn on the power. Turn on the ring pump. Clamp the ammeter onto one of the supply wires. Measure the current. If the current is high on one power line, there may be a loose wire connection, or the power supply may be unbalanced. *Pulling Large Slugs of Water*: This problem should not occur if an equalizing drum is used. If the problem persists, an equalizing drum with a greater surface area must be used. *High Backpressure*: The manufacturer recommends that the backpressure remain below 2 psig when the liquid ring pump is operated at 20-inch Hg vacuum. If fouling occurs in the lines on the discharge side of the pump, excessive backpressure may be placed on the liquid ring pump. Clean out the lines.
		Improper Seal Water Flowrate: If the extraction flowrate is high, the seal water flowrate may need to be reduced, otherwise the liquid ring pump may draw too many amperes and shut off. Check the flowmeter located in line between the pump and the liquid ring pump reservoir. Follow the manufacturer's literature for setting the proper seal water flowrate; G.C., 5 gpm for 7½ mp liquid ring pump.

Problem	Probable Cause	Solution
Liquid ring pump shuts off (Continued)	Pump shuts down due to overcurrent (continued)	*Scale Buildup*: If scale has fouled the inside of the pump housing, the motor may not start. Attempt to rotate the vanes (located at the rear of the motor housing) with a screwdriver. If they will not move, scale buildup probably is the problem. The pump head can be removed to determine if scale is present. If the pump requires descaling, contact the manufacturer for acidizing instructions. (Appendix A)
	Pump shuts down due to thermal overload	The liquid ring pump motor is equipped with a thermal overload switch. The contacts will open up if the motor becomes too hot. If a thermal overload condition occurs, wait 10 to 15 minutes and restart the system. The reset button does not need to be pressed prior to restarting the system. If it must be pressed, the malfunction is related to excess current. Determine the cause of the overload before restarting the pump. Some possible causes include improper seal water level, faulty thermostat, scaling, and faulty motor. Check thermostat leads with an ohmmeter. If the circuit is open, the motor has either overheated or burned out, or the thermostat is bad.
	Pump motor turns off when start button is released	The electrical control circuit is open. This will occur when one of the three float switches is opened, the thermostat is opened, or a relay on the annunciator panel is open. See above sections concerning the float switches and thermostat. Press the reset buttons on the annunciator panel.
Liquid ring pump will not start but electric power is present at the input to the pump control	Transformer has burned out	Turn off the power at the disconnect. Open control panel. Check voltage across X1 and X2 on transformer secondary. The voltage should be approximately 120 V.
	Transformer fuse has blown	Turn off the power at the disconnect. Check the fuse. If the fuse is blown, there may be a short in the 120-volt control circuit. Determine the location of the short.

Problem	Probable Cause	Solution
Liquid ring pump loses vacuum	Scale has built up in the Y strainer at the liquid ring pump inlet	Clean strainer.
	System vacuum has decreased	Examine all valves to determine if they are in their proper positions. Measure vacuum at ring pump, knockout tank, LNAPL tank, and wells to determine if there is a leak in the system. Repair leak if present. High seal water temperature is preventing a proper seal from forming inside the pump head. Check the operation of the heat exchanger.

Section 6.0: HEALTH AND SAFETY REQUIREMENTS

The full-scale bioslurper must be constructed and maintained in a manner that maximizes the protection of health and safety for workers and the public. The bioslurper design must incorporate features to avoid unsafe conditions and activities. The health and safety program must comply with OSHA's provisions in 29 CFR 1910.120 and other OSHA requirements. All laboratory activities must comply with the OSHA chemical hygiene standards defined in 29 CFR 1910.1450. Additional health and safety standards generally applicable to protection of workers at bioslurper sites are summarized in Table 4.

Table 4. Applicable Health and Safety Regulations

Topic	Reference
General industry standards - 29 CFR Part 1910	
Walking and working surfaces	Subpart D 1910.21-.32
Occupational noise exposure	Subpart G1910.95
Hazardous Waste Operations and Emergency Response	Subpart H 1910.120
Personal protective equipment	Subpart I 1910.132-.140
Sanitation	Subpart J 1910.141
Medical and first aid	Subpart K 1910.151-.153
Toxic and hazardous substances	Subpart Z 1910.1000-.1500
Construction industry standards - 29 CFR Part 1926	
Occupational health and environmental controls	Subpart D 1926.50-.57
Personal protective and life-saving equipment	Subpart E 1926.100-.107
Fire protection	Subpart F 1926.150-.155
Signs and signals	Subpart G 1926.200-.203
Motor vehicles and mechanical equipment	Subpart O 1926.600-.604
Excavations, trenching, and shoring	Subpart P 1926.650-.652
Power transmission and distribution	Subpart V 1926.950-.957

Field activities are controlled by a site Health and Safety Plan (HASP), per 29 CFR 1910.120. The HASP must assign roles and responsibilities, establish standard operating procedures, and provide for safety contingencies. A typical HASP consists of a site description; project and technology descriptions; key personnel and training requirements; hazardous and toxic materials identification; hazard evaluation; site control procedures; monitoring procedures; protective, monitoring, and emergency equipment; decontamination and disposal procedures; and emergency procedures.

The HASP used by Battelle for pilot-scale testing at NAVSTA Mayport is found in Appendix F. This HASP may not cover the full range of activities which are associated with installation and operation of a full-scale system. It is expected that parties contracted to conduct bioslurper activities will revise a version of their own HASP to address site-specific conditions and the nature of the demonstration activities to be conducted. Table 5 lists the primary health hazards and threshold limit values (TLVs) expressed as time-weighted averages (TWAs) for the primary contaminants that would be encountered at a site where bioslurping would be used to remediate petroleum hydrocarbon contamination.

Table 5. Primary Health Hazards and Threshold Limit Values for Chemical Substances Expected at NAVSTA Mayport

Compound	TLV-TWA[a] (ppm)	Primary Health Hazard
Total Petroleum Hydrocarbons	300	Dizziness, drowsiness, irritated eyes
Benzene	10	Irritated eyes and nose, headache, nausea, fatigue, carcinogenic
Toluene	50[b]	Irritated eyes and nose, nausea, affects liver and central nervous system
Xylenes	100	Irritated eyes and nose, nausea, affects liver and central nervous system
Mineral Spirits	100	Irritated eyes and nose, nausea, dizziness, affects liver and central nervous system
Diesel Fuel	NA[c]	Irritated eyes and nose, nausea, dizziness, affects liver and central nervous system

(a) American Conference of Governmental Industrial Hygienists, 1995.
(b) Skin contact.
(c) Not available.

Personnel working at field operations must recognize and understand the potential health and safety risks associated with work at the site and must be trained in accordance with the OSHA 29 CFR 1910.120 regulations described in Section 3.1.1. The health and safety program also must include a medical surveillance program that complies with the regulations and guidelines set forth in OSHA 29 CFR 1910.120(f) and 29 CFR 1910.134. As a prerequisite to fieldwork, all workers must undergo a physical examination that includes a medical examination and documentation of work history with emphasis on symptoms related to the handling of hazardous substances, health hazards, and fitness for expected tasks, including the ability to wear any required personal protective equipment.

During employment, a physical examination must be performed at regular intervals as determined by the health and safety officer and the attending physician. In addition, upon termination of employment, another examination must be performed. Any worker who has received a potentially harmful level of exposure to a hazardous material must undergo a supplemental examination. Copies of medical documentation certifying that each worker is medically qualified to perform the tasks associated with bioslurper installation and operation must be maintained on site at all times and include the date of the individual's last exam.

As part of the health and safety program, procedures must be implemented to maintain site-specific documentation. Documents required on site at all times include the HASP, material safety data sheets

(MSDSs) for every chemical that is used and/or stored on site, medical records, health and training certification, and accident reports. These documents must be readily accessible by all field personnel.

Section 7.0 REFERENCES

American Conference of Governmental Industrial Hygienists (ACGIH), 1995. *1995-1996 Threshold Limit Values (TLVs™) for Chemical Substances and Physical Agents and Biological Exposure Indices (BEIs™).*

Battelle. 1996a. *Full-Scale Conceptual Design of Bioslurper System for SWMU7 at Naval Station Mayport, Florida.* Columbus, Ohio.

Battelle. 1996b. *Best Practices Manual for Bioslurping.* Columbus, OH.

Florida Department of Environmental Protection. 1994. *Petroleum Contamination Site Cleanup Criteria.* Ch. 62-770.

APPENDIX A

MANUFACTURERS' LITERATURE

LIQUID RING PUMP

1.0 GENERAL DESCRIPTION - FLUID VAC® SYSTEM

Fluid-Vac liquid ring vacuum pumps are designed to operate over the full vacuum range from 0 - 28" Hg. Because of the unique axial flow design the pumps operate at constant horsepower throughout the full vacuum range. They are designed to handle groundwater as well as extracted vapor, and so Fluid-Vac pumps are used extensively for dual phase extraction of liquids and gases. Inlet separator tanks, required by competing vacuum pumps, are not necessary on Fluid-Vac systems.

Atlantic Fluidics soil venting vacuum pump packaged units consist of a Fluid-Vac liquid ring vacuum pump, close coupled to motor, seal water reservoir tank with gauge glass, electrical motor controller, inlet strainer, low water shut off switch, water make up valve, seal water flow control valve, and interconnecting piping and wiring, fully mounted and assembled on steel baseplate. Dual phase extraction systems include a centrifugal transfer pump, float switches for operating the transfer pump, piping, and wiring to electrical controller. The system described above is illustrated in Figure 1.

OPERATION - VAPOR EXTRACTION

The liquid ring vacuum pump suction is connected to the soil venting wells and its function is to extract vapors from contaminated soil. The vacuum pump utilizes water for its pumping action. A description of the vacuum pump is provided in the attached brochure.

In operation, the vacuum pump extracts vapors from the soil, and the vapors and seal water are discharged to the water reservoir tank. There, water and vapor are separated, and the vapor is vented to atmosphere or piped to incinerators or activated charcoal adsorbers. The water is recirculated from the bottom of the tank to the vacuum pump inlet, thus providing a closed loop seal water system. A gauge glass is provided on the tank to indicate water level.

The vacuum pump system is designed to operate unattended continuously, 24 hours per day, 365 days per year. It can operate in a vacuum range of 0-28" Hg vacuum. Vacuum in the suction lines can be adjusted by means of air bleed valves or vacuum relief valves.

The electrical control consists of a motor starter with push button on/off switch and a float switch. The function of the float switch is to shut down the vacuum pump when seal water is depleted from the tank. Since there are evaporation losses the seal water must be replenished periodically. A fresh water supply pipe or hose may be piped to the 1/2" connection on the float valve. If pressurized water is not available the tank must be filled periodically by hand.

A Y strainer is provided on the vacuum pump suction. Its function is to prevent particulate matter from entering the pump. It should be checked periodically and cleared of collected debris. Normally, some sediment will pass through the inlet

strainer, and it will collect in the seal reservoir tank. The tank drain should be opened periodically to remove accumulated sediment. The strainer in the recirculated seal water line must be checked also and cleared of sediment. It is important to insure that the flow of recirculated seal water is not restricted.

When operating in the high vacuum range it is possible for cavitation to occur. This condition is usually accompanied by noisy operation with the pump making a gravelly sound. Cavitation is caused by the pump being starved of air or noncondensable gas. The cure is to provide an air bleed on the suction piping close to pump inlet or a vacuum relief valve.

When using an air bleed valve, open it just enough to stop the noisy operation but not so much as to decrease pump capacity.

2.0 OPERATION - DUAL PHASE EXTRACTION

Fluid-Vac soil remediation systems designed for dual phase extraction of groundwater as well as vapor, are provided with a centrifugal transfer pump and float switches to operate the transfer pump. A typical electrical control system schematic is described on Figure 2.

Switches are provided in the reservoir tank to operate as follows:

1. Low-Low Switch. Normally open. Closes with water in tank. If water level drops below Low-Low switch the Fluid-Vac pump stops. This prevents pump from running dry.

2. High-High Switch. Normally closed. Opens when water fills the tank to upper permissible level. When water level rises above High-High switch the Fluid-Vac pump stops. This prevents water from being blown out of the tank vent.

Transfer Pump Controls

1. Low Switch. Normally open. Closes when ground water fills tank above level of the switch. Opens when water level falls below switch level.

2. High Switch. Normally open. Closes when ground water rises to switch level, starting the transfer pump.

The transfer pump pumps water out of the tank until the Low switch stops the pump. The pump starts and stops on demand from the High and Low switches.

START UP

Start up instructions for the vacuum pump are outlined in detail in the appended Installation and Service Manual. The necessary connections are as follows: piping from the extraction wells is connected to the pump inlet. It is recommended that the piping be looped up to a height above the water level in the reservoir tank so that, in the event of leakage past the check valve, the water will not be able to drain out of the reservoir tank.

The water supply should be piped to the hose connection on the seal water make-up valve. The ball float valve opens when the water level drops and closes when the water level is at the desired level. If pressurized water is not available, the seal water tank should be filled periodically as required by hand.

The vapors are discharged from a pipe fitting at the top of the reservoir tank. The tank is designed to hold pressure up to 15 psig, and so on certain applications it may be desirable to utilize the back pressure to pump the vapors through carbon adsorption cannisters or to incinerators.

SHUT DOWN

After the field has been stripped of contaminants, the vacuum pump package can be shut down. The water in the reservoir will have become contaminated by the vapors and so it is desirable to strip contaminants out of the water before draining the system. This can be done simply by opening the suction to atmosphere and sucking fresh air through the vacuum pump. After a short period of time the clean air flow will effectively strip out contaminants contained in the system and the water can then be disposed of without additional pollution to the environment.

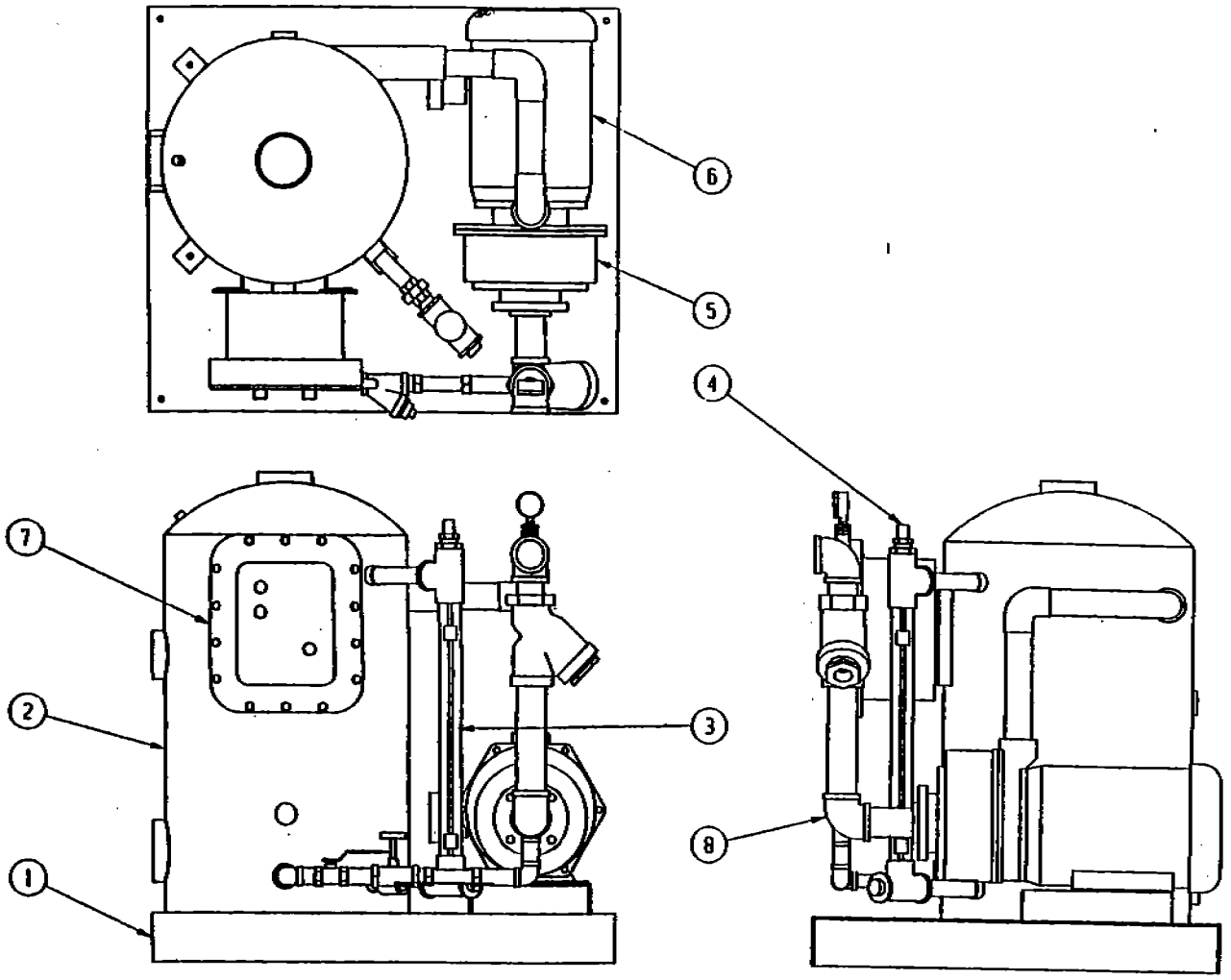
3.0 SYSTEM COMPONENTS

1. Water Make-up Valve. The purpose of the seal water make-up valve is to ensure that there is a constant level of water in the seal water reservoir tank. When no groundwater is being brought into the system water is lost because of evaporation. The make-up valve provides a means of replenishing evaporative losses.

The valve has a ball float with lever arm that actuates the valve. The valve is connected by 1/2" NPT pipe fitting to a pressurized seal water source. The ball floats on the surface of the water in the tank. As water level drops the ball float drops, opening the valve. This permits water, under pressure, to enter the reservoir tank. When the proper level is achieved the valve closes.

If the valve leaks check for scale build-up or deterioration of the valve seat. If water supply pressure is excessive leakage may occur. This can be corrected by

REVISIONS			
REV	DESCRIPTION	DATE	APPROVED



NO.	DRAWING NO.	DESCRIPTION	QTY
8	A204-A100-04	PIPING ASSEMBLY	1
7	A207-A100-06	ELECTRICAL CONTROL	1
6	A219-A100-02	MOTOR	1
5	B999-A100-01	A100 VACUUM PUMP ASSEMBLY	1
4	A222-A75-15	FLOAT SWITCH ASSEMBLY	1
3	A221-A75-02	SIGHT TUBE	1
2	B213-A100-08	TANK	1
1	B023-A100-05	BASEPLATE	1

Drawn: KK
Date: 08/10/95

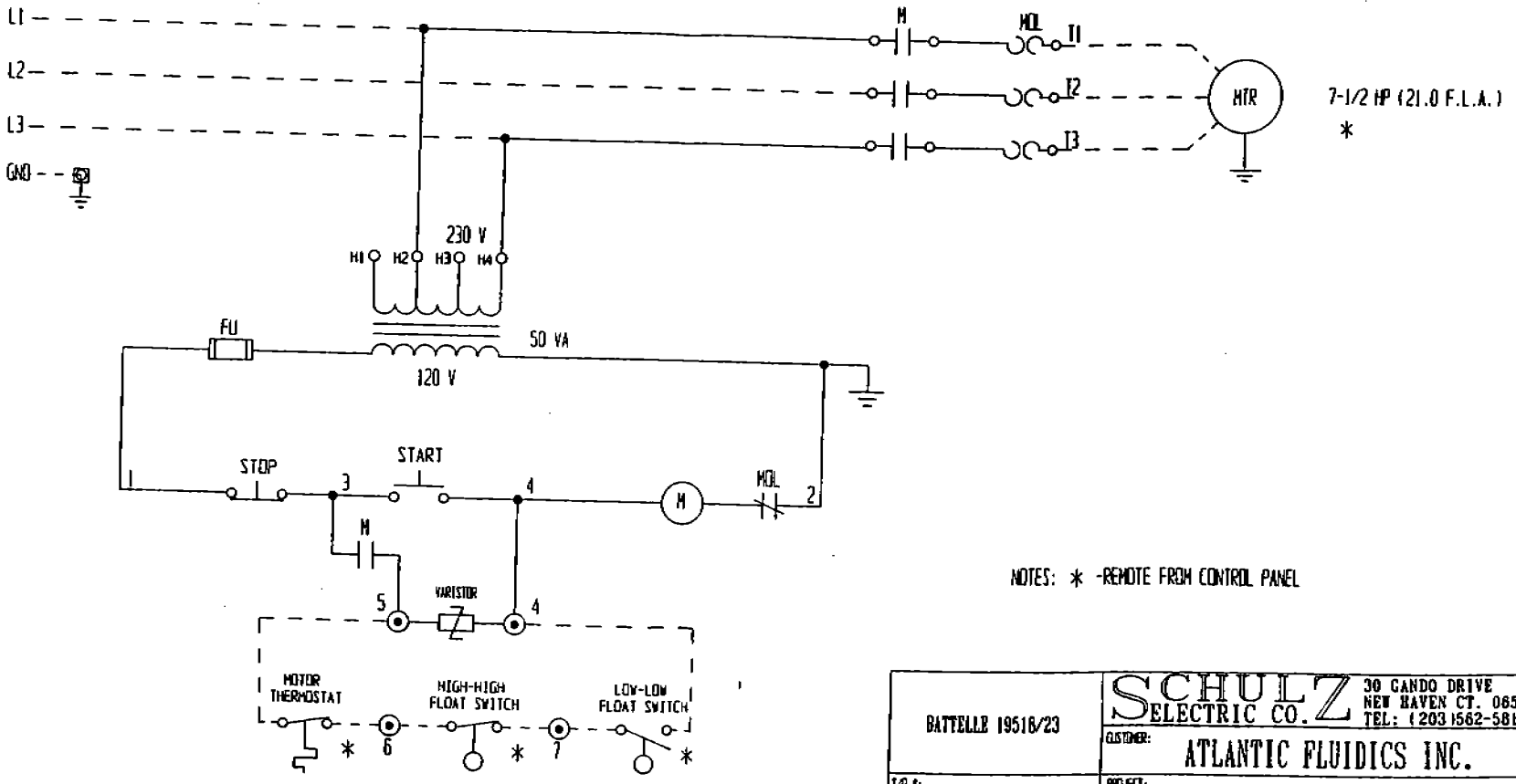
atlantic fluidics, inc.

A100 SOIL REMEDIATION PACKAGE
(SIMPLEX/BASIC/3Ø/7.5HP/GALV.42S/EXT)

SIZE	FSCM NO.	DWG NO.	REV
B		B996-A100-04	A
SCALE 1:10	CAD FILE NO: 996-066A	SHEET 1 of 1	

REVISIONS			
REV	DESCRIPTION	DATE	APPROVED

INCOMING: 230V 3PH 60HZ

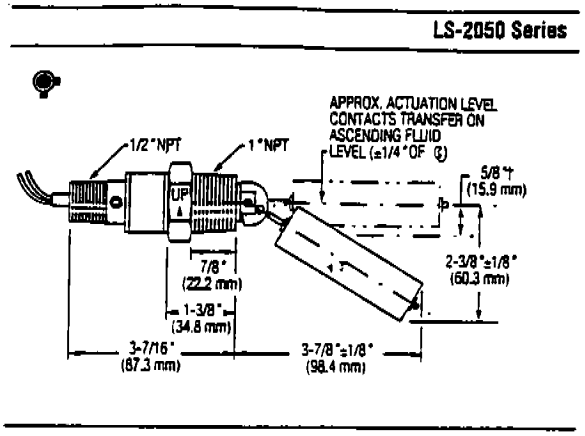


NOTES: * -REMOTE FROM CONTROL PANEL

BATTELLE 19516/23	SCHULZ ELECTRIC CO. 30 GANDO DRIVE NEW HAVEN CT. 06513 TEL: (203)562-5811		
	CUSTOMER: ATLANTIC FLUIDICS INC.		
S/O #: 7969-23	PROJECT: NEMA-7 CONTROLLER 7-1/2HP 230V 3 PHASE		
DWG BY: C. JANUS	SIZE B	DATE: 2/21/96	DWG NO. 96018B01 REV
APP BY: J. KOWERDOVICH	SCALE N/A		SHEET 1 OF 1

installation of a pressure regulating valve that can reduce water pressure to 15 psig. A Watts Model 1156F or S1156F valve is recommended.

2. Low Level Shut Off Valve. In order to ensure that the Fluid-Vac pump does not run dry a low level shut off valve is installed in the tank or in the external sight glass. The tank mounted valve is IMO (Gems Div) Model LS-2050 series shown below.



When the float is in the up position electrical contact is closed. When the float drops to the down position contact is open and the Fluid-Vac pump is automatically shut down.

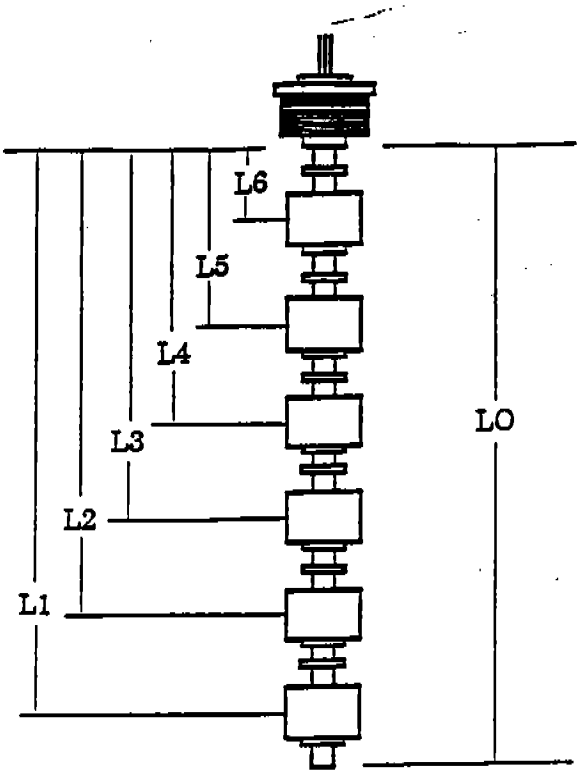
Late model Fluid-Vac soil remediation systems have liquid level switches mounted on a common stem in an external sight glass. Wires from multiple switches are color coded as shown on the attached IMO (Gems Sensors Div) specification sheet.

3. Transfer Pump. A centrifugal pump is provided on dual phase extraction systems. Its function is to pump away groundwater recovered from the wells. The pump is started and stopped on command from high and low level switches in the seal water reservoir tank. The pump is sized to handle the maximum groundwater extraction rate of the Fluid-Vac pump.

A spring loaded check valve is provided on the pump discharge. Its function is to overcome up to 2 psi tank pressure to prevent water from being displaced from the tank when the transfer pump is not operating.

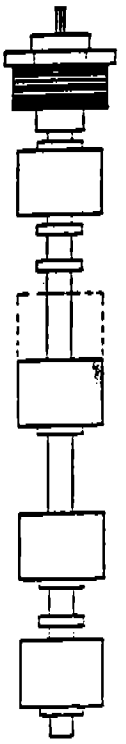
4. Strainers. A strainer is provided on the Fluid-Vac pump suction. Its function is to remove any particulate matter that may be harmful to the pump, such as gravel, sand, etc. The strainer should be checked periodically and cleared of debris.

Actuation Levels . . .



Actuation level distances and overall unit length is measured from inner surface of mounting plug or flange.

Minimum Actuation Levels . . .



A - 2-1/16" min. distance to highest level

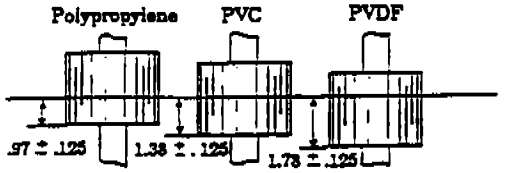
B - 2-11/16" distance from end of unit to lowest level

C - 3-1/2" min. distance between levels

D - 1/4" to 3-1/2" between level actuation points using one float ONLY.

Float Submersion Depths . . .

(In Water (Sp. Gr. of 1.0)

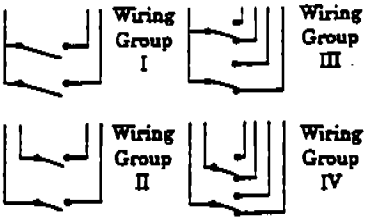


Actuation Levels Tolerance: ± .125"

Float Specific Gravity: PP = .41 ± .01 . . . . PVC = .58 ± .01
PVDF = .75 ± .01

Typical Wiring Diagrams . . .

LSP-800 Standard Units



Two actuation levels are shown in each group diagram. Switches are shown in normal (dry) position.

Switch Ratings . . .
SPDT - 20VA
SPST - 100VA

	SPST SWITCHES			SPDT SWITCHES				
	Group I	Group II		Group III		Group IV		
Wire Size	#22 AWG	#22 AWG		#22 AWG		#22 AWG		
Unit Com.	Black	None		Black		None		
	NO/NC	Sw. Com.	NO/NC	NO	NC	Sw. Com.	NO	NC
L1	Red	Red	Red	Red	Wh/Red	Red	Wh/Red	Wh/Blk/Red
L2	Yellow	Yellow	Yellow	Yellow	Wh/Yel	Yellow	Wh/Yel	Wh/Blk/Yel
L3	Blue	Blue	Blue	Blue	Wh/Blu	Blue	Wh/Blu	Wh/Blk/Blu
L4	Brown	Brown	Brown	Brown	Wh/Brn	Brown	Wh/Brn	Wh/Blk/Brn
L5	Orange	Orange	Orange	Orange	Wh/Orn	Orange	Wh/Orn	Wh/Blk/Orn
L6	Gray	Gray	Gray	Gray	Wh/Gra	Gray	Wh/Gra	Wh/Blk/Gra

A seal water strainer is provided to remove abrasive material from the seal water system prior to its entering the Fluid-Vac pump. Periodic cleaning is required.

Note: The strainers do not remove fine particles or clay and there may be a buildup of sediment in the bottom of the seal water reservoir tank. A 4" hand hole is provided near the bottom of the tank to facilitate tank clean-out.

4.0 DESCALING INSTRUCTIONS

1. Take water sample from seal water reservoir tank. The drain cock on the gauge glass can be used. Alternately, a water sample can be obtained by removing the plug from the seal water strainer or the tank drain connection.

2. Check pH of the water sample. If pH is 8.0 or above the seal water is alkaline. It can be lowered to neutral 7.0 pH by adding descaling compound. If pH is 6.0 or lower the seal water is acidic. It can be raised the neutral 7.0 pH by adding caustic.

3. Calcium carbonate scales are the most commonly encountered in hard water areas. This scale can be removed by muriatic acid, which is available in hardware stores, or other agents used for descaling condensors, cooling towers, etc. RYDLYME, a descaling agent manufactured by Apex Engineering Products Corp, Tel: 800-451-6291 is non- hazardous, biodegradable, and USDA and FDA approved. When using descaling agents take special precautions to follow manufacturers use and safety instructions.

4. If the pump is in running condition it is easy to descale the pump while it is running by following these descaling instructions:

a) Close off the valve on the pump suction connection so that vacuum reading on the gauge is over 20" Hg. This will reduce the air flow out of the discharge. If the pump is pulling up groundwater close off the valve to prevent the introduction of water in the system.

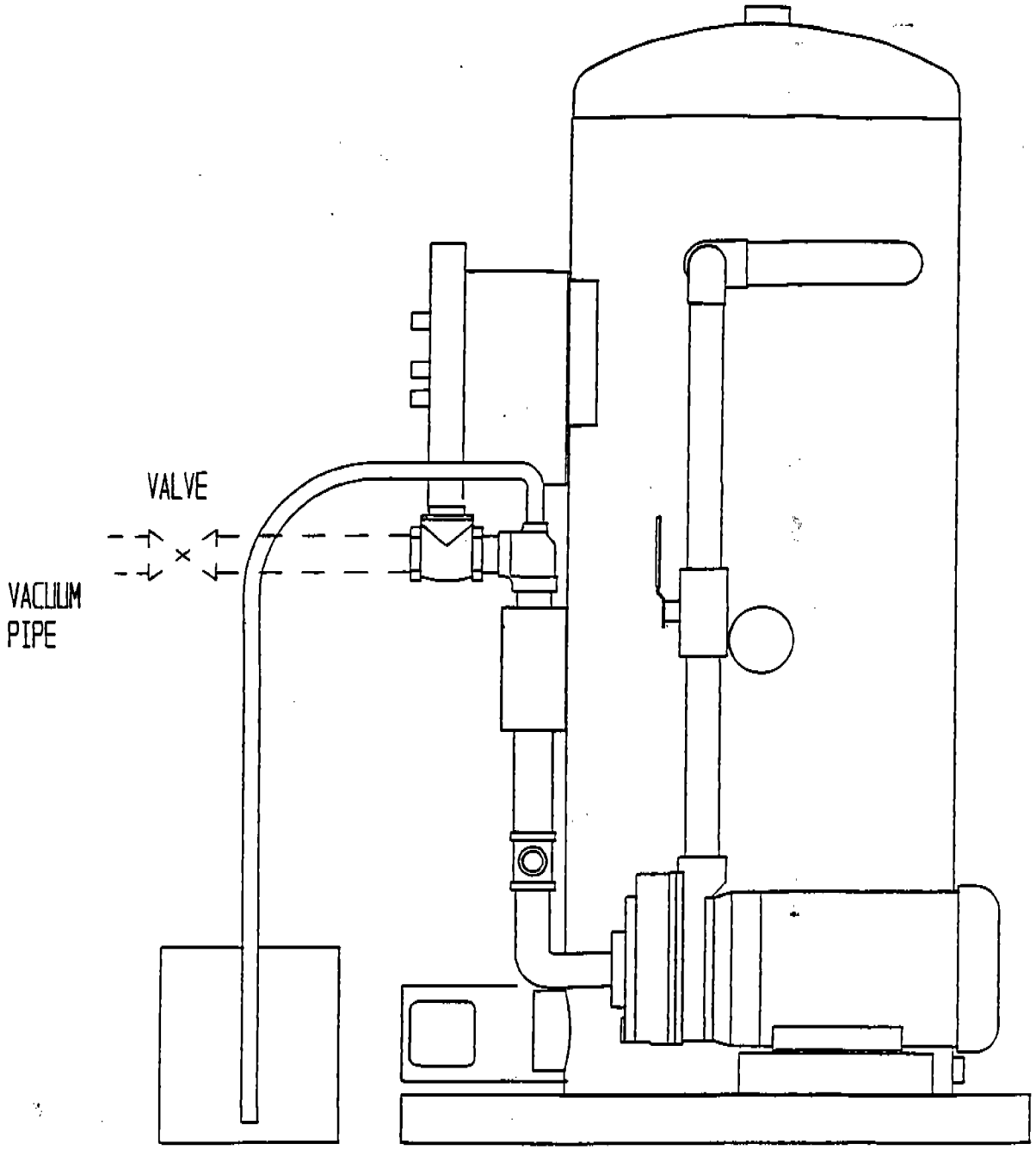
b) Attach a tube and valve connection on the inlet piping. (See Fig. 3) Place tube end in a container of descaling compound and allow the vacuum to draw the compound into the pump. The descaling compound will immediately go into solution with the seal water in the pump and will remove rapidly the scale from the pump interior. The reaction will produce CO2 gas which is vented out of the reservoir tank discharge.

c) After running for a few minutes withdraw another sample of seal water from the tank and check pH. Add additional descaling compound until the pH is below 7.0. This will indicate that the seal water has been neutralized. Be sure the vapor discharge or the tank is vented so that there is no build-up of pressure caused by the liberation of carbon dioxide.

d) The above procedure can be repeated on scheduled intervals so that the concentration of scale never builds up to the point where pump clearances are closed and the rotor locks in the casing.

5. Scale build-up may cause the pump rotor to bind up and the motor cannot turn. The scale can often be removed by the following descaling method:

a) Shut off ball valve in seal water line between tank and pump inlet.



1. REMOVE GAUGE & PLUG
2. INSTALL VALVE, PIPING & HOSE CONNECTION
3. INTRODUCE DESCALING COMPOUND INTO PUMP SUCTION

(FIG. 3)

b) Remove plug from the tee on pump inlet vacuum piping and add descaling compound. Late model pumps have a 1/8 NPT vent cock on the upper part of the cover. Connect tube to vent and place the end in a bucket or container. During descaling carbon dioxide is formed with accompanying froth. Some froth will spill out of the tube into the container.

c) The vacuum pump discharge must be open so as to vent off carbon dioxide to the reservoir tank.

d) Add descaling compound and let it react with scale in the pump until all scale has been removed. Be sure to use safety glasses, gloves and protective wear whenever using descaling compounds-observe manufacturers recommendations.

e) Remove fan cover from back of motor and rotate the motor shaft by use of wrench. Do no exert unnecessary force. Rotate the shaft slowly so that the descaling compound can react to all of the pump internals.

f) After the pump has been descaled drain out residual descaling compound and plug the vent connection. **DO NOT START PUMP UNTIL IT HAS BEEN DRAINED AND RE-PRIMED.**

6. If scale build-up has progressed to the point that the rotor will not turn, it may be necessary to disassemble the pump. The disassembly procedure is as follows:

a) Shut off the seal water line by closing the ball valve between the tank and the pump.

b) Disconnect the seal water piping at the union on the flow control valve. Remove four retaining bolts on the pump suction flange and remove the inlet piping manifold.

c) Remove four hex head bolts and two Allen head bolts from the cover (Models A10-A20 have four hex head bolts only).

c) Tap cover lightly with soft blow hammer and try to work the cover loose by pulling forward. If not tightly bound up the cover and port cylinder assembly should slide off of the rotor. Do not use a mechanics steel hammer, chisel, screwdriver or other object that would damage the bronze cover or casing.

d) If the cover can turn, rotate it a few degrees and use long jack screws on opposite sides of the cover to start jacking the cover off the rotor. In order to not damage the face of the casing steel shims should be inserted between the cover and the casing so that the jack screws work against the shims instead of the bronze face of the casing.

e) Check to see if the rotor will rotate. If it is not free to rotate it must be removed by means of a gear or wheel puller. If the rotor is tightly locked on the shaft heating the hub will cause the metal to expand and the rotor should break loose. **BE SURE TO PROTECT MOTOR SHAFT THREADS WHEN APPLYING PULLER.**

f) If the rotor is free to rotate, remove scale build-up on the port cylinder and/or rotor bore and slide the cover/port cylinder assembly back on the rotor. When repositioning the cover on the pump turn the motor shaft by hand from the fan end of the motor. Replace the cover bolts with four hex head bolts on tap and side and two Allen head bolts on the bottom.

g) Once the pump is reassembled and can be started, replace the inlet manifold and seal water line. Open the seal water valve and allow water to fill the pump. Then, to clean away residual scale build-up follow the descaling procedure outlined in (4) above.

5.0 TOOLS REQUIRED FOR FIELD REPAIR

15/16"	Open End Wrench	(Flange Bolts)
3/4"	Open End Wrench	(Cover Bolts)
3/8"	Allen Wrench	(Cover Bolts)
9/16"	Socket w/extension	(Lock Bolt)
11"	Two Jaw Gear Puller	(Rotor)
3/16"	Allen Wrench	(Port Cylinder)
9/16"	Open End Wrench	(Pump Mounting)
18"	Pipe Wrench	(Union on Discharge Pipe)
	Flat head screwdriver	(Fan & Fan Cover)

SPECIAL TOOLS

Extension Screw for Gearpuller

Jacking Bolts & Plates for removing cover when scaled & locked

6.0 FREEZE PROTECTION

Fluid-Vac liquid ring pumps are normally sealed with water which freezes at 32°F. When operating in an environment where the ambient temperature is below 32°F freeze protection must be provided.

While operating, the vacuum pump is not subject to freezing because the heat of compression is absorbed by the seal water. Liquid velocity and heat input are adequate to prevent freezing. However, when the equipment is shut down and ambient temperature is below 32°F residual water in the pump, piping and reservoir tank must be freeze protected.

Anti-freeze. In some installations it is possible to add antifreeze (glycol) to the seal water to lower its freeze point. Addition of glycol does not affect pump performance, but evaporation losses are to be expected. An environmentally safe antifreeze should be used.

Electrical heaters. If the Fluid-Vac system is not in an enclosure that can be heated strip heaters can be applied to all surfaces where water is subject to freezing. Flexible heating tapes, blanket heaters and strip heaters are available from a number of sources, including Graingers, McMaster-Carr and BriskHeat Company. In hazardous locations, care should be taken to provide electrical equipment meeting NEC code specifications as outlined in the attached, as reprinted from BriskHeat Bul EG-543.

NOTE: Any time the Fluid-Vac system is to be transported or put into storage the Fluid-Vac pump, transfer pump, piping, and tank **must be drained.**

7.0 FLUID-VAC SOIL REMEDIATION TROUBLE SHOOTING GUIDE

Pump will not start:

1. Check power to control panel with a voltmeter.
2. Check wiring connections in control panel.
3. Check voltage on transformer secondary. It should be approx 120 V.

Pump motor turns when ON button is pressed, but stops when button is released. Cause: Electrical control circuit is open.

1. Make sure water is in the reservoir tank. With ohmmeter check wires connecting the low level switch. If open the float switch is stuck. Remove switch and check operation.

2. Check fuse. If the fuse has blown there is a short in the 120 volt control circuit. Check for location of the short. Check for loose wires.

3. With ohmmeter check motor thermostat leads. If circuit is open the motor is overheated or burned out.

4. On dual phase extraction units check with an ohmmeter the wire connections to the high-high switch. If the switch is open it is either inoperative, or the tank is overfilled with water.

Pump runs but kicks out on overload.

1. Check the amperage setting on the overload protector on the motor starter. Make sure it is set properly.

2. When pump is running, check amps on all legs of the power supply. If amps are high on one leg you may have a loose wire connection, or power source is unbalanced.

Pump is drawing too high amperage.

1. If you are pulling up groundwater the flow rate may be excessive, causing high amps and spiking. Throttle back the valve on the piping to wells so as to reduce the water flow rate.

2. Check seal water flow from the reservoir tank to the pump and adjust if necessary.

3. Scale build-up in the pump can cause rubbing and increased amperage. If pump requires descaling follow acidizing instructions.

1.0 General Description

1.1 LIQUID RING VACUUM PUMPS - PRINCIPLE OF OPERATION

The liquid ring pump removes gases by means of an impeller rotating freely in an eccentric casing. The pumping is done by a liquid, usually water, that is fed into the pump and thrown by centrifugal force into a moving ring along the casing or cover wall.

When gas or vapor enters the suction port, it is trapped by the whirling impeller blades and a liquid piston that expands in the eccentric lobe of the casing. As the impeller rotates, the liquid is then pushed inward by the narrowing space between rotor and casing, compressing the trapped pocket of gas. Finally the compressed gas is released through a discharge port as the impeller completes the revolution.

The direct contact between the liquid ring and the gas makes the pump ideal for wet applications and for handling condensibles that are discharged with the gas and liquid. Unlike rotary vane and piston pumps, the operation of a liquid ring vacuum pump is nearly isothermal and without vibration. There is no oil to be changed or pollutant released into the environment. Because there are no valves and no rubbing parts, a liquid ring pump is virtually maintenance-free.

With liquids other than water, vapor pressure in the pump can be reduced for high vacuum or compatibility achieved with specific process gases. In some cases, distillate or another fluid is introduced directly into the suction pump inlet and used as the liquid seal.

Liquid ring pumps are also commonly staged with positive displacement blowers, air and steam ejectors for greater capacity and higher vacuum. Atlantic Fluidics offers many such staged units—including its patented Fluid-Vac two-stage system with roots-type blower, liquid ring back up and unique fluid coupling design.

1.2 FLUID-VAC SPECIAL FEATURES

One of the distinguishing features of an Atlantic Fluidics' pump is an axial flow design that permits the widest range and highest vacuum of any single-stage liquid ring pump. A fixed port cylinder concentric with the rotor bore directs the gas along the shaft axis, into the suction ports of the rotor, and finally back through the rotor and rear of the pump for discharge.

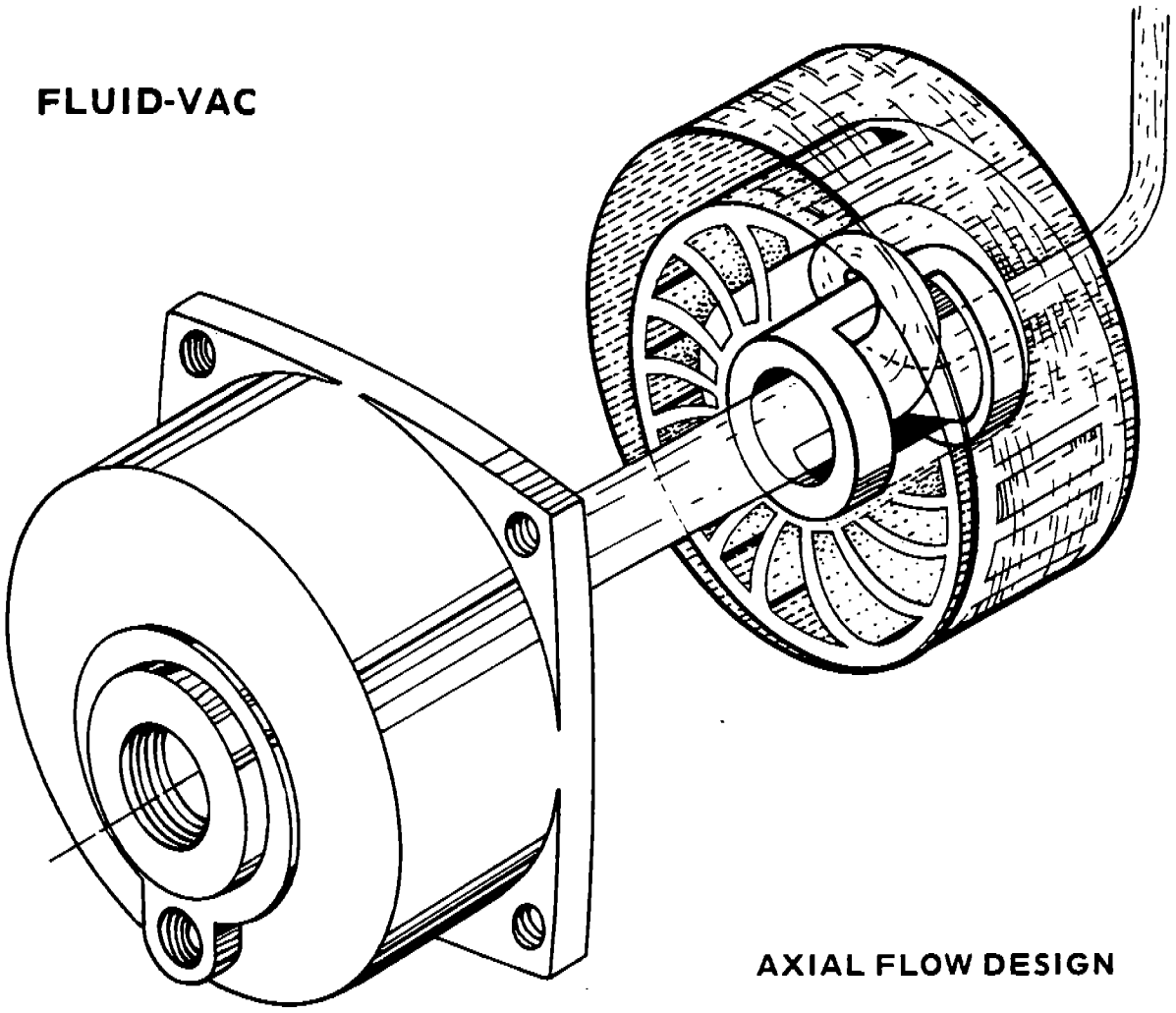
Because the gas flow is along the motor shaft (and not at right angles), the pump can start flooded without damage and has excellent water handling capacity. The use of a shrouded rotor also increases pumping efficiency for high vacuum and lower water consumption. The pump head, close-coupled to a "C"-Face motor, is extremely compact and requires no interstage manifold as do the older style pumps and their copies.

Further advantages to Fluid-Vac pumps include the use of modern O-Rings and Mechanical Seals rather than gaskets and stuffing boxes, and a replaceable port cylinder for fast in-the-field repair. The standard material of construction is bronze with a hardened aluminum bronze rotor so that any wear or damage is relegated to the least expensive parts.

1.3 WARRANTY

The seller warrants and guarantees products of its manufacture against defective workmanship or material for a period of one year from the date of shipment from its factory. This warranty and guarantee is expressly and strictly limited to replacing without charge any part or parts which prove to its satisfaction, upon examination, to have been defective and which have not been neglected, abused or misapplied, provided the Buyer gives the Seller immediate

FLUID-VAC



AXIAL FLOW DESIGN

written notice upon discovery of any claimed defect. Material deemed defective must be returned to the factory, transportation charges to and from the factory to the place of origin pre-paid, F.O.B.

Anything herein to the contrary notwithstanding, the Seller will guarantee component parts manufactured by others, including, but not limited to, prime movers, starting equipment, electrical apparatus, and auxiliary fittings only to the same extent of the guarantee made by the manufacturer of such equipment.

1.4 SERVICE and PARTS

Fluid-Vac pumps are 100% designed and manufactured in the United States. All parts are maintained in inventory for immediate shipment from our factory in Stamford, Connecticut. At the back of this manual is a list of parts and recommendations for spares to keep on hand.

The reputation of Atlantic Fluidics is staked on fast service and practical assistance in designing vacuum systems for specific applications. Specializing in the liquid ring field, the company was created by and for ENGINEERS.

2.0 Installation

2.1 LOCATION

Because of its close-coupled design, a Fluid-Vac pump is ideal for applications where space is critical. Its vibrationless operation permits direct bolting to the floor or mounting on a baseplate anywhere that is convenient for piping. The standard motors furnished by Atlantic Fluidics are of either the Open Drip Proof (ODP) variety, for dry indoor locations, or Totally Enclosed Fan Cooled (TEFC) for areas where the motor may be exposed to water. Special motors are available for hazardous locations.

The pump needs no adjustment, alignment or coupling, guard, etc., and because the pump runs **COOL**, no special ventilation is necessary—or access for checking sight glasses and oil.

In choosing a location, the main consideration should be the pump's proximity to the vacuum system and convenience for draining discharge and piping the seal water.

2.2 GENERAL PIPING INSTRUCTIONS

The Inlet, Discharge and Seal Water Piping require observance of three basic rules:

A. Piping must be free of all welding shot, slag and other foreign matter that could damage pump.

B. Piping must be supported independently to avoid stress on pump casing.

C. Piping should be of the same diameter as the pipe connections on pump.

2.21 VACUUM INLET PIPING

Inlet piping is a simple matter of connecting the pump to the vacuum system. Models A10, A15 and A20 vacuum pumps have threaded one inch connections on their covers for direct piping. The larger pumps feature flange faces.

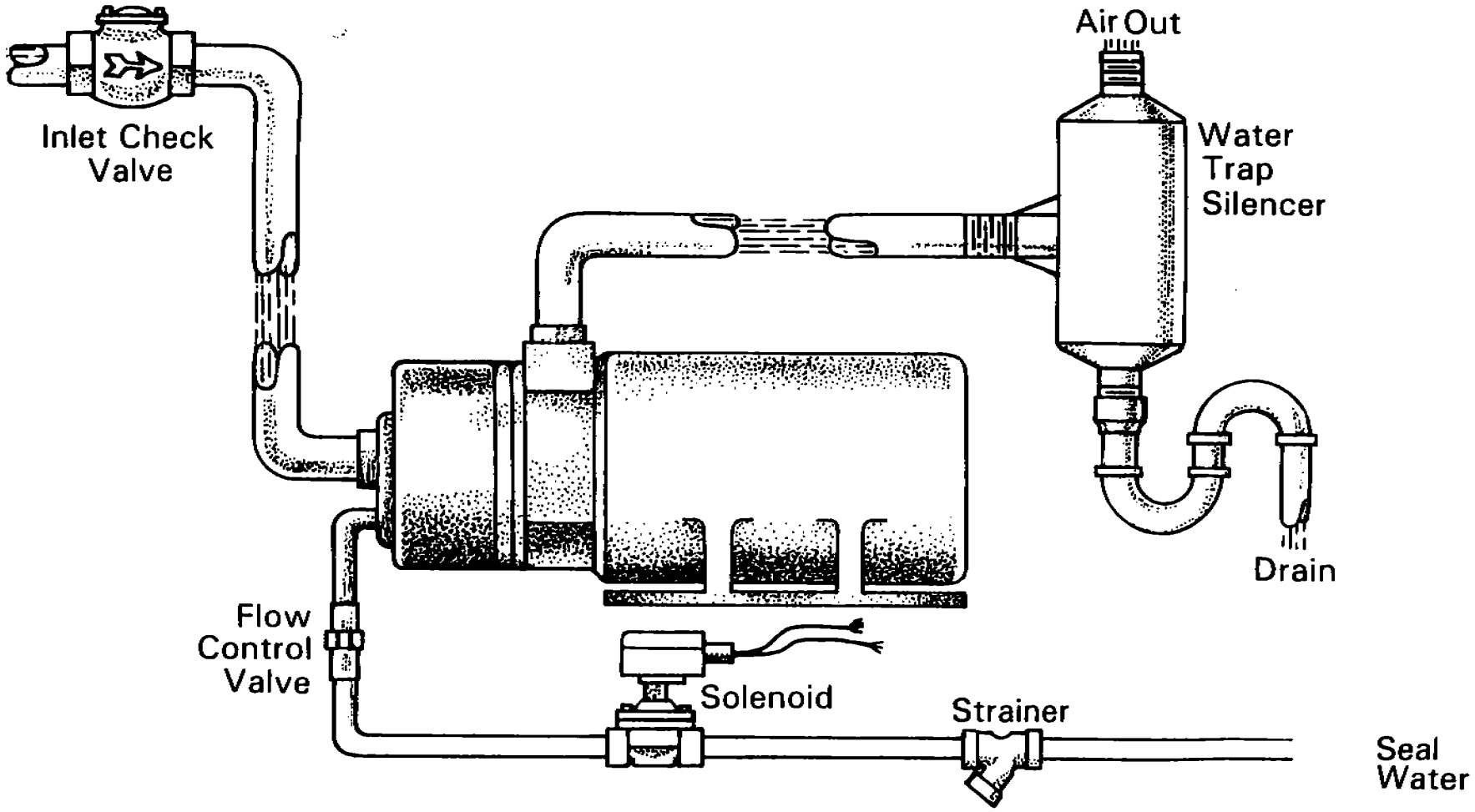
An inlet check valve is recommended to prevent vacuum loss and back streaming when the pump shuts down. Avoid using spring loaded valves not designed for vacuum service.

An optional vacuum gauge can be mounted between the pump and check valve to measure inlet vacuum.

2.22 DISCHARGE PIPING

Depending on the application, there are a number of ways to handle the discharged liquid and gas. If there are no pollutants, the simplest scheme is to discharge directly into a drain. An Atlantic Fluidics pump can carry up to a ten foot discharge head provided the piping from that height is pitched toward a drain or other receptacle. EXCESSIVE BACK PRESSURE CAN ADVERSELY AFFECT PUMP PERFORMANCE.

A second method is to run the discharge through a mechanical separator removing water from the gas. Water contaminated by sanitary waste or noxious gas may be recirculated as seal water or discharged into a sanitary sewer or tank. The nature of the contaminant will determine how often recirculated water must be changed.



PIPING SCHEMATIC

2.23 SEAL WATER PIPING

Unless liquid is pumped directly through the vacuum inlet connection, most applications require separate piping for seal water to enter the pump. The seal water inlet is located directly below the vacuum inlet on the pump's face. Water, the most widely used liquid seal, can be piped directly from a tap or recirculated from a discharge separator tank. Be sure to specify if seal liquids other than water are to be used: Atlantic Fluidics will make recommendations regarding compatibility of materials, power requirements etc.

The following accessories are recommended:

A. Flow control valve (see Seal Water Requirements)

B. Solenoid Valve (to shut off water when pumping stops)

C. Strainer (to prevent foreign matter from entering the pump)

For more information about recirculating seal water, consult Atlantic Fluidics.

2.3 ELECTRICAL CONNECTIONS

Refer to the motor label or conduit box for correct wiring. Most motors are three phase and will be damaged if single phased. Derating for 50 cycle operation at different voltages is possible if specified on motor label. Otherwise, refer questions to manufacturer or Atlantic Fluidics.

Be sure to jog motor before start-up to insure correct wiring and rotation.

3.0 Operation

3.1 SEAL WATER REQUIREMENTS

Fluid-Vac liquid ring pumps, because of their exclusive axial flow design, have the ability to handle large amounts of water and can start up flooded without damage.

Seal water flow is not critical and flow rates can be adjusted for a wide variety of applications. For most applications the optimum seal water rates are given below:

	Vacuum Range		
Pump Model	0" - 10" Hg.	10" - 25" Hg.	Over 25" Hg.
A5	1.0 GPM	1.5 GPM	2.0 - 3.0 GPM
A10	1.0 GPM	1.5 GPM	2.0 - 3.0 GPM
A15	1.5 GPM	2.0 GPM	2.0 - 3.0 GPM
A20	2.0 GPM	2.0 GPM	2.5 - 3.5 GPM
A75	2.0 GPM	2.5 GPM	3.0 - 4.0 GPM
A100	2.0 GPM	2.5 GPM	3.0 - 4.0 GPM
A130	2.0 GPM	3.0 GPM	4.0 - 5.0 GPM
A200	3.0 GPM	5.0 GPM	6.0 - 8.0 GPM

The water supply can be regulated by either a flow restrictor or manually by valve. The object is to balance performance against water consumption and power.

THE PUMP MUST NEVER RUN DRY. The solenoid valve must be in an open position for pumping.

3.2 START-UP

Once the pump is fully piped and wired for operation, be sure no foreign matter rnay enter and possibly damage the pump. Check for welding shot, slag or other metal bits.

Before starting the pump, turn the motor shaft by hand to be sure it is free to rotate. On TEFC motors, you may turn the rear fan. With ODP motors, the rotor can be turned via the discharge port or the front vents beneath motor.

If a hard rub is experienced, the pump should be checked internally for interference. As long as the shaft can be turned by hand, the pump is operable. A hard rub is indicative of improper alignment, and the pump should be disassembled and realigned.

A final check is to jog the motor, making sure water is introduced into the pump and that rotation is in accordance with the arrow cast on pump face. If no flow of air or vacuum reading is immediately apparent, rewire the motor accordingly. Rotation should be counter clockwise facing the pump inlet.

The pump is now ready for operation.

3.3 STOPPING PUMP

Once the power is shut off, be sure water is stopped from entering the pump. A solenoid valve in the seal water line is recommended to shut off flow simultaneously with cessation of pumping.

An inlet check valve is recommended to prevent vacuum loss or back flow to the system.

3.4 MAINTENANCE

As a general rule, maintenance is not required for Fluid-Vac pumps. Because there are no rubbing parts and with water acting as coolant and lubrication during pumping, wear is minimized. It is recommended that the motor bearings be greased every four years. For further information refer to the Trouble-Shooting Chapter of this manual.

To prevent foreign matter from entering the pump, a strainer is recommended for the seal water line and the usual precautions taken in the pump inlet piping.

4.0 Trouble shooting

4.1 PUMP WILL NOT TURN ON START-UP

(a) Check wiring and power to pump.

(b) Remove pump cover to check for anything that may be binding the rotor. Be sure that the rotor turns freely by hand. (Sec. 3.2)

(c) On cast iron pumps, check for internal rust if pump has been left idle for a long period. Rust can build up to the point where internal clearances are closed. Remove rust and reassemble.

(d) In areas where there is hard water being fed into the pump, check for scale deposits that may hinder rotation. Scale should be removed by acidizing, but refer to the factory for recommended procedures.

(e) If the motor fails to turn, be sure it isn't a motor problem. Burn-out may occur if a three-phase motor is single phased.

4.2 NO PUMPING ON START-UP

(a) Check pump rotations. It may be rotating in reverse. Rewire motor to correct.

(b) Check seal water. Water must be fed continuously into the pump.

4.3 POOR PUMP PERFORMANCE, LOW VACUUM

(a) Check vacuum pump while running by sealing off inlet piping and reading vacuum at the pump suction. If high vacuum is achieved, look for leaks in the vacuum system. The pump capacity is a function of high vacuum performance and will conform to the published performance curve at standard conditions. High seal water temperatures will lower the vacuum because of the increase in vapor pressure. Altitude, barometric pressure, and gas temperature can also affect high vacuum performance.

(b) If high vacuum is not achieved on blank-off, the problem lies in the vacuum pump. Poor pump performance can be caused by the following:

- Pump may not be getting enough water. Adjust water supply and observe change in the performance.

- Internal parts may be worn or badly scarred. Remove cover/port cylinder assembly and check for wear on the port cylinder, rotor and cover lands. Most wear will be limited to the softer bronze port cylinder which should slide easily into the rotor bore. Replace port cylinder if necessary. You may also polish the port cylinder and rotor bore with a fine emery cloth for smooth fit.

4.4 PUMP UNUSUALLY NOISY

(a) Unusual continuing noise from the motor end is probably an indication that the motor bearings are bad. Remove cover and spin rotor by hand. You should be able to detect bearing noise. If indicated, replace motor bearings.

(b) Cavitation. The vacuum pump should not be operated on blank suction for any length of time. When liquid ring vacuum pumps are starved for air, cavitation will result in a rattling noise and vibration in the pump. Cavitation can be eliminated by providing a slight air bleed into the vacuum system.

4.5 HIGH AMPS

(a) Flooding the pump with too much water, particularly at low vacuum, can overload the motor. Adjust seal water supply.

(b) Internal rubbing of rotor with stationary parts can cause excessive loading. Shut off pump and rotate by hand (see 3.2) to see if rotor turns freely. Internal rubbing may be due to scale build-up, a galling foreign material or by misalignment of parts. (see 4.1 & 4.3b)

5.0 Service and Repair

5.0 SERVICE and REPAIR

Fluid-Vac liquid ring vacuum pumps have been designed to minimize down time by allowing for fast in-the-field repair. Time and money-saving features include:

- Modern O-Rings and mechanical seals for zero leakage and easy replacement.

- Front end disassembly for fast access to major internal parts.

- Shaft mounted assembly for easy alignment and indicating.

- Replaceable port cylinder that unscrews from cover and requires no special shimming or adjustment.

- Standard rotor made of G-metal and Aluminum bronze to relegate wear and damage to the softer port cylinder.

- American-made stock parts available for immediate shipment.

5.1 DISASSEMBLY OF PUMP

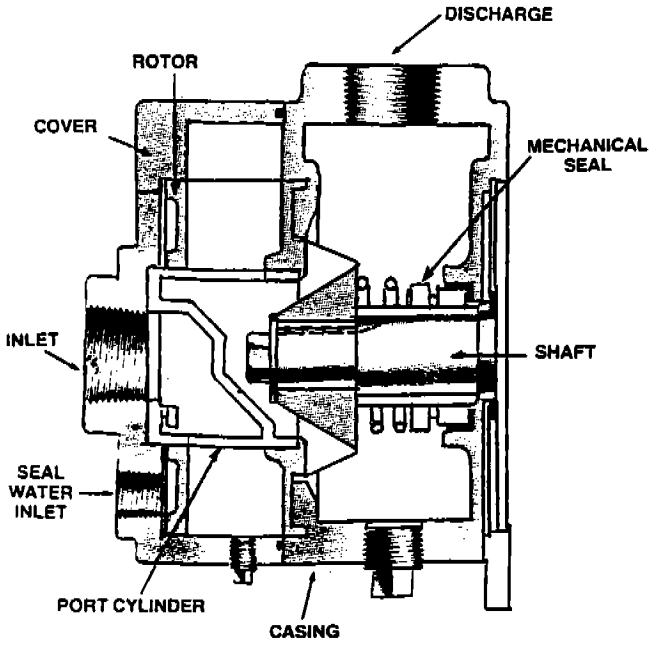
The pump may be disassembled while bolted to the baseplate by removing suction and seal water piping and working from cover to motor. Most repair work will not require full disassembly, but please refer to the exploded pump diagram in following these steps:

(a) Shut off all valves controlling flow of fluids to and from the pump casing. Disconnect external piping.

(b) Remove bolts connecting cover to casing. The cover and port cylinder assembly will slide straight outward. The port cylinder is dismounted from cover by removing three socket head cap screws.

(c) Remove hex head lock screw and washer from motor shaft. Use a bearing puller to remove rotor without damage to casing. Be sure to protect the threaded shaft bore.

(d) Slide shims, mechanical seal, sleeve bushing and O-Ring off shaft.



(e) Unbolt casing from motor face.

(f) Save any and all shims from shaft and casing assemblies for proper realignment.

5.2 ASSEMBLY OF PUMP

Before commencing assembly of the pump, carefully inspect all parts for signs of unusual wear, abrasion and corrosion. O-Rings should be checked for cracks or brittleness and the carbon face of the mechanical seal examined for scratches.

Replace all parts as needed and proceed as follows:

STEP ONE: Casing, Sleeve and Seal Assembly

The mechanical seal is composed of a seat (#8a), seal (#8b), and spring (#8c). The seat is a ceramic ring with a rubber boot that is pressed firmly into the rear of casing. Lubricant is recommended for ease in inserting rubber boot in the seal housing bore. BE VERY CAREFUL NOT TO SCRATCH THE CERAMIC FACE DURING HANDLING AND INSERTION.

Once the seal seat is in place, mount casing (#1) on the motor face using the original shims for alignment. The larger pump casings are mounted on four studs extending from motor face, while the smaller casings (Models A10, 15, 20) are secured by four hex head bolts.

Next slip the small O-Ring (#11) over shaft till it touches the shaft shoulder and place the sleeve/bushing (#9) on top so that its chamfered end presses against O-Ring.

To complete the assembly, lubricate the sleeve so that the rest of the mechanical seal (#8b) can be pressed on with the carbon face in flat sliding contact with the ceramic seat. Again, AVOID SCRATCHING OR TOUCHING THE CARBON FACE. Proper tension between the seal faces is provided by the spring – leading to Step 2.

STEP TWO: Rotor Assembly and Alignment

The rotor is secured to the shaft by means of a key (#15), a hex head lock screw (#13), and a brass washer (#14). In order for the rotor to turn freely, there must be some clearance between it and the casing. On models A10, A15, and A20, this clearance is established by adding shims (#10) until no rub is felt between the back of the rotor and the casing face. On the larger pumps, shims are used to position the rotor so that the casing face lines up with the inside wall of the rotor shroud. (See photograph below)

Be sure to use a bearing puller when removing rotor to add more shims. Avoid damage to the casing face and to the threaded shaft bore. Once secured, the rotor should spin freely without any interference or rub from the casing.

To insure proper alignment, you may indicate the run-out on the front edge of the rotor. If the rotor appears to be cocked more than 2 or 3 thousandths when tightened down, find the high spot and if it is not drastically out, a light rap with a mallet will bring the rotor into correct alignment. Tightening down the rotor is facilitated by using a long bolt and several washers before inserting the actual lock bolt.

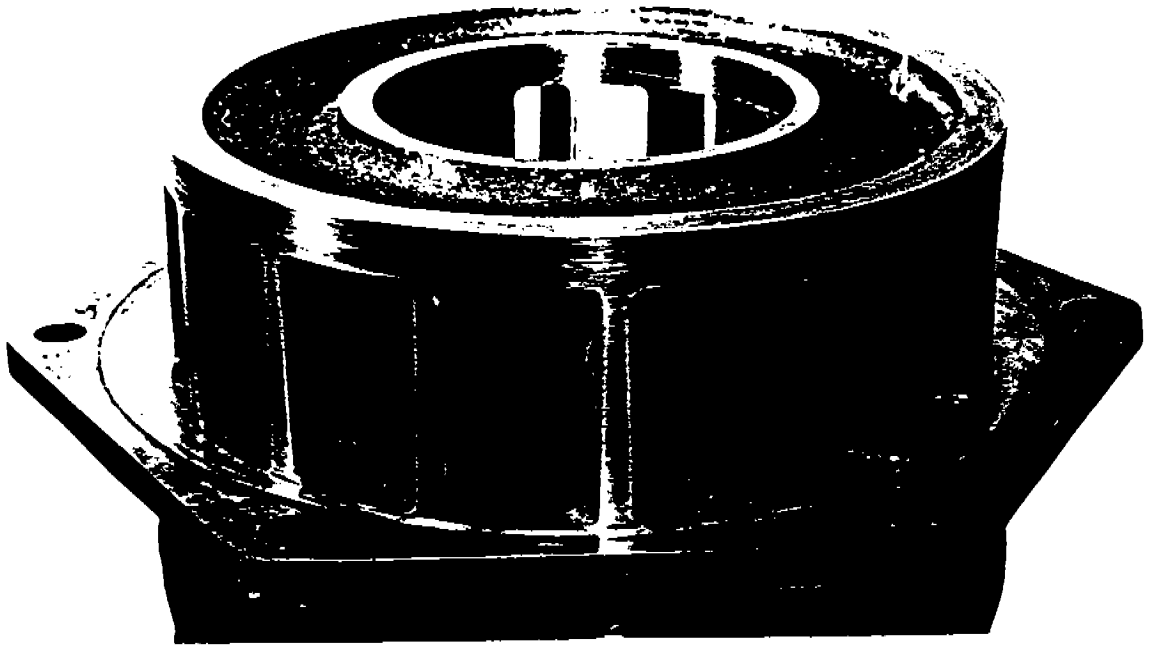
STEP THREE: Port Cylinder Assembly and Cover

The port cylinder (#3) is readily mounted on the cover (#4) by three socket head cap screws with nylon plugs (#6). A fiber gasket (#5) is used to seal the surface between cover and port cylinder while the alignment of tapped holes insures correct placement.

The final assembly is to insert O-Ring (#12) into the cover groove and then to slide the port cylinder/cover assembly into the rotor bore. The surface where cover and casing meet will be sealed by the O-Ring.

In securing the cover to the casing, the cover bolts (#19) must be drawn up uniformly. During tightening, the rotor should be turned by hand to insure easy rotation when the pump is fully assembled. Loosen the bolts and then tighten again if a hard rub is experienced. (Note that Models A75 and A100 have two socket head bolts which should be used in the bottom cover holes.)

After the drain plugs (#17, #18) have been installed with teflon tape on the threading, the vacuum pump is ready for service.



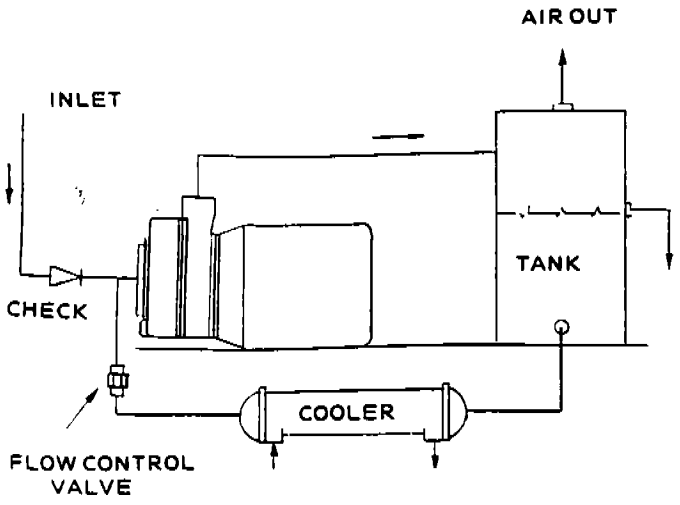
Save Water, Time and Money with FLUID-VAC Sealant Recovery Systems

In applications where water is costly, scarce or unavailable, Fluid-Vac Sealant Recovery Systems provide simple, compact and environmentally safe options for recirculating seal water and storing waste.

THE BASIC SYSTEM

The standard configuration for recirculating seal water is to pipe the pump discharge into a small separator tank where non-condensed gas is vented into the atmosphere and the water returned to the pump inlet. By having a tee connection in the inlet piping for the return (rather than through the separate seal water inlet), the pump will draw its own water requirement controlled by a flow restrictor in the return line.

The basic system offered by Atlantic Fluidics is a completely self-contained pumping system that fits almost anywhere for intermittent or low vacuum use. The package includes a close-coupled pump, baseplate, stainless steel separator tank with complete seal water and discharge piping.



HEAT EXCHANGERS

For continuous high vacuum use, a heat exchanger is recommended to counter the temperature rise from the heat of compression. Higher seal water temperatures will increase the partial gas pressure inside the pump and limit high vacuum performance. Used in conjunction with water chillers, refrigeration units, fan coils or cooling towers, a properly sized heat exchanger will maintain seal water temperatures for maximum performance.

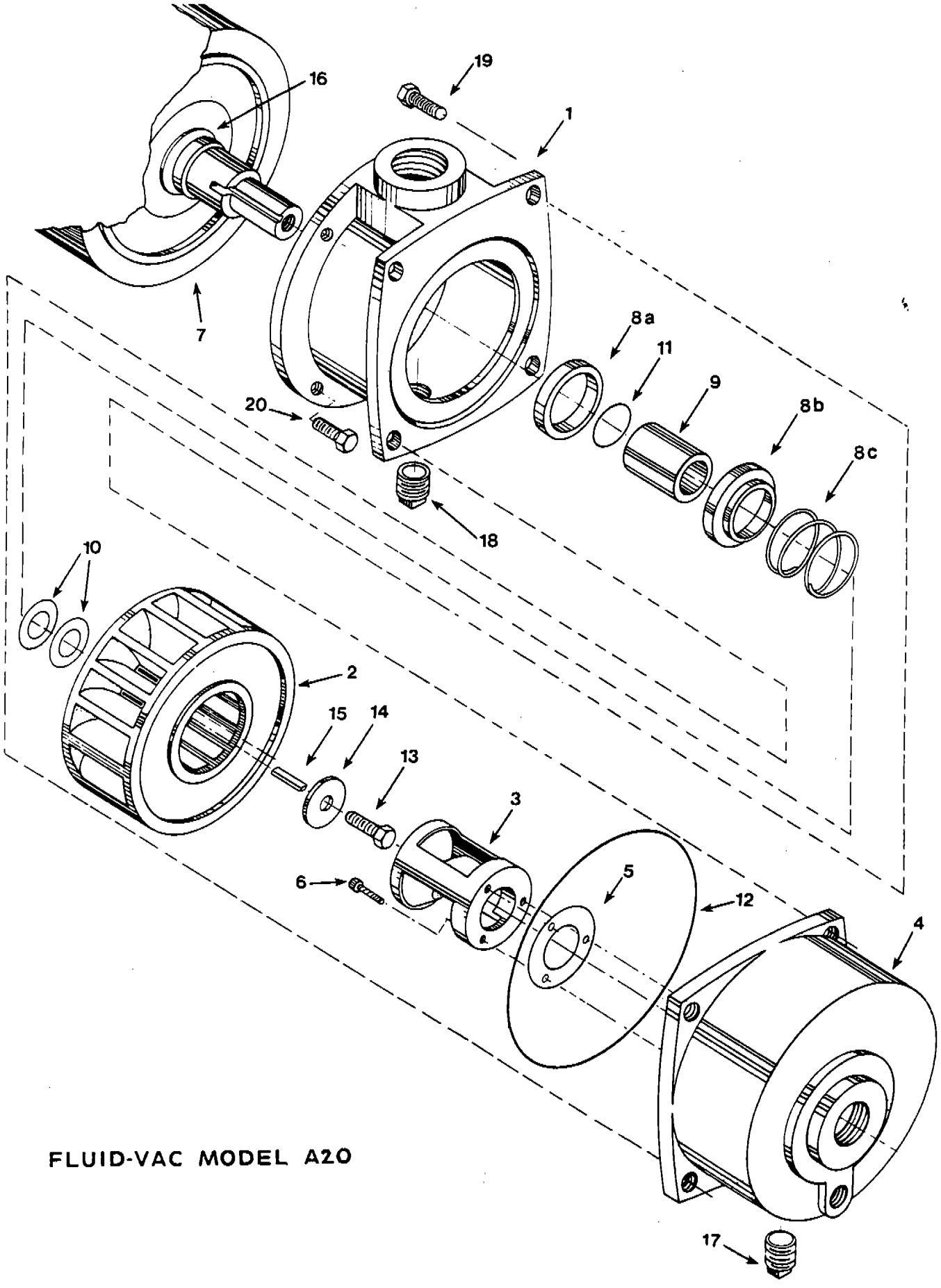
Depending on the heat to be removed and cooling system available on location, Atlantic Fluidics will specify or furnish a heat exchanger to best suit your application. For space-saving and cleaning convenience, Fluid Vac Recirculation packages can be designed with a stainless steel heat exchanger built into the separator tank. In situations where sea water is available for cooling, a separate copper/nickel heat exchanger would be recommended for handling the corrosive salt water.

OTHER ALTERNATIVES

Among the other options for reusing liquid sealant are partial recirculation systems and specially packaged units using sealants other than water (i.e. oil, perchlorethylene, etc.). In a partial recirculation loop, a certain amount of make-up water is fed into the pump to minimize temperature rise yet allow for substantial water savings.

For sealants other than water, be sure to consult Atlantic Fluidics for assistance with both the pump and recirculation sizing.

As one of two American companies specializing in liquid ring pump applications, Atlantic Fluidics invites you to inquire about specific, practical and inexpensive methods for cutting operating costs and for saving that precious natural resource - water.



FLUID-VAC MODEL A20

Parts List for Models A5 through A200

Ref.No.	Part
1	Casing
2	Rotor
3	Port Cylinder
4	Cover
5	Gasket (Port Cylinder)
6	Cap Screws (Port Cylinder)(3)
7	Motor
8	Mechanical Seal Assembly a) Seat b) Seal c) Spring
9	Shaft Sleeve
10	Shims (Set)
11	O-Ring, Shaft
12	O-Ring, Cover
13	Lock Bolt
14	Washer
15	Key
16	Slinger
17	Drain Plug, Cover
18	Drain Plug, Casing
19	Cover Bolts (4) A10-20 (6) A75-200
20	Casing Bolts (4)
20a	Casing Nuts (4) A75-A200 only

Parts Recommended to Keep on Hand

#3	Port Cylinder
#5	Gasket (Port Cylinder)
#8	Mechanical Seal Assembly
#10	Shims (Set)
#11	O-Ring, Shaft
#12	O-Ring, Cover
#13	Lock Bolt

Parts can be ordered directly from our Norwalk factory for immediate shipment. All parts are MADE IN AMERICA.

Contact:
PARTS DEPARTMENT
Atlantic Fluidics, Inc.
21 South Street
South Norwalk, CT 06854
(203) 853-7315
Fax (203) 866-8218

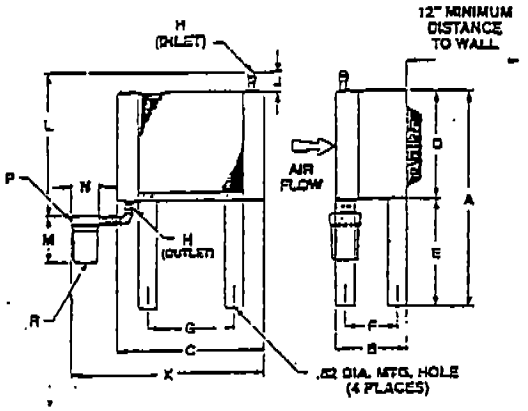
We will be happy to assist you with any questions which might arise and for advice on your application.

HEAT EXCHANGER

Heat Exchanger

thermal transfer products
Racine WI

AA SERIES



DIMENSIONS

Model	A	B	C	D Approx	E	F	G	H NPT	J	*K Approx	*L Approx	OPTIONAL SEPARATOR M	N	P NPT	R	RECOMMENDED OPTIONAL SEPARATOR MODEL NUMBER
AA-35	46.50	14.75	30.50	22.50	24.00	10.75	19.09	1.00	4.00	41.12	34.50	10.00	4.62	1	¼	S-100M or AO
AA-50																
AA-65											35.00					
AA-80																
AA-100			43.50				32.09	1.50		54.12	37.10	12.10	4.70	1		S-200M
AA-120										54.20	38.60					
AA-150														1½		S-300M
AA-240	49.50		47.63	25.50			36.09	2.00		58.33	40.90					
AA-300	55.50		51.68	31.50						62.38	49.30					

*Dimension will vary depending on the separator model used and the piping between the separator and cooler.

CAPACITY SELECTION CHART MAX. SCFM @ 5, 10, 15 and 20°F Approach

INLET TEMP. °F		150				200				250				300				350				RECOMMENDED OPTIONAL SEPARATOR MODEL NUMBER
APPROACH TEMP. °F		5	10	15	20	5	10	15	20	5	10	15	20	5	10	15	20	5	10	15	20	
AFTERCOOLER MODEL NUMBER	AA-35	25	42	58	73	18	31	43	53	15	25	35	44	13	22	30	37	11	19	26	32	S-100M or AO
	AA-50	34	58	79	99	25	43	59	74	21	36	50	62	18	31	42	52	16	27	36	47	
	AA-65	42	73	99	125	32	55	77	96	27	47	65	81	24	41	57	71	22	37	52	65	
	AA-80	50	87	119	150	40	69	94	117	34	59	80	100	30	52	71	89	28	47	65	82	
	AA-100	60	102	140	177	48	81	112	140	43	73	100	124	38	64	87	110	34	58	81	100	
	AA-120	81	138	190	235	61	105	142	177	51	87	120	150	43	73	102	127	40	69	94	118	S-200M
	AA-150	92	160	220	270	73	125	172	215	63	110	150	187	55	95	130	160	50	86	120	146	
	AA-240	160	275	380	425*	120	207	285	355	100	175	240	300	84	145	204	250	78	135	185	231	S-300M
	AA-300	184	318	440	460*	145	250	345	430	125	217	300	375	110	190	257	320	100	175	240	300	

Above specifications are based on 80 to 125 PSIG operating pressures.
Maximum pressure drop, less than 3 psi.
*Maximum ratings restricted by pressure drop, actual thermal capacities are higher.
A flexible metal hose must be properly installed between the compressor and aftercooler to validate warranty.

ELECTRIC MOTOR & FAN DATA

Model	Fan CFM	Motor H.P.	Standard Motor (ODP) Voltage	Standard Motor (ODP) Full Load Amps/Motor	Optional Motor (TEFC) Voltage	Optional Motor (TEFC) Full Load Amps/Motor	Optional Motor (TEFC) Voltage	Optional Motor (TEFC) Full Load Amps/Motor	Approximate Shipping Weight (lbs.)
AA-35	1375	¼	115/1/60*	7.2	115/230 230/1/60	5/2.5-2.5	208-230V 460/3/60	1.4-1.3/.65	110
AA-50									120
AA-65									
AA-80									
AA-100	2450								140
AA-120									
AA-150	2750								145
AA-240	4600	½ (2)							200
AA-300	4700								300

Standard Motor(s) = 1800 RPM, Custom Frame. Equipped with Thermal Overload. Optional Motor(s) = 1725 RPM, Nema 48 Frame, No Thermal Overload.
Published electrical ratings are approximate and may vary because of motor brand. Actual ratings are on motor nameplate.

NOTE: We reserve the right to make reasonable design changes without notice.

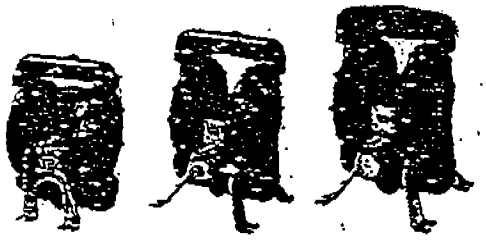
TRANSFER PUMPS

U.L. Listed Fuel Transfer Pumps

These Aro Diaphragm Pumps have been designed specifically for dispensing petroleum-based fuel. These pumps meet UL-79 specification, code and are compatible with:

- GASOLINE
- AVIATION FUEL
- DIESEL FUEL
- FUEL OIL
- KEROSENE
- UNLEADED FUEL

Used for high-volume transfer, bulk-unloading or fueling applications. To meet UL-79 specification, a pressure relief valve opens and bleeds off excess pressure. The relief valve can be plumbed to return the bleed-off fuel to the storage container.



1-inch 1-1/2 -inch 2-inch

Air Connectors Not Included.

Performance Specifications

	1-inch	1-1/2-inch	2-inch
RATIO:	1:1	1:1	1:1
MAXIMUM G.P.M. (Liters):	29 (110)	75 (284)	105 (397)
AIR INLET:	1/4-inch NPT(F)	1/2-inch NPT(F)	1/2-inch NPT(F)
FLUID INLET:	1-inch NPT(F)	1-1/2-inch NPT(F)	2-inch NPT(F)
FLUID OUTLET:	1-inch NPT(F)	1-1/2-inch NPT(F)	2-inch NPT(F)
MAX. OPERATING PRESSURE PSI (bar):	50 (3.4)	50 (3.4)	50 (3.4)
SUSPENDED SOLIDS MAX. DIA. IN. (mm):	1/8-inch (3.2)	1/4-inch (6.4)	1/4-inch (6.4)
WEIGHT - LBS. (Kg):	18.5 (8.4)	44 (20.0)	46 (20.9)

Dimensional Data

See 1-inch, 1-1/2-inch, and 2-inch (ports) metallic pump dimensional data on pages 10, 11, and 12.

Model / Material Selection

	MODEL	FLUID INLET/OUTLET PORT SIZE	SEAT CONSTRUCTION	BALL CONSTRUCTION	DIAPHRAGM & O-RING CONSTRUCTION
→	650709-C	1-inch NPT	Kynar®	Acetal	Buna N
Unleaded	650717-C	1-inch NPT	Kynar	Acetal	Viton®
	650710-C	1-1/2-inch NPT	Kynar	Acetal	Buna N
Unleaded	650718-C	1-1/2-inch NPT	Kynar	Acetal	Viton
	650711-C	2-inch NPT	Kynar	Acetal	Buna N
Unleaded	650719-C	2-inch NPT	Kynar	Acetal	Viton

Viton Diaphragms are recommended for use with unleaded fuels.

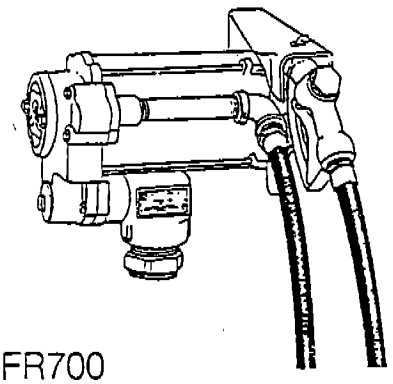
Pump System Technology

FILL-RITE

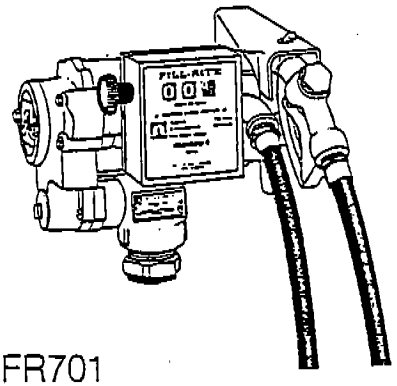
Parts and Technical Service Guide

SERIES 700B PUMP

For models: FR700, FR700R, FR701, FR701R, FR720, FR721, FR730, & FR731



Model FR700

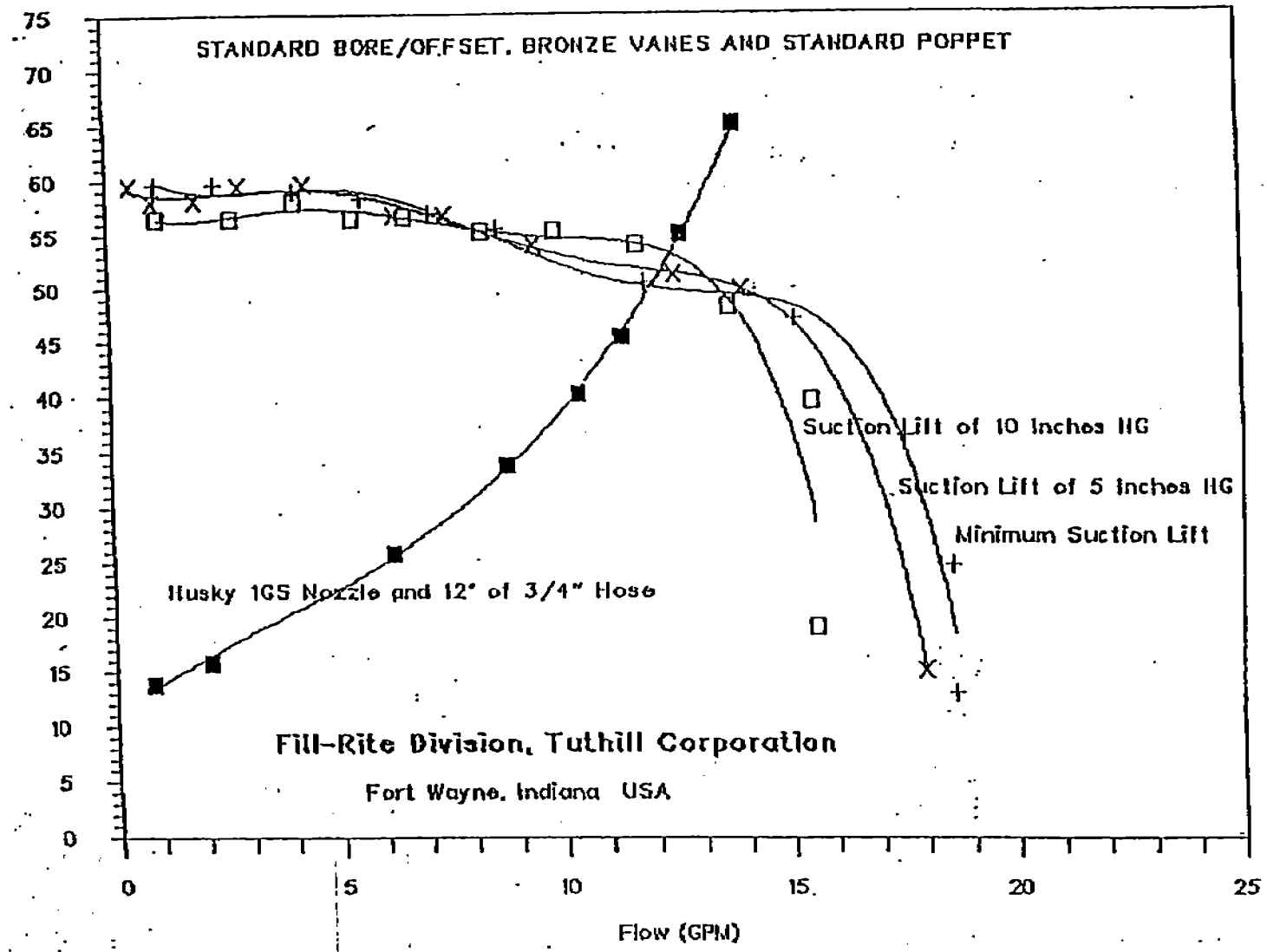


Model FR701

OUTSTANDING FEATURES

- Up to 18 GPM / 69 LPM
- UL listed pump and motor
- Full 1/3 HP 115 VAC-60Hz motor, optional 220/240 VAC-50/60Hz
- Thermal overload protector
- Heavy duty double pole switch
- Integral check valve
- Built-in bypass valve

700B Economy Pump Characterization

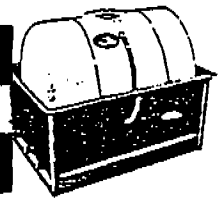


As a Function of Varying Inlet Vacuum

SURGE TANKS

Portable Storage Tanks

Skid-Mount Polyethylene Tanks

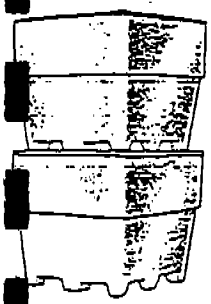


Durable tanks come with a sturdy steel skid for quick, easy transport with a forklift. Skids have two-way forklift entry. Tanks are made of seamless linear polyethylene that complies with FDA regulations for handling food and potable water. They can also be used for storing herbicides, insecticides, liquid fertilizer, and other chemicals. Tanks won't rust, corrode, or delaminate. They're ultraviolet stabilized and resistant to many corrosive chemicals. The translucent walls and a molded-in gallon scale make it easy to determine the liquid level. All models have a threaded fill cap with an EPDM gasket. A recessed sump is molded into the tank floor for drainage. Maximum operating temperature is 140° F.

Round-bottom tanks have a 1½" ball valve drain. Flat bottom tanks are loaf-shaped for a low center of gravity and greater stability. Tanks have a threaded vent plug and a 2" outlet drain fitting.

Cap., Gal.	Dimensions Lg. × Wd. × Ht.	Tank Bottom	Fill Cap	No.	NET EACH
110	49" × 32" × 37"	Round	6"	3664K16	$594.23
150	66" × 32" × 38"	Round	6"	3664K17	649.09
200	75" × 36" × 42"	Round	6"	3664K18	745.45
210	50" × 46" × 40"	Flat	6"	3664K11	796.75
300	77" × 41" × 49"	Round	6"	3664K19	840.00
300	50" × 46" × 49"	Flat	6"	3664K12	918.46
400	78" × 45" × 49"	Round	6"	3664K21	927.59
500	81" × 52" × 57"	Round	6"	3664K22	981.97
500	50" × 46" × 79"	Flat	6"	3664K13	1109.23
800	80" × 72" × 54"	Flat	12"	3664K14	1323.08
1200	80" × 72" × 71"	Flat	12"	3664K15	1423.08

Stackable Polyethylene Bulk Storage Bins

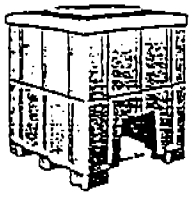


If you need a tank that can be used for over-the-road shipping as well as in-plant handling, these fit the bill. Great for storing liquid and dry-flowable materials. Tanks are FDA and USDA approved, and feature seamless, one-piece construction that's easy to keep clean. Tapered design allows nesting when tanks are empty to save floor space. Tanks allow four-way forklift entry and are stackable two high when used with the optional ¼" thick stacking lids (sold separately below). Dust covers are also available to keep tank contents free of contaminants. Capacity is 2000 lbs. Temperature range is −40° to 150° F.

Tanks are available in single- and double-wall styles. Walls are ¼" thick. Double-wall tanks have two ¼" thick walls for added strength and secondary containment.

Capacity Cu. Ft.	Gal.	Dimensions Lg. × Wd. × Ht.	Tanks No.	Tanks NET EACH	Stacking Covers No.	Stacking Covers NET EACH	Dust Covers No.	Dust Covers NET EACH
SINGLE-WALL TANKS								
30	225	50" × 42" × 36"	3674K11	$427.14	3674K16	$152.25	3674K17	$124.54
34	250	50" × 42" × 39"	3674K12	450.00	3674K16	152.25	3674K17	124.54
39	290	50" × 42" × 45"	3674K13	482.86	3674K16	152.25	3674K17	124.54
48	360	50" × 42" × 52"	3674K14	527.14	3674K16	152.25	3674K17	124.54
53	400	50" × 42" × 55"	3674K15	551.43	3674K16	152.25	3674K17	124.54
DOUBLE-WALL TANKS								
30	225	50" × 42" × 36"	3674K21	544.29	3674K23	152.25	3674K25	124.55
35	260	52" × 44" × 42"	3674K22	634.29	3674K24	152.25	3674K26	124.55

Polyethylene Bulk Storage Hoppers



Versatile hoppers handle a wide variety of materials—from foods and chemicals to powders, granulars, and tablets. FDA-approved linear polyethylene construction is easy to maintain. Hoppers have a removable top for easy loading. Top also allows them to be stacked two high.

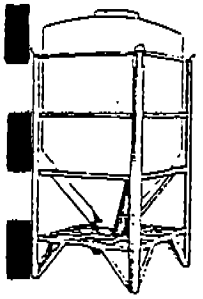
Maximum operating temperature is 150° F.

The 18 and 20 cu. ft. models have a 25° side angle discharge and a 6" opening with screw cap. Base permits two-way forklift entry.

The 35 cu. ft. model has 45° bottom discharge with a 13½" opening and a slide gate valve. Hopper permits four-way forklift entry.

Capacity Cu. Ft.	Lbs.	Dimensions Lg. × Wd. × Ht.	No.	NET EACH
18	1000	40" × 48" × 38"	3782K21	$697.66
20	1200	40" × 48" × 40½"	3782K22	724.09
35	1200	44" × 44" × 50"	3782K23	1215.71

Stackable Polyethylene Bulk Storage Hoppers

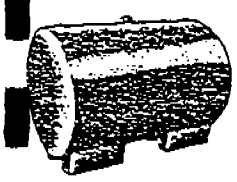


These heavy-duty hoppers made of FDA-approved seamless, linear polyethylene have a slick, nonadhering surface and a 60° slope for unimpeded flow of liquids and solids. Ideal for storage, transport, and dispensing. Hoppers have a 16" top-loading manhole with a raised-lip fill opening and snap-on cover. Top has a vent and cap; bottom has a fast-opening valve.

Hoppers have white translucent walls so you can see material level. A steel stand with a blue epoxy coating is included with each hopper. Stand allows four-way forklift entry. Hoppers are available to store either liquids or solids. Maximum operating temperature is 140° F.

Capacity Cu. Ft.	Gal.	Dimensions Lg. × Wd. × Ht.	Solid Storage Hopper w/8" Butterfly Valve No.	Solid Storage Hopper w/8" Butterfly Valve NET EACH	Liquid Storage Hopper w/2" Ball Valve No.	Liquid Storage Hopper w/2" Ball Valve NET EACH
24.5	183	39" × 39" × 60"	3697K5	$1869.09	3697K25	$1636.36
35	260	44" × 44" × 66"	3697K6	1860.00	3697K26	1710.91
54	400	44" × 44" × 86"	3697K7	2060.00	3697K27	1938.33

Skid-Mount Steel Tanks



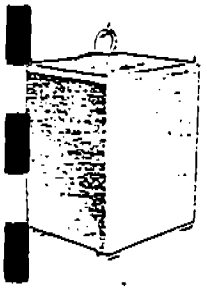
Store fuel and waste oil in these steel tanks with lifting lugs and a high-visibility red enamel overcoat. Tanks are available in light-duty and heavy-duty models.

Light-duty tanks have a 1" drain. Skid runners are 2" × 2" × ¼" angle iron.

Heavy-duty tanks have welded legs that allow forklift entry. Drain is ¾". These tanks are pressure tested and meet UL 142 specifications.

Cap., Gal.	Dimensions Dia. × Lg.	Wall Thick.	Vent Fittings	No.	NET EACH
LIGHT-DUTY TANKS					
300	36" × 60"	14 ga.	3-2", 1-1½"	37415K61	$296.58
560	48" × 72"	12 ga.	4-2"	37415K62	497.22
1000	48" × 144"	12 ga.	3-2", 1-3"	37415K63	993.43
HEAVY-DUTY TANKS					
300	36" × 60"	12 ga.	4-2"	37415K71	543.86
560	48" × 72"	12 ga.	3-2", 1-4"	37415K72	684.21
1000	64" × 72"	10 ga.	3-2", 1-4"	37415K73	1076.92
1500	64" × 108"	7 ga.	3-2", 1-6"	37415K74	1478.87

Double-Walled Waste and Oil Storage Tanks



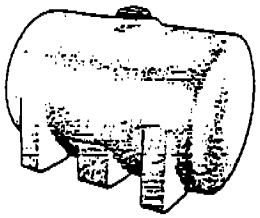
Environmentally safe, vented, transportable tanks are perfect for storing waste oil, solvents, antifreeze, and most products that require double-wall containment. UL-listed tanks have a 6" fill opening with a locking hinged cap and strainer, plus two 2" bungs and a 2" side drain. A ½" diameter side pipe with rod lets you check for leaks in the interior tank.

Tanks are made of welded steel painted safety red with channels on the bottom for two-way forklift entry.

Cap., Gal.	Wall Thick.	Dimensions Lg. × Wd. × Ht.	No.	NET EACH
120	12 ga.	26" × 30" × 36"	3696K71	$692.86
240	12 ga.	52" × 30" × 36"	3696K73	978.57
360	12 ga.	77" × 30" × 36"	3696K75	1271.43
480	10 ga.	102" × 30" × 36"	3696K77	1824.32

Storage Tanks

Free-Standing Horizontal Polyethylene Tanks



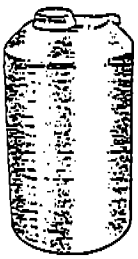
Forget about saddles, stands, and cradles—these tanks stand on their own! Horizontal tanks have molded legs so you can mount them on a flat surface without any additional support.

Tanks are available in natural high-density polyethylene that meets FDA regulations for food and potable water applications, and in cross-linked high-density polyethylene that's ultraviolet-stabilized for outdoor use.

Both styles have gallon and liter graduations. Maximum operating temperature is 150° F. Wall thickness is ¼". Natural color.

Cap., Gal.	Dimensions Lg. × Wd. × Ht.	Fill Opening	Linear Polyethylene No.	Linear Polyethylene NET EACH	Cross-Linked Polyethylene No.	Cross-Linked Polyethylene NET EACH
60	38½" × 23" × 24½"	6"	3764K11	$116.67	3764K21	$146.36
125	49" × 30" × 30¾"	10"	3764K12	180.65	3764K22	227.27
230	51½" × 38" × 38¾"	10"	3764K13	215.17	3764K23	273.68
300	71½" × 38" × 38¾"	10"	3764K14	237.70	3764K24	309.32
500	75" × 48" × 48¼"	10"	3764K15	349.52	3764K25	463.93

Vertical Polyethylene Storage Tanks



Save floor space with these rotationally-molded, polyethylene tanks that you store vertically. Tanks are more lightweight and less expensive than fiberglass and stainless steel tanks.

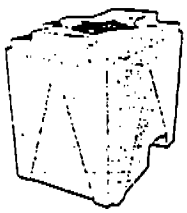
One-piece seamless units have gallon and liter graduations Translucent walls let you see liquid levels. Top head has flats for fitting installations. Tanks provide excellent low-temperature impact resistance and are ultraviolet-stabilized for outdoor use.

30 to 100 gallon tanks are molded of linear polyethylene and have a screw-on fill cap with an EPDM gasket. Top bung is 2" buttress thread. HDPE resin complies with FDA 177.1520 for food service use. Operating temperature range is −94° to +150° F. Color is translucent white.

300 to 1100 gallon tanks are molded of cross-linked polyethylene for superior strength, stress-crack resistance, and corrosive chemical resistance. Lever-lock tank cover simplifies manway opening and closing. Operating temperature range is −180° to 150° F. Color is translucent gray.

Cap. Gal.	Dimensions Dia. × Ht.	Wall Thick.	Fill Opening	No.	NET EACH
30	18" × 36¾"	.188"	6¼"	38555K31	$98.11
55	22" × 39½"	.250"	6¼"	38555K32	120.75
100	28½" × 51¼"	.250"	6¼"	38555K33	270.91
300	35" × 80"	.220"	16"	38555K34	496.15
550	48" × 84"	.250"	16"	38555K35	685.71
850	64" × 74"	.280"	16"	38555K36	921.43
1100	64" × 93"	.370"	16"	38555K37	942.86

Polyethylene Dike Tank



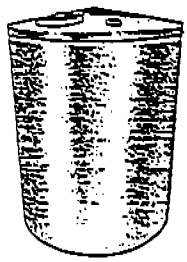
With Optional Stackable Frame

More than just a tank, more than just a secondary containment vessel—it's a tank within a tank. System consists of a 110-gallon interior tank and a 160-gallon exterior dike. The tank has a 10" diameter screw-on lid and three 2" NPT fittings. A 1" high wall keeps leaks and spills from running down the side of the tank. There are two flat areas on the top for mounting pumps.

Tank is 29½" wide × 39½" long × 37" high. The dike is designed to easily accommodate the tank. It measures 29½" wide × 39½" long × 33¼" high. Both the tank and dike are made of ¼" thick polyethylene. Operating temperature is 140° F. Tanks can be stacked up to three high using the optional steel frame sold separately below. Frame permits four-way forklift entry and has a black enamel finish.

Description	No.	NET EACH
Tank/Dike System	3762K55	$494.37
Stackable Frame	3762K77	207.69

Double-Wall Polyethylene Tanks



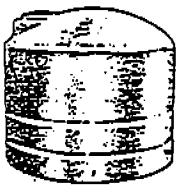
Seamless, corrosion-resistant tanks are double-walled for maximum leak protection—the perfect solution for chemical and hazardous material storage. One-piece unit consists of an inner and outer tank. The outer tank capacity is approximately 110% of inner tank capacity.

Linear polyethylene construction complies with FDA regulation 177.1520. Polyethylene has great structural rigidity, excellent chemical- and impact-resistance, plus it's UV stabilized for outdoor use. Maximum service temperature is 140° F.

Top of tank has an 8" manhole and a 1" vent. Color is translucent white.

Cap., Gal.	Dimensions Dia. × Ht.	No.	NET EACH
100	35" × 39"	3741K1	$475.07
200	41" × 52"	3741K2	608.31
500	50" × 58"	3741K3	1353.43

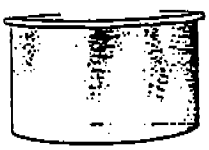
Reinforced Polyethylene Storage Tanks



Reinforcing cylindrical ribs make these tanks extra rigid to minimize bulge even with the heaviest liquids. Tanks are made from rotationally-molded linear polyethylene treated with ultraviolet stabilizers to prevent deterioration caused by exposure to sunlight. Chemical-resistant polyethylene won't rust or corrode, and won't delaminate or wick like fiberglass can. Resins comply with FDA regulations for food and potable water applications. Walls are translucent white, so no sight gauge is needed to determine liquid levels. Operating temperature is 140° F. Tanks have a coarse-threaded fill well, gallon graduations, and a 2" adapter fitting, except Nos. 3662K16 and K18, which have a 1½" fitting.

Cap., Gal.	Dimensions Dia. × Ht.	Fill Opening	No.	NET EACH
125	29" × 47"	10"	3662K18	$236.36
165	31" × 59"	6"	3662K16	262.50
300	46" × 49"	15"	3662K17	324.56
525	46¼" × 79"	15"	3662K11	406.78
1100	80" × 63"	15"	3662K12	634.62
1600	90" × 66"	15"	3662K13	754.55

Secondary-Containment Polyethylene Basins

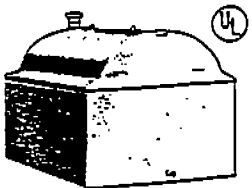


One-piece molded basins provide an effective barrier between your storage tank and the environment. They're designed to answer growing concerns over contamination from hazardous chemical spills and leaks. Linear polyethylene construction resists impact and ultraviolet rays—excellent for outdoor use. Maximum service temperature is 140° F.

Basin capacity is approximately 110% of maximum tank capacity. Color is translucent white.

Approx., Cap., Gal.	Max. Recommended Tank Size, Gal.	Dimensions	No.	NET EACH
ROUND BASINS				
605	550	82" Dia. × 30" Ht.	3737K11	$478.97
935	850	84" Dia. × 46" Ht.	3737K12	621.72
SQUARE BASINS				
1100	1000	84" Sq. × 48" Ht.	3737K15	980.31
1650	1500	84" Sq. × 60" Ht.	3737K16	1092.00

Secondary-Containment Steel Tanks

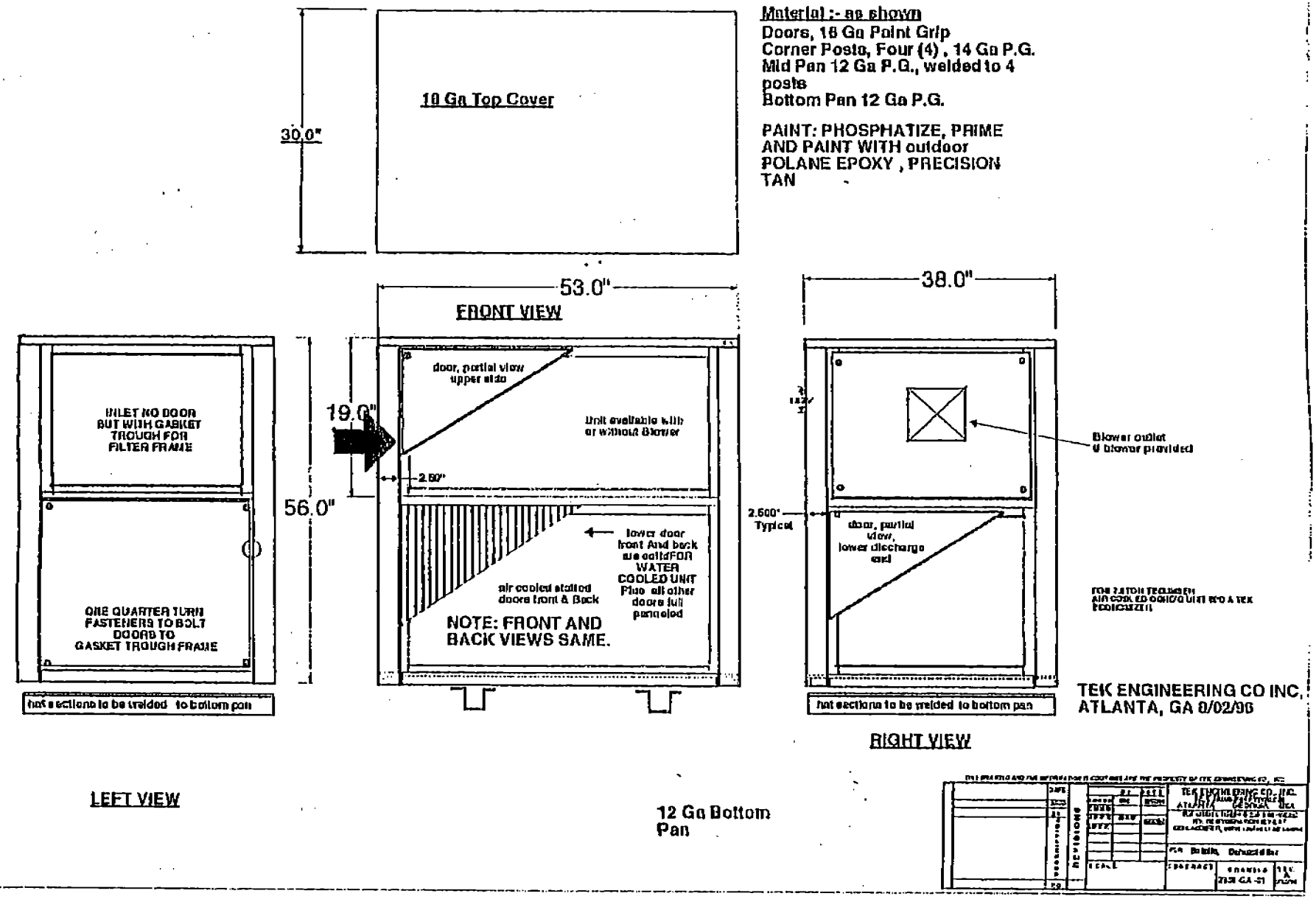


Above-ground storage tanks may be used indoors and out to protect against leaks and ruptures. These units combine round or obround storage tanks with rectangular secondary containment tanks for extra protection from leaks. Ideal for storing motor fuel, heating and waste oil, and lubricants. The containment tanks are designed to hold 110% of the storage tank capacity. They also feature weatherproof flashing to keep rain water and other debris out of the containment sections.

Tanks have a 1½" threaded pipe drain opening and are heavy-gauge carbon steel and coated with rust-resistant primer and beige-colored enamel. Tanks meet UL 142 standards for above-ground storage.

Cap., Gal.	Dimensions Lg. × Wd. × Ht.	Wall Thick.	Fill Openings	No.	NET EACH
150	56" × 38" × 33"	12 ga.	4-2"	3658K51	$1078.56
270	68" × 46" × 39"	12 ga.	1-4", 3-2"	3658K55	1348.20
525	84" × 54" × 50"	12 ga.	1-4", 3-2"	3658K53	1807.59
1000	84" × 72" × 68"	10 ga.	1-6", 3-2"	3658K54	2846.21

DEHUMIDIFIER


Material :- as shown
Doors, 18 Ga Paint Grip
Corner Posts, Four (4) , 14 Ga P.G.
Mid Pan 12 Ga P.G., welded to 4 posts
Bottom Pan 12 Ga P.G.
PAINT: PHOSPHATIZE, PRIME AND PAINT WITH outdoor POLANE EPOXY , PRECISION TAN
18 Ga Top Cover
30.0"
53.0"
FRONT VIEW
38.0"
INLET NO DOOR BUT WITH GASKET TROUGH FOR FILTER FRAME
ONE QUARTER TURN FASTENERS TO BOLT DOORS TO GASKET TROUGH FRAME
hot sections to be welded to bottom pan
19.0"
56.0"
door, partial view upper side
Unit available with or without Blower
2.50"
lower door front And back are solidFOR WATER COOLED UNIT Plus all other doors full panneled
air cooled slotted doors front & Back
NOTE: FRONT AND BACK VIEWS SAME.
Blower outlet if blower provided
2.500" Typical
door, partial view, lower discharge end
hot sections to be welded to bottom pan
TEK ENGINEERING CO INC, ATLANTA, GA 8/02/96
LEFT VIEW
RIGHT VIEW
12 Ga Bottom Pan

	A	B	C	D	E	F
1	Airflow	270	scfm	O.K. / program 8/20/93		
2	Pressure	0	PSIG			
3	Inlet Temp	100	°F	Change cells in this box only		
4	Inlet RH	99	%			
5	Outlet Temp	50	°F		CASE 4	
6	Outlet RH	100	%			
7						
8	Dry air movement	1218.04511	lbm/hr			
9	Moisture removed	42.522928	lbm/hr			
10		297660.496	gr/hr			
11	Total heat	61827.7181	btu/hr	5.1523	tons	45°F Suct.
12	Sensible heat	14616.5414	btu/hr			Tons
13	Latent heat	47211.1767	btu/hr			
14	SHR	0.23640756				
36	*Inlet Values*					
41	W	0.04254125	lbm/lbm	humidity ratio		
42	gr/lb Mass	297.788778	gr./lbm			
46	v	15.07	ft3/lbm	specific volume		
47	h	71.03	btu/lbm	enthalpy		
49	Dewpoint	99.63	°F			
72						
73	*Outlet Values*					
78	W	0.00763046	lbm/lbm	humidity ratio		
79	gr/lb mass	53.4131855	gr/lbm			
83	v	13.01	ft3/lbm	specific volume		
84	h	20.27	btu/lbm	enthalpy		
86	Dewpoint	50.06	°F			
87	*values per pound of dry air*					
88		One DX & One Reheat Coil with air precooled by Water coil				
89		with Pump & Remote Dry Cooler (Glycol Water				
90	NOTE: MUST precool air from Ring vac. Pump to 100°Fusing ducted coil with remote air cooled					
91	Dry cooler with Pump (glycol 40% solution)					
92						
93	CFM	270				Reheat°F
94	°FDB	100.00	73	50.		79.4
95	%R.H.	99	96%	100		30
96	Enthalpy, BTU/LB	71.03	EC1 63.97 DX 1.	20.27	EC2	
97						
98	Enthalpy	H1	H2	H3		
99						
100						
101	(EAT-LDP)*.60 EFF		29.4	Reheat		
102	(LDPT+C102)		79.4			
103	CFM*4.5*H1EAT		86295.50			
104	CFM*1.08*C114		8,573.04			
105	(C104-C105)/45000		63.97			Air cooled unit
106	DX1 LOAD, BTUH		53,100.11	4.43	Tons @ 35°F	6HP Compr.
107					for 45°F D.Pt also attainable.	
108	100CFM needs 3HP Compr @28°F Suction with 100°f Sat'd inlet (precooled by coil and remote dry coole					
109	150 CFM needs 4HP @28°F Suction with 100°F Sat'd Inlet(precooled by Coil and remote dry cooler.					
110	230 CFM Needs a 6 HP @28°F Suction with 100°F Sat'd inlet					
111	precooled by a coil and remote dry cooler w/ a recirc'g pump with glycol-water solution closed circuit					
112						

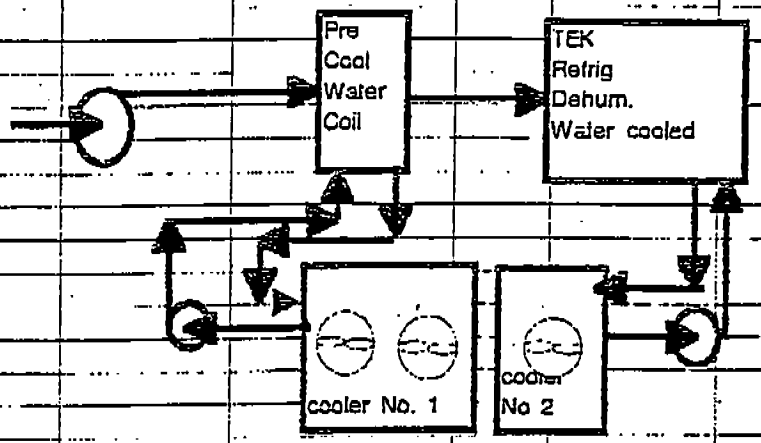
	A	B	C	D	E	F
113						
114						
115	Case I , 100 CFM air flow(8/02/96)					
116	TEK 3HP Air Cooled Refrigeration Reheat Dehumidifier, Model RRDH-3-100-230-1-60ACEC					
117	Estimating price $7,000.00					
118	Coil and Pump and Air cooled Dry Cooler :-estg price , $3950.00 to precool air from 140°F to 100°F satd					
119	Case 2-150 CFMair flow(8/02/96)					
120	TEK -4HP Air Cooled RRDH unit, $8,900.00					
121	Coil, Pump Dry Cooler Price :- $4600.00					
122	Case 3-230 CFM Air Flow(8/02/96)					
123	TEK 6 HP RRDH Dehumidifier $9,900.00					
124	Coil, Pump, Dry Cooler $5750.00					
125	Case 4-270 CFM Air Flow(8/13/96)					
126	TEK 6HP RRDH Dehumidifier, $9,900.00 a D.Pt of +45°F is attainable with this compressor.					
127	Copil, Pump, Dry Cooler $5750.00					
128	TEK was specified for a Chevron job by Camp Dresser & Mckee Boston ,MA for a job at Cape Cod in 1985					
129	TEK SOLD A DEHUMIDIFIER & CARBON TOWER (A 500 CFM ADSORPTION TOWER)TO PROVIDE ULTRA					
130	FILTERED OUTSIDEAIR TO A CONTROL ROOM IN A FERTILIZER PLANT (AMMONIA PRODUCTS) IN 1994					
131	TOWER LIFE 12 MONTHS PER CHARGE OF CARBON.					
132	Note a water cooled Dehumidifier may be used by using a larger Dry Cooler and providing another 20 GPM					
133	of Glycol water for easier year round operation of the Dehumididifer. ; This adds about $2,000.00					
134	to the price of the Dry Cooler.					
139						
140						
141						
142						
170						
171						
172						

Precool 140°F Air to 100°F from Vac Pump TEK Engineering Co Atlanta, GA

	A	B	C	D	E	F
1	Airflow	270	scfm	O K. / program 8/20/93		
2	Pressure	0	PSIG			
3	Inlet Temp	140	°F	Change cells in this box only		
4	Inlet RH	100	%			
5	Outlet Temp	100	°F		Precool VAC Pump &	
6	Outlet RH	100	%		Cool Water Cooled Condenser.	
7						
8	Dry air movement	1218.04511	lbm/hr			
9	Moisture removed	133.284188	lbm/hr			
10		932989.326	gr/hr			
11	Total heat	162322.914	btu/hr	13.53	tons	cooling
12	Sensible heat	11693.2331	btu/hr			
13	Latent heat	150629.681	btu/hr			
14	SHR	0.07203686				
29						
30						
31	*Input*					
32	Temp	140	°F			
33	RH	100	%			
34	Pressure	0	psig			
35						
36	*Inlet Values*					
41	W	0.15242535	lbm/lbm	humidity ratio		
42		1066.97742	gr./lbm			
46	v	18.82	ft3/lbm	specific volume		
47	h	204.80	btu/lbm	enthalpy		
49	Dewpoint	140.02	°F			
72						
73	*Outlet Values*					
78	W	0.04300067	lbm/lbm	humidity ratio		
79		301.004702	gr/lbm			
83	v	15.09	ft3/lbm	specific volume		
84	h	71.53	btu/lbm	enthalpy		
86	Dewpoint	99.96	°F			
87	*values per pound of dry air*					
88						
89						
90						
91						
92						
93						
94						
95						
96						
97						
98						
99						
100						

Precool 140°F Air to 100°F from Vac Pump TEK Engineering Co Atlanta, GA

	A	B	C	D	E	F
101						
102	Precool outlet from Vac Pump with Cooling coil & Dry Cooler					
103	CFM	270				
104	EAT, °F	140				
105	Inlet Rh	100				
106	LAT.°F	100				
107	Outlet R.H.	100				
108						
109						
110						
111						
112	VACPump					
113						
114						
115						
116						
117						
118						
119						
120						
121						
122						
123	Cooler No 1 load	162,322BTUH	14 ton Cooler			
124	Cooler No. 2	90,000 BTUH	6 Ton x 1.25			
125	TWO COOLERS. One to precoolEAT. & other for cooled condenserusing Glycol Water 40%.					
126			TwoPumps required			
127						



VAPOR-PHASE ACTIVATED CARBON

VAPOR PHASE ACTIVATED CARBON

Vapor Phase Coconut Carbon

GRADE: **SHER-FRAN VP1-COC**

DESCRIPTION: High quality granular activated carbon produced to tight specifications from selected grades of Coconut shell. Specifically designed for vapor phase applications.

SPECIFICATIONS:

Mesh Size U.S. (Sieve Series)	4x8
Iodine Number:	1150 mg/g minimum
Bulk Density:	0.50 - 0.52 gm/cc
Moisture as Packed:	3% maximum
Hardness:	98% minimum
Ash Content:	3% maximum

STANDARD PACKAGING: Fifty-five (55) pound polyline polypropylene bags, fiber drums, and 1,000 pound supersacks.

SHER-FRAN® CORPORATION
459 Marion Avenue • P.O. Box 596 • Plantsville, Connecticut 06479 • Tel: 860/628-8684 • Fax: 860/621-7528

VAPOR PHASE ACTIVATED CARBON

Vapor Phase Coal Carbon

GRADE: **SHER-FRAN VPI-COL**

DESCRIPTION: High quality granular activated carbon produced to tight specifications from selected grades of coal. Specifically designed for vapor phase applications.

SPECIFICATIONS:

Mesh Size U.S. (Sieve Series)	4x6, 4x8
Iodine Number:	1100 mg/g minimum
Bulk Density:	0.44 - 0.46 gm/cc
Moisture as Packed:	3% maximum
Hardness:	98% minimum

STANDARD PACKAGING: Fifty-five (55) pound polyline polypropylene bags, fiber drums, and 1,000 pound supersacks.

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VAPOR CARBON ADSORPTION SYSTEMS

Vapor Phase Adsorbers

MODEL:	**SFV-2000**	
DIMENSIONS:	*Diameter:*	*48"*
	Overall Height:	*92"*
CONNECTIONS:	*Inlet:*	3" NPT side
	Outlet:	3" NPT side
	Drain	1" on bottom

DESIGN FEATURES:

OPERATING PRESSURE:	15 psi maximum
CARBON:	Virgin 4x8 coconut shell
IODINE NUMBER:	1150
CARBON WEIGHT:	2,000 lbs.
ADSORBER:	Carbon Steel with epoxy internal coatings. PVC internals. DOT rated.

MAXIMUM FLOW (cfm):	800
SHIPPING WEIGHT:	3,000 lbs.

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CARBTROL® Corporation

PROJECT: Battelle

FLOW IN CFM: 270.00
FLOW IN CFD: 388800.00

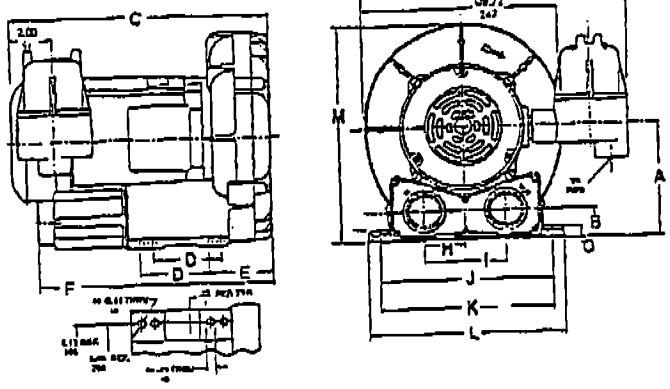
PERFORMANCE:

CONTAMINANT	CONC(ppmv)	#CONT /DAY	#CARBON /DAY	#CONT /100,000cf	#CARBON /100,000cf
Benzene	0.24	0.02	0.27	0.00	0.07
Toluene	0.46	0.04	0.28	0.01	0.07
Ethylbenzene	0.58	0.06	0.39	0.02	0.10
Xylene	1.6	0.17	0.94	0.04	0.24
TPH (as Benzene)	250	19.43	90.93	5.00	23.39
TOTALS	252.88	19.72	92.81	5.07	23.87

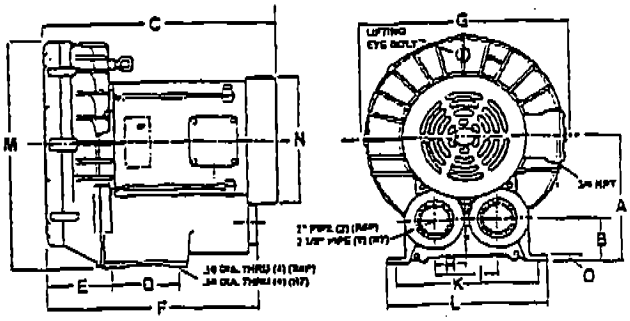
INDUCED-DRAFT BLOWER

SOIL VAPOR EXTRACTION PUMPS – REGENERATIVE BLOWERS

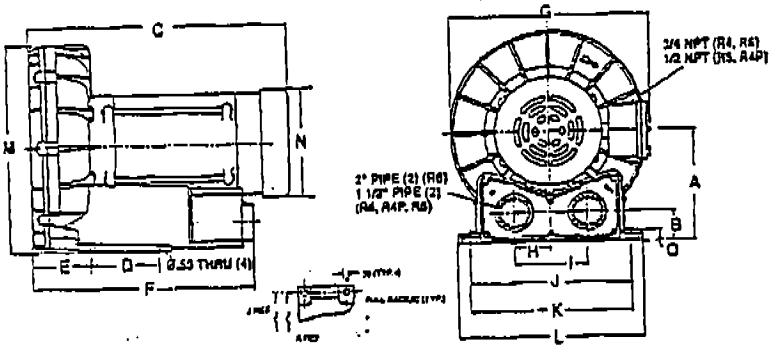
Model R3



Models R6P, R7



Models R4, R4P, R5, R6



Product Dimensions Metric (mm) U.S. Imperial (inches)

Model	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
R3105N-50	131	35	310	83	80	281	324	49	99	205	206	238	258	-	13
	5.17	1.37	12.20	3.25	3.03	11.06	12.75	1.94	3.88	8.06	8.12	9.38	10.15	-	.53
R4110N-50	157	43	389	95	72	316	313	50	101	225	227	254	293	175	11
	6.18	1.68	15.30	3.75	2.85	12.44	12.31	1.98	3.96	8.86	8.93	10.00	11.73	6.88	.44
R4310P-50	157	43	356	95	72	316	313	50	101	225	227	254	293	175	11
	6.18	1.68	14.03	3.75	2.84	12.44	12.31	1.98	3.96	8.86	8.93	10.00	11.73	6.88	.44
R4P115N-50	177	47	442	114	83	354	338	60	121	260	262	298	346	175	15
	6.98	1.84	17.41	4.50	3.25	13.93	13.31	2.38	4.75	10.25	10.31	11.75	13.6	6.88	.60
R5125Q-50	178	46	445	114	91	361	344	60	121	260	262	298	350	173	15
	7.00	1.82	17.50	4.50	3.58	14.22	13.56	2.38	4.75	10.25	10.31	11.75	13.78	6.81	.59
R5325R-50	178	46	423	114	91	361	344	60	121	260	262	298	350	183	15
	7.00	1.82	16.66	4.50	3.58	14.22	13.56	2.38	4.75	10.25	10.31	11.75	13.78	7.19	.59
R6130Q-50	197	49	511	140	98	404	389	62	125	289	290	329	391	217	13
	7.75	1.94	20.13	5.50	3.85	15.89	15.30	2.46	4.92	11.38	11.42	12.96	15.38	8.56	.52
R6340R-50	197	49	478	140	98	404	385	62	125	289	290	329	390	217	13
	7.75	1.94	18.82	5.50	3.85	15.89	15.17	2.46	4.92	11.38	11.42	12.96	15.34	8.56	.52
R6P155Q-50	248	80	602	140	137	438	428	64	127	-	290	325	463	257	13
	9.77	3.15	23.7	5.51	5.39	17.25	16.87	2.50	5.00	-	11.42	12.80	18.21	10.12	.50
R6P355R-50	248	80	554	140	137	438	428	64	127	-	290	325	463	257	13
	9.77	3.15	21.80	5.51	5.39	17.25	16.87	2.50	5.00	-	11.42	12.80	18.21	10.12	.50
R7100R-50	274	92	577	216	212	545	457	100	200	-	375	410	509	257	14
	10.79	3.64	22.72	8.50	8.33	21.46	18.00	3.94	7.88	-	14.76	16.14	20.02	10.12	.56

Notice: Specifications subject to change without notice.

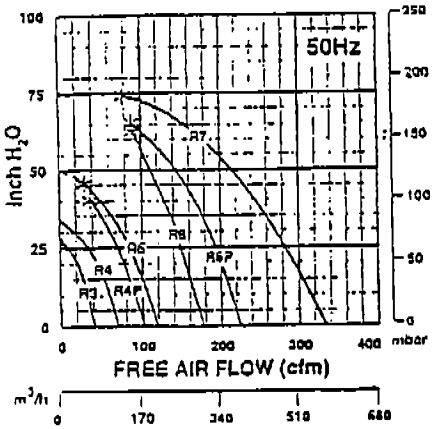
SOIL VAPOR EXTRACTION PUMPS – REGENERATIVE BLOWERS

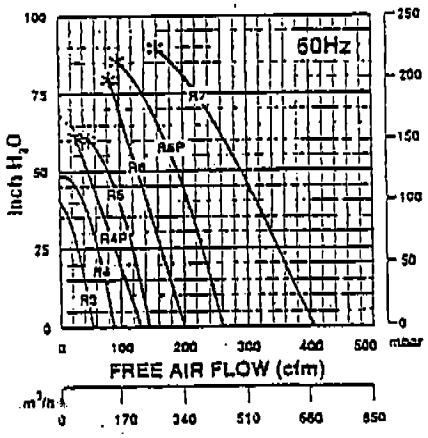
Product Specifications

Model Number	Phase	Hz	Motor Specifications Voltages	HP	Full Load Amps	Max Vac "H_2O	Max Vac mbar	Max Pressure "H_2O	Max Pressure mbar	Max Flow cfm	Max Flow m^3/h	Net. Wt. lbs	Net. Wt. kg
R3105N-50	Single	50	110/220-240	.33	3-8/1.9-2.0	28	70	31	77	43	73	52	24
		60	115/208-230	0.5	5.2/2.9-2.6	40	100	43	107	53	90		
R4110N-50	Single	50	110/220-240	0.6	9.2/5.2-4.6	35	87	38	95	74	126	60	28
		60	115/208-230	1.0	11.4/6.2-5.6	48	120	51	127	92	156		
R4310P-50	Three	50	220/380	0.6	3.2/1.6	35	87	38	95	74	126	58	27
		60	208-230/460	1.0	3.4-3.3/1.65	48	120	51	127	92	156		
R4P115N-50	Single	50	110/220-240	1.0	15.2/7.6-8	40	100	45	112	112	190	79	36
		60	115/208-230	1.5	18.2/9.7-9.1	60	149	65	162	133	226		
R5125Q-50	Single	60	115/230	2.0	25/12.5	60	149	55	137	160	272	77	35
R5325R-50	Three	50	190-220/380-415	1.5	5.0-4.4/2.5-2.6	47	117	50	125	133	226	75	34
		60	208-230/460	2.0	6.0-5.6/2.8	60	149	65	162	160	272		
R6130Q-50	Single	50	220-240	2.5	14.7-13.5	65	162	75	187	182	309	129	59
		60	230	3.0	16.3	70	174	60	149	215	365		
R6340R-50	Three	50	190-220/380-415	3.0	14.4-13.4/7.2-6.8	65	162	75	187	180	306	112	51
		60	208-230/460	4.0	13-12/6	80	199	100	249	215	365		
R6P155Q-50	Single	50	220-240	4.0	20.8-19.1	65	162	80	199	235	399	243	110
		60	230	5.5	29.9	85	212	95	237	280	476		
R6P355R-50	Three	50	190-220/380-415	4.5	14.9-11/7.45-5.8	65	162	80	199	232	394	233	105
		60	208-230/460	6.0	20-18/9	85	212	100	249	280	476		
R7100R-50	Three	50	190-220/380-415	8.0	20.8-18.9/10.4-9.5	72	179	80	199	350	595	297	134
		60	208-230/460	10.0	26.5-24/12	90	224	90	224	420	714		

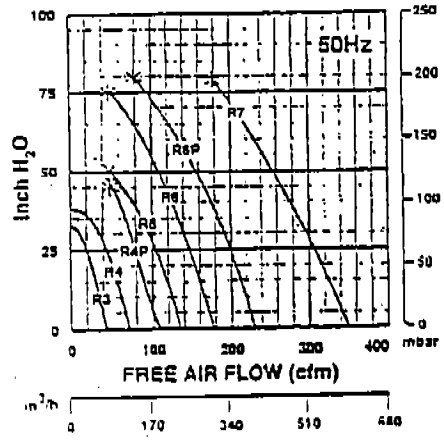
NOTICE: Performance specifications subject to change without notice.

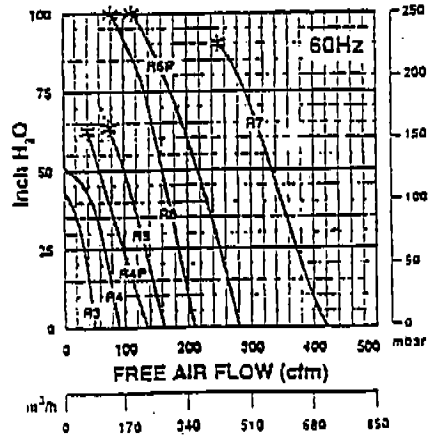
VACUUM





PRESSURE





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THERMAL OXIDIZER

EPG COMPANIES

Manufacturer of Solutions to Environmental Pollution Problems

September 3, 1996

Mr. Jerry Tompkins
Battelle
505 King Avenue
Columbus, OH 43201

Re: Thermal Oxidizer quote

Dear Jerry:

EPG Companies Inc. is pleased to offer the following proposal for your vapor extraction and off-gas treatment equipment needs.

To eliminate contaminants in a vapor stream with a destruction rate efficiency of 99+%, we recommend an EPG Oxidair™ thermal oxidizer with ceramic venturi-jet high efficiency burner. The thermal oxidizer shall include the fume mixing chamber, auxiliary fuel supply piping, draft air fan, and easy to operate process controls.

The EPG Oxidair™ Model EH 100 is offered for your flow of 80 SCFM which is capable of burning a maximum fume flow of 100 SCFM with a maximum heating value of 157,200 BTUH. The maximum fuel consumption at 80 SCFM with no fume stream concentrations is 90,547 cubic feet of natural gas per month(approximate cost of $425.00) operating in the thermal mode, or 35,572 cubic feet of natural gas per month(approximate cost of $170.00) operating with the addition of the catalytic module.

The thermal oxidizer shall operate at 1400°F with a residence time of 0.5 seconds. The process operating temperature shall be controlled by a digital temperature controller receiving signal from a type "K" thermocouple for temperature sensing. The Honeywell Series 7800 Burner controller contains a first out annunciator with contacts that assist in operation.

Corporate Offices
19900 County Road 81 ◆ Maple Grove, MN 55311

Mailing Address
P.O. Box 410 ◆ Rogers, MN 55374

612-424-2613 ◆ 800-443-7426 ◆ FAX 612-493-4812

Equipment Specifications for an EPG Oxidair™ Model EH Thermal Oxidizer

1. Oxidair™ burner features include:

   - Ceramic venturi-jet tile -- design accelerates the flow through the burner and thereby eliminates the possibility of flash back. The burner shall be a cast and fired ceramic material which will not breakdown or erode from harsh chemicals.

   - Windbox – Controls the ratio of combustion air brought through and around the ignition tube which regulates the air/fuel ratio. The windbox shall be manually adjustable.

   - Ignition tube – Contains the flame to produce a higher destruction efficiency and reduce the production of NO_X and CO. The ignition tube shall be lined with a low specific heat castable refractory.

   This unique burner design uses the oxygen and heating value from the fume stream reducing the amount of makeup air needed. The result is a typical fuel savings of 30% over competitive thermal oxidizers.

2. Draft air fan:

   The draft air fan shall supply supplemental air into the combustion chamber for the purge cycle and startup. The draft air inlet shall be equipped with an automatic modulating damper.

3. Cylindrical casted combustion chamber:

   The combustion chamber shall be cylindrical to eliminate dead air spots and to maximize the mixing of fumes and heat of combustion. The cylindrical design also allows for a monolithically cast liner which eliminates hot spots and increases refractory life. A low specific heat, lightweight insulation shall be used for its excellent durability and high insulating value.

4. Control Panel:

   A NEMA 4 enclosure shall house the Honeywell programmable burner process controller with flame strength indicator, high temperature limit controller, strip chart recorder, purge timer, alarm silencing push-button, indicator lights to show operating conditions, burner start push-button, ignition transformer, fan motor starter, motor load fuses, step down transformer (if required), terminal strips, and control circuit fuses.

5. Factory Mutual equivalent natural gas or propane pipe train:

   The auxiliary full pipe train shall include a safety shutoff valve, automatic modulating gas flow control valve, high and low gas pressure switches, pressure gauge, manual isolating valves, pilot gas regulator, and pilot solenoid shutoff valve. All interconnecting piping mounted on the unit shall be supplied, and all control items shall be fully wired.

6. Fume pipe train:

   The fume piping train shall include a safety shutoff solenoid valve, fume pressure switch, and pressure gauges.

Installation

The EPG Oxidair™ Model EH 100 thermal oxidizer will need at least the following items to be supplied by others:

1. Suitable structural support for the thermal oxidizer.

2. Connection of all utilities to the thermal oxidizer system terminal points, including 230 Volt, single phase (or as specified by customer), 60 Hz power and natural gas (or propane) regulated at 5 PSIG.

3. Ducting to the thermal oxidizer.

4. Any permits, such as air pollution control approvals, building permits, and any other regulatory documents that may be required.

5. All testing required for regulatory permits.

6. Installation and start up of the thermal oxidizer (or with recommended EPG assistance; see Rate Table, Bulletin 3120c).

The thermal oxidizer would be built and tested at EPG's manufacturing facility. After testing is finished the thermal oxidizer shall be disassembled only as necessary for shipment.

Two(2) sets of operations and maintenance manuals shall be provided and will include the following: parts list, general arrangement drawings, operations and maintenance instructions, and installation instructions.

Approval drawings including an equipment layout drawing, process diagram, piping and instrumentation schematic, and an electrical schematic can be submitted within two(2) weeks after receipt and acceptance of your purchase order. Testing can take place within eight(8) weeks after receipt of approved drawings and shipment can take place two(2) weeks after testing. If a shorter time schedule is desired, it can be provided upon request depending on the schedule of existing orders. Additional funds may be required for the overtime needed to meet the shortened schedule.

1 ea.	**EPG Oxidair™ Model EH 100** thermal oxidizer, horizontal skid mount. Includes burner, fume mixing chamber, exhaust stack, auxiliary fuel fume stream pipe trains, draft air fan, vapor extraction blower package(based on 80 SCFM at 25" W.C. vacuum) with CS-16b condensate separator, high level shut off switch, dilution air valve, vacuum relief valve, piping, and controls.	**$ 27,760.00**

Options:

1 ea.	**EPG Oxidair™ Model EH 100T** thermal oxidizer, trailer mounted. Includes burner, fume mixing chamber, exhaust stack, auxiliary fuel fume stream pipe trains, draft air fan, vapor extraction blower package(based on 80 SCFM at 25" W.C. vacuum) with CS-16b condensate separator, high level shut off switch, dilution air valve, vacuum relief valve, piping, and controls.	**$ 30,385.00**
1 ea.	**Catalytic Module**, to convert to catalytic oxidizer with 98%+ efficiency at an operating temperature of ~550°F, with a maximum auxiliary fuel consumption of 49,406 BTUH. Maximum VOC concentration at 80 SCFM without dilution air is up to 25% LEL or approximately 2,000 ppmV. With no known contaminants, the precious metal catalyst has an expected life of three to five years.	**$ 3,590.00**

Thank you for allowing us to quote on this project. All prices quoted are based on information supplied for bidding and our interpretation of that information along with our recommendations and/or changes for fabrication. Prices are subject to review and possible adjustment for any changes made that deviate from our outline given.

All prices are quoted F.O.B. our dock in Maple Grove, Minnesota. Standard terms of payment are net thirty(30) days from date of invoice subject to credit approval. If you have any questions or would like to place an order, please call me at (800) 443-7426.

Sincerely,
EPG Companies Inc.

Jim Bailey

Jim Bailey
Applications Specialist

Enclosures: EH 100 Thermal Oxidizer Specification, Bulletin 3125
EPG Drawing 1645
EPG Drawing 1842
Rate Table, Bulletin 3120c
Terms of Sale, Bulletin 3400b
Limited Warranty, Bulletin 0200c

STANDARD SPECIFICATION
EPG OXIDAIR™ MODEL EH 100 THERMAL OXIDIZER

1. OVERVIEW

A. This is a specification for a horizontal forced draft fume thermal oxidizer for destroying hydrocarbon vapors.

B. The standard unit consists of a high efficiency venturi jet burner system, combustion chamber, exhaust stack, pipe trains for auxiliary fuel and fume stream, draft air fan, and easy to operate process controls.

2. SPECIFICATIONS

A. 100 SCFM maximum fume flow with a maximum heating value of 157,200 BTUH.

B. 1400°F operating temperature with 0.5 second residence time.

C. Destruction rate in excess of 99.9%

D. Auxiliary burner turndown range of 4:1.

E. Vapor concentrations may vary from 0% LEL through and above the explosive range (100% LEL).

F. Carbon steel construction with internal insulation.

G. Factory Mutual style pipe train for natural gas or LPG which branches to provide fuel to the pilot as well as to the multi-burner system.

H. Factory Mutual style pipe train for hydrocarbon vapors.

I. The unit shall be pre-piped, wired and tested before shipping.

3. GENERAL OPERATION

A. The fumes enter a distribution plenum. The air which is carrying the fumes will be used as the oxygen supply for the combustion process, eliminating the need for outside combustion air. A unique venturi multi-jet burner system is used which eliminates the possibility of flashing back. It can be turned down, without hazard, until the fire is extinguished, and then readily re-ignited from the pilot. The burner produces a large cross-sectional area flame pattern for efficient mixing with the fumes, which minimizes fume bypass.

B. The combustion safeguard pilot is easily and safely applied because the pilot becomes, in effect, another burner jet. The combustion chamber is insulated by a low specific heat, lightweight, insulating, castable refractory which is molded to an engineered contour for the most intimate mixing of the combustion gases and the cold fumes. In addition, an arrangement of mixing baffles is supplied so that optimum fuel gas/air/fume mixing is obtained which results in minimum operating temperature for economical fuel requirements. When specified, the inlet plenum is insulated to further conserve heat and eliminate condensation of fumes. The refractory is encased in a circular steel shell for maximum strength. The shell is structurally supported, with its centerline matching the blower centerline.

4. MAJOR COMPONENTS

A. Horizontal insulated cylindrical casing, with sight ports and lifting lugs.

B. Draft air inlet plenum with automatic modulating damper.

C. Gas burner with a gas-electric igniter pilot. The venturi multi-jet burner design promotes intimate mixing of fuel and combustion air, which results in complete combustion and maximum heat release.

D. A U.L. listed, hinged, weather-resistant control panel enclosure shall contain the temperature indicating controller, high/low temperature limits, ultraviolet combustion safeguard system, alarm silencing push-button, operating lights to show normal operation, ignition push-button system, ignition transformer, draft air control, enable and disable circuit for fume blower, terminal strips, control circuit fuse, and nameplates.

E. Auxiliary fuel pipe train, including safety shutoff valve, automatic modulating gas flow control valve, high and low gas pressure switches, pressure gauge, manual isolating valves, pilot gas regulator, pilot solenoid shutoff valve and pressure taps. All interconnecting piping mounted on the unit will be supplied, and all control items will be fully wired.

F. Fume pipe train including pressure gauge, automatic shutoff valve, low vapor pressure switch, and manual valves.

G. Operating manuals (2) shall include a set of drawings, equipment maintenance requirements and component specifications.

5. COMBUSTION SAFEGUARD SYSTEM

A. An EPG nozzle-mixing type burner is used which eliminates the possibility of flash back. It can be turned down, without hazard, until the fire is extinguished and then readily re-ignited from the pilot. The oxidizer reaches operating temperature in approximately ten(10) minutes from a cold start.

B. An electronic controller, with thermocouple burnout safeguard, shall modulate a throttling electric motor-driven gas flow control valve to hold the incineration temperature at the set point. Should the temperature control system fail, a temperature limit will protect the oxidizer by activating both the fume and the main burner gas safety shutoff valves.

C. In order to assure that the burner is not operating unless it is burning normally and the start-up sequence has been properly followed, combustion safe-guard relay with UV flame monitor will be supplied. The combustion safeguard relay is interlocked to the high and low gas pressure switches, high temperature limit, and alarm.

D. A Factory Mutual approved main gas safety shut-off valve and pilot solenoid will be installed in the gas lines to automatically shut off the main gas and pilot gas in an alarm condition. An audible alarm shall be annunciated and an alarm light will be activated..

E. A U.L. listed NEMA 4 enclosure shall be supplied which will contain the electrical controls, including the control transformer for converting supply power to control power, operating lights to show normal operation, flame-rectification combustion safeguard system, fan motor starter, starting push-button, gas pilot ignition push-button system, audible alarm with silencing push-button, temperature recorder, terminal strips, control circuit fuse, and nameplates.

6. OPERATING ECONOMY

A. The Oxidair™ units are able to achieve low operating costs for the following reasons:

1. EPG will assist the customer in designing the fume gathering system so that only the optimum amount of air will be incinerated.
2. The auxiliary fuel valve and draft air damper shall automatically modulate as vapor concentrations change so that the entire heating value of the fume stream is utilized.
3. Operating temperature shall be controlled at the lowest permissible level with the smallest differential to minimize the amount of auxiliary fuel required.
4. When the fume stream contains a minimum of 16% oxygen, it shall be used as the source of combustion air for the burner and incineration process, eliminating the need for additional heat absorbing outside combustion air.
5. . Shall not require LEL or O_2 sensors for safe operation which eliminates time spent cleaning and calibrating sensors.

7. ASSEMBLY AND TESTING

A. The unit will be completely assembled and tested in our plant. The unit shall be finished with a heavy coat of high temperature synthetic enamel. It will be partially disassembled for shipping to the site for installation to be completed by others.

B. All field work will be done by others. Written instructions concerning proper operation of the equipment shall be furnished.

8. INSTALLATION

The Oxidair™ units will need at least the following items to be supplied by others:

A. Suitable flat, level, stable foundation.

B. Connection of all utilities to the thermal oxidizer system terminal points, including appropriate electrical power and pressure regulated natural gas or LPG (to be determined at time of purchase) to the burner mounted on the thermal oxidizer.

C. Connection of fume blower control circuitry to the N.C. enable/disable contacts in the thermal oxidizer control panel.

D. Any permits, air pollution control approvals, and any other regulatory documents which may be required.

E. Installation of the thermal oxidizer system.

F. Installation engineering and supervision.

G. Start up (or with recommended EPG assistance; see Rate Table, Bulletin 3120b).

H. Air pollution compliance testing.

9. OPTIONAL EQUIPMENT

A. Trailer mounted.

B. Extended combustion chamber to increase residence time.

C. Heat exchanger.

D. Catalytic modules.

E. Flame arrestor.

F. Fume blower.

G. Condensate separator.

H. Autodialers or telemetry systems.

Note: Custom designs such as special controls and physical arrangements, can be provided upon request.

10. AIR POLLUTION GUARANTEE

A. We guarantee the destruction of all hydrocarbon materials to comply with the requirements of the local air pollution control authority as of the date of our proposal.

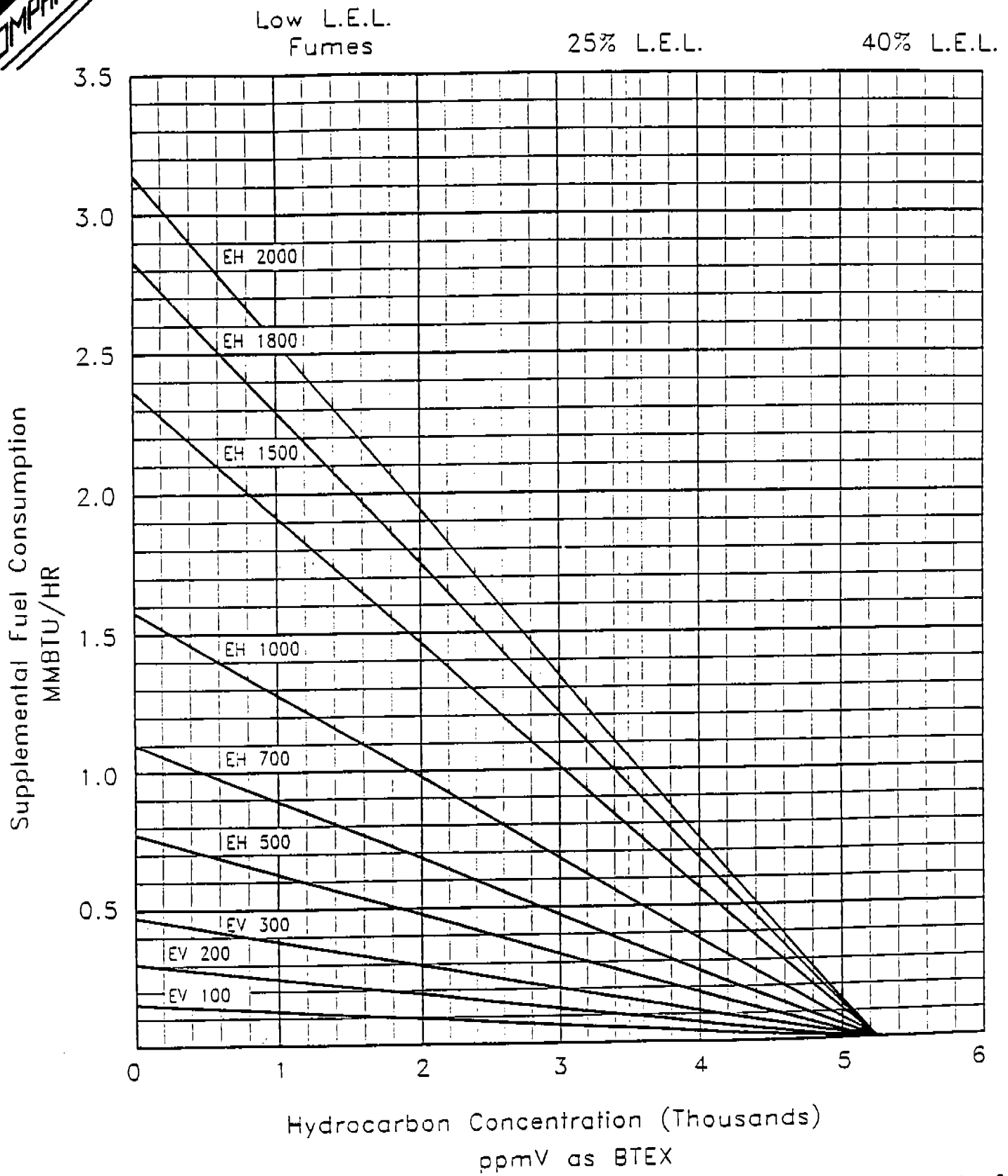
11. DELIVERY

Approval drawings including and equipment layout drawing, process diagram, piping, and instrumentation schematic, and an electrical schematic, can be submitted within two(2) weeks after receipt of your purchase order. Testing can take place within eight(8) weeks after receipt and acceptance of approved drawings and shipment can take place two(2) weeks after testing. If a shorter time schedule is desired, it can be provided upon request depending on the schedule of existing orders. Additional funds may be required for the overtime needed to meet the shortened schedule.

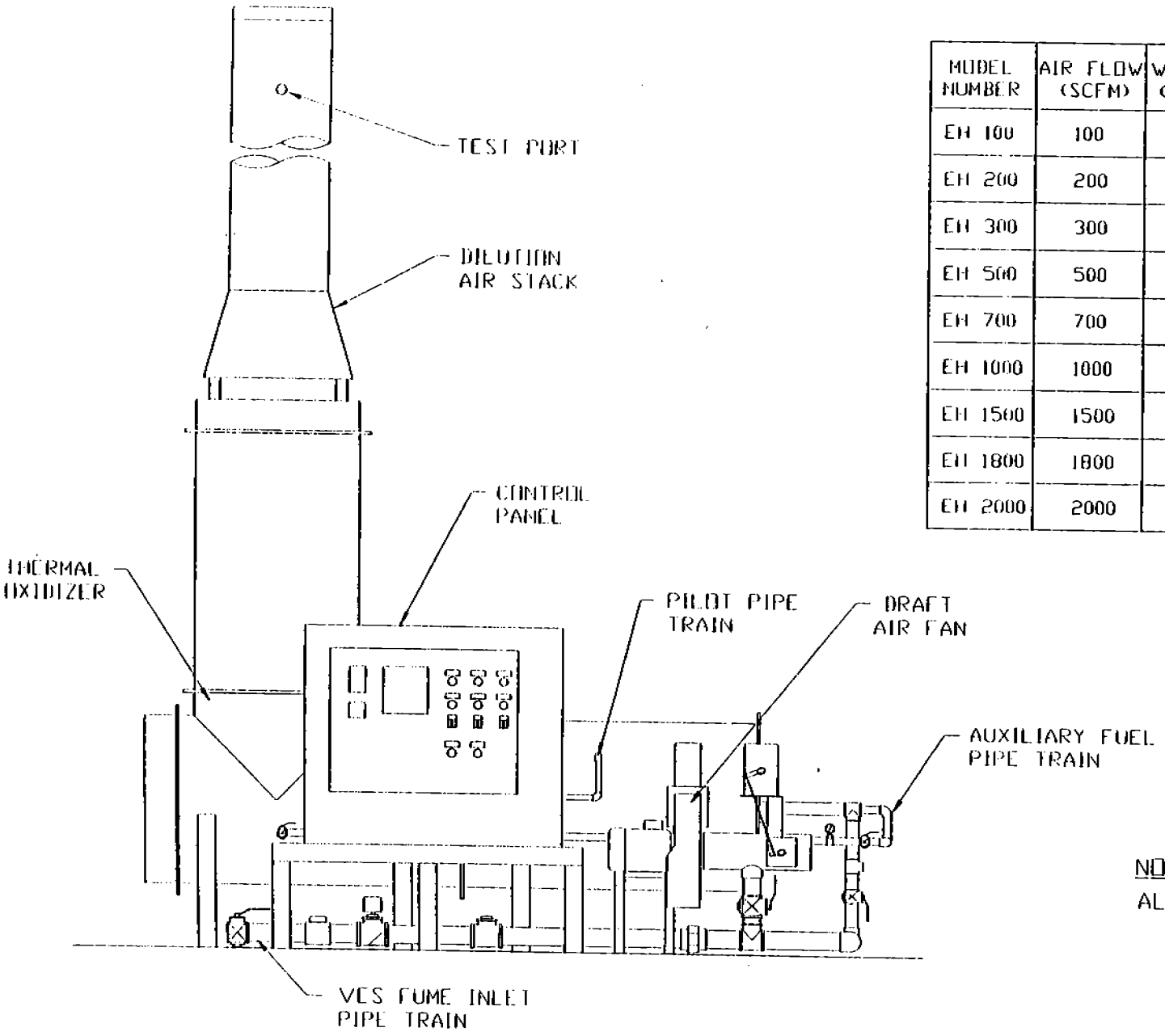
EPG COMPANIES

OXIDAIR™ THERMAL OXIDIZER

0395



This curve is based on an operating temperature of 1400°F. The catalytic oxidizer will require approximately 60% less fuel.



MODEL NUMBER	AIR FLOW (SCFM)	WEIGHT (LBS.)	DIMENSIONS		
			LENGTH	WIDTH	HEIGHT
EH 100	100	1300	10'-0"	4'-6"	12'-0"
EH 200	200	1500	10'-0"	4'-6"	12'-0"
EH 300	300	2000	10'-9"	4'-10"	12'-8"
EH 500	500	3200	10'-9"	4'-10"	12'-8"
EH 700	700	3600	11'-3"	5'-0"	13'-8"
EH 1000	1000	4500	12'-0"	6'-0"	13'-8"
EH 1500	1500	5500	13'-6"	6'-9"	14'-6"
EH 1800	1800	6600	13'-6"	7'-6"	14'-6"
EH 2000	2000	7000	13'-6"	7'-6"	14'-6"

NOTE:

ALL WEIGHTS AND DIMENSIONS ARE APPROXIMATE.

EPG COMPANIES

EPG OXIDAIR™ THERMAL OXIDIZER

DRAWN BY	C.A.S.	SCALE	NONE
CHK'D		DATE	05-19-95
APP'D			

DRAWING NO. 1842

RATE TABLE

LABOR CHARGES:	PER HOUR*	PER DAY
Principal Engineer	$200.00	$1,600.00
"A" Engineer	125.00	1,000.00
"B" Engineer	100.00	800.00
Programming	85.00	680.00
Drafting	55.00	440.00
Purchasing	50.00	400.00
Clerical	40.00	320.00
SERVICE OR TESTING:		
Start-up, Senior Test Technician, Installation Supervisor	85.00	680.00
"A" Mechanic	65.00	520.00
Shop Labor	55.00	440.00

NOTES:

1. All work to be done during normal working hours.

* 2. Rates 1.5 times those shown for:
   A. Hours in excess of eight(8), but not more than twelve(12) hours per day (Monday through Friday).
   B. Saturday work (up to eight hours).
   C. Sunday work if worked in lieu of Saturday at our option.

* 3. Rates 2.0 times those shown above will apply for:
   A. All holidays.
   B. Sundays, except as excluded above.
   C. Hours in excess of twelve(12) per day (Monday through Friday).
   D. Hours in excess of eight(8) for Saturday work.

4. All field rates are based on portal to portal time.
5. Travel time charged at straight time.
6. Minimum labor charge is four(4) hours.

TRAVEL AND PER DIEM:	
Mileage	$ .45/mile
Commercial transportation/car rental	Cost + 10%
Per diem (lodging and subsistence only)	$100.00 per day minimum, not less than cost + 10%
TEST INSTRUMENT:	$125.00 per day
EQUIPMENT RENTAL:	Cost + 25%

EPG Companies Inc.

January 1995

TERMS OF SALE

All sales of equipment are expressly conditioned upon the terms set forth below. Buyer's acceptance of these terms shall be presumed from the buyers acceptance of all or any part of the goods or services ordered. No addition or modification of these terms shall be binding upon EPG Companies (EPG) unless agreed to by EPG in writing. If a purchase order or other correspondence contains terms or conditions contrary to the terms contained here, EPG's acceptance of any order shall not be construed as assent to any additional terms and conditions, nor will that constitute a waiver by EPG of any of the terms contained here.

1. Until all sums due are paid in full, buyer hereby grants to EPG a security interest in and to the property described herein.

2. Should buyer fail to make any payment when due or fail to fulfill any promise or condition herein, all sums payable shall be, at EPG's option and without notice, immediately due and payable. EPG may take possession of the property and for that purpose may enter any premises where the property may be and remove the same thereby terminating all buyer's right and may retain all payments received as liquidated damages, or EPG may enforce any other remedy allowed by law.

3. In the event of default, buyer agrees to pay all costs incurred by EPG, including reasonable attorney fees, to secure payment of the amounts due or collection of the properties identified.

4. No credit will be allowed for goods returned without our written permission. There will be a 20% restocking charge for items accepted for credit; items to be returned to Seller's plant, transportation prepaid and subject to inspection.

5. Payment terms are as follows:
   Rental equipment - due upon receipt of invoice
   Services calls and system startups - due upon receipt of invoice
   Freight charges - Net 10 days from date of invoice
   All other billings - Net 30 days from date of invoice

   A service charge of 1.5% per month may be added to all accounts not paid within thirty(30) days of the invoice date. All payments must be made in U. S. dollars.

6. EPG shall not be liable for any production delay resulting in whole or in part from acts of God, labor disruptions, shortages, inability to procure product, supplies, or raw materials, severe weather conditions, or any other circumstances or cause beyond the control of EPG. In no case shall EPG be liable for any consequential or special damages arising from any delay in delivery.

7. Acceptance of any order is subject to credit approval and acceptance of order by EPG. If Buyer fails to comply with these terms and conditions of sale or if Buyer's credit becomes unsatisfactory to EPG at its sole discretion, EPG reserves the right to terminate credit arrangement upon notice to Buyer without liability to EPG.

8. Buyer shall be responsible for payment of any or all state or local taxes directly to the taxing authority, although EPG will collect state and local taxes for shipments made to locations in Minnesota.

9. Deliveries are F.O.B. Maple Grove, MN. Quoted prices do not include freight. Title and risk of loss shall pass to Buyer upon tender of the products by EPG to a common carrier. In absence of specific written instruction from Buyer, EPG will select the common carrier, but EPG shall not incur any liability in connection with shipment. Buyer shall be responsible for any freight charge. If the products are shipped freight prepaid, Buyer shall pay EPG the freight and handling charge, which will be shown as a separate item on the invoice. Payment terms on freight charges are *net 10 days*.

LIMITED WARRANTY

This agreement shall be deemed to have been entered into in the State of Minnesota, and shall be construed in accordance with the laws of the State of Minnesota, including Minnesota's enactment of the Uniform Commercial Code. Buyer hereby stipulates and agrees that Hennepin County, Minnesota shall be the proper jurisdiction for adjudicating all claims and controversies arising from this agreement.

Products manufactured by EPG Companies Inc. are warranted for a period of 12 months from date of installation or eighteen(18) months from date of manufacture* to be free from defects of materials and workmanship. It is expressly agreed that the exclusive remedy under this warranty is limited solely to the repair or replacement, at the sole discretion of EPG, of the part that failed. The cost of labor for any field repairs is not covered by this warranty. EPG Companies will not be liable for any damage or wear due to abnormal conditions or improper installation.

Products not manufactured by EPG Companies Inc. are covered by the original manufacturer's warranty, which EPG Companies passes through to the purchaser. Warranty determination will be made by the actual manufacturer.

To have a defective part repaired or replaced, you must return the defective product to EPG Companies. Please call (800) 762-8418 or (612) 424-2613 to obtain a Return Goods Authorization (RGA) number. Send defective product (freight prepaid) with RGA #, description of installation, installation data and failure date to EPG Companies Inc., 19900 County Rd. 81, Maple Grove, MN 55311.

EPG Companies will not be held liable for any incidental or consequential damages, losses or expenses incurred from installation, use or any other reason. THERE ARE NO OTHER WARRANTIES, EXPRESSED OR IMPLIED, INCLUDING IMPLIED WARRANTIES OF EITHER FITNESS FOR A PARTICULAR PURPOSE OR OF MERCHANTABILITY, WHICH EXTEND BEYOND THOSE SPECIFICALLY LISTED HERE.

If equipment is to be stored for a period greater than six months, proper storage precautions must be taken if the warranty is to be maintained. Please call EPG Companies for specific requirements regarding product storage.

The following is a partial list of items which will void the warranty:

- Opening of a motor for any reason.
- Using undersized electrical wire.
- Making unauthorized circuit changes. Please call EPG Companies before making any changes.
- Operating a three phase submersible motor from single phase power through a phase converter unless 3-leg ambient-compensated quick trip overload protectors are used and complete details are sent in writing to EPG Companies.

* To qualify for the delayed installation warranty you must contact EPG Companies Inc., at (800) 762-8418 or (612) 424-2613 within 60 days of purchase.

limit, approximately 10,000 SCF of air is required for every gallon of solvent evaporated. To determine the minimum safe exhaust rate the following formula may be used:

$$\text{Exhaust SCFM} = \frac{\text{GPH} \times 10{,}000}{60}$$

Where: GPH is the actual evaporation of solvent expressed as gallons per hour.

When the solvent concentration is known in PPM, the following conversion table may be used:

L.E.L. - %	2.5	5.0	7.5	10.0	12.5	15.0	17.5	20.0	22.5	25.0
Gal. per 10,000 SCF	.1	.2	.3	.4	.5	.6	.7	.8	.9	1.0
PPM (Gasoline)	350	700	1,050	1,400	1,750	2,100	2,450	2,800	3,150	3,500
PPM (Methane)	1,250	2,500	3,750	5,000	6,250	7,500	8,750	10,000	11,250	12,500

HEAT REQUIREMENTS

The heat required to raise the temperature of a known volume of air can be determined from the following formula:

$$\text{BTUH} = \text{SCFM} \times (t_2 - t_1) \times 1.1$$

Where: t_2 is the final temperature in ° F.
t_1 is the initial temperature in ° F.

BASIC HEATING DATA

- 1 BTU (British Thermal Unit) = heat required to raise 1 lb. of water 1°F
- Specific heat of water = 1 BTU
- Specific heat of air = 0.24 BTU
- 1 cubic foot of air @ 32°F = 0.085 lb.
- 1 cubic foot of air @ 60°F = 0.075 lb.
- 1 BTU will heat 1 cubic foot of air 55°F
- 1 gallon (U.S.) of water = 8.33 lbs.
- 1 gallon (U.S.) of water = 231 cubic inches @ 39.2°F
- 1 cubic foot of water = 7.48 gallons
- 1 cubic foot of water = 62.418 lbs. @ 39.2°F
- Natural gas = 18,000 BTU/lb. or 1,000 BTU/ft³
- Propane = 21,500 BTU/lb. or 2,500 BTU/ft³
- Gasoline = 17,857 BTU/lb. or 4,921 BTU/ft³
- 1 gallon of LP gas = 36.6 ft³
- 1 gallon of LP gas = 4.25 lbs
- 1 gallon of gasoline = 125,000 BTU
- 1 gallon of propane = 91,375 BTU

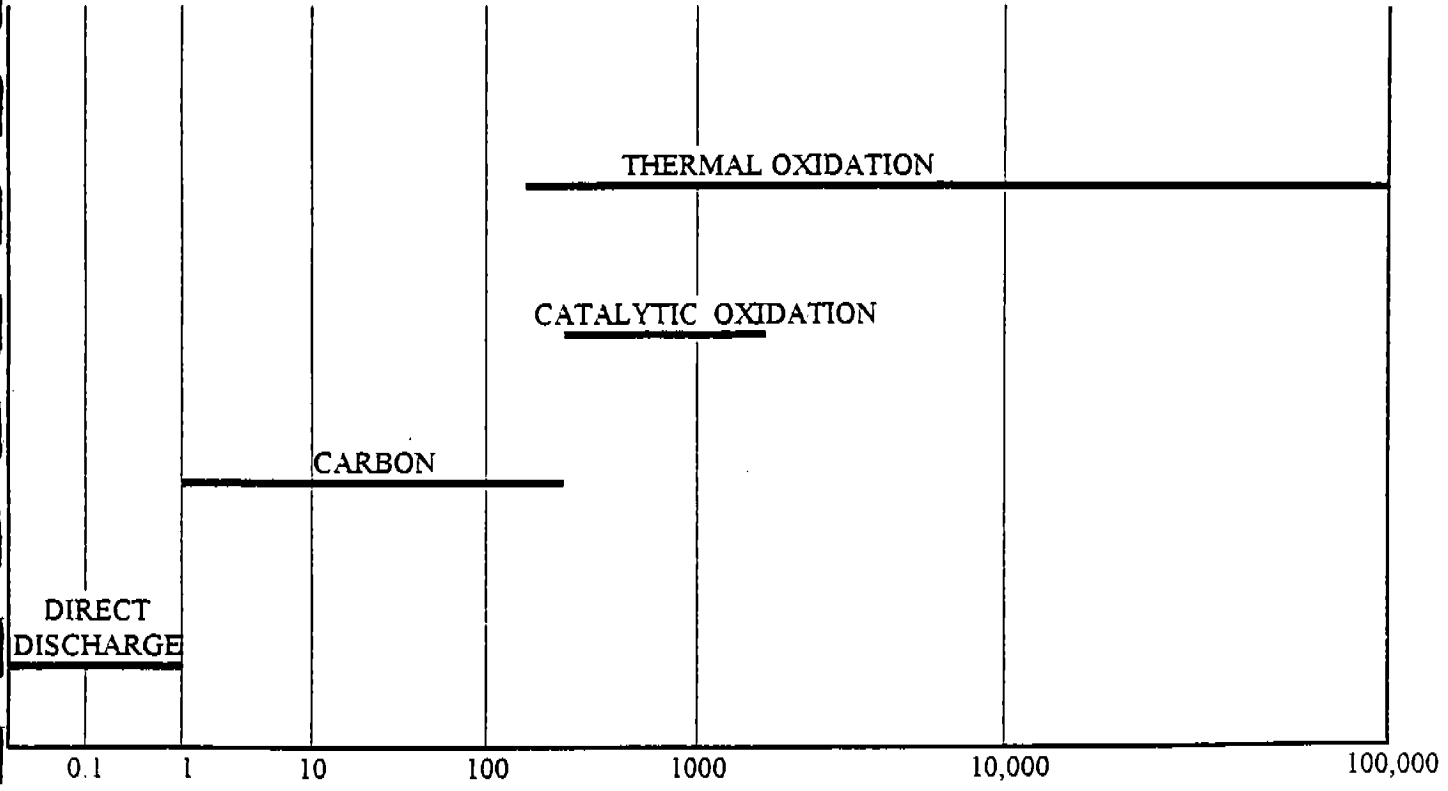
SUBSTANCES THAT INFLUENCE CATALYST ACTIVITY

TYPE OF INHIBITORS	EFFECT
Fast Acting Inhibitors	
Phosphorus, Bismuth, Lead, Arsenic, Antimony, Mercury	Irreversible reduction of catalyst activity at rate dependent on concentration and temperature.
Slow Acting Inhibitors	
Iron, Tin, Silicon	Irreversible reduction of catalyst activity. Higher concentrations than those of fast acting catalyst inhibitors may be tolerated.
Reversible Inhibitors	
Sulfur, Halogens, Zinc	Reversible surface coating of catalyst active area at rate dependent on concentration and temperature.
Surface Maskers	
Organic Solids	Reversible surface coating of catalyst active area. Removed by increasing catalyst temperature.
Surface Eroders and Maskers	
Inert Particulate	Surface coating of catalyst active area. Also erosion of catalyst surface at rate dependent on particle size, grain loading and gas stream velocity.

THERMAL OXIDIZERS

Fume Stream Characteristics	**Operations Recommendations**
High concentrations of VOCs and high oxygen content.	Dilution of VOCs may be required.
High concentrations of VOCs and low oxygen content.	Dilution air required for supplemental oxygen (~16% minimum). Further dilution of VOCs may also be required.
Low concentrations of VOCs and high oxygen content.	Addition of catalytic module recommended for longer term projects. Consider the use of carbon or direct discharge if applicable.
Low concentrations of VOCs and low oxygen content.	Dilution air required for supplemental oxygen (~16% minimum). Addition of catalytic module recommended for longer term projects. Consider the use of carbon or direct discharge if applicable.

RECOMMENDED RANGES OF OPERATION FOR VARIOUS METHODS OF OFF-GAS TREATMENT



COMPARISON OF VARIOUS METHODS FOR OFF-GAS TREATMENT

METHOD	ADVANTAGES	DISADVANTAGES
CARBON ABSORPTION	- Can be energy efficient with high fume flow rates and low organic concentration. - Possibility of recovering valuable wastes. - Low maintenance.	- Disposal/regeneration of spent carbon is expensive. - Cannot acheive high removal effiency. - Limited to flows with low concentrations of contaminants.
CATALYTIC OXIDATION	- Ducts and catalysts usually the only maintenance. - Heat recovery possible. - Theoretically lower operating temperature under ideal conditions where fume constituents have similar characteristics and can react completely.	- High equipment costs. - Replacement catalyst costs can be as much as the price of a thermal oxidizer. - Catalysts are not able to handle all the constituents found in a complex fume due to its selectivity. - When heat recovery equipment is used, comparatively large exchange surfaces are required due to lower temperature differentials. - SO_2 in fume oxidized to SO_3 which must be scrubbed with caustic. - High pressure drop across catalyst increases energy costs.
EPG OXIDAIR™ THERMAL OXIDATION	- Provides a final solution to the problem. - No carbon or catalysts to dispose of. - Economical heat recovery possible. - Oxidation completion not affected by hydrocarbon vapor particle size. - Rich hydrocarbon fumes safely accommodated, and can be almost self-incinerating reducing fuel requirements to practically nil. - Fumes containing 16% or more 0_2 can be used as the source of fuel combustion air saving up to 30% of fuel requirements. - Incineration temperature readily adjustable to minimum required for complete destruction. - Minimum maintenance since there are no fouling or further disposal problems.	- Inorganic materials not destroyed. - Fumes with a dew point above 120°F should be cooled, and condensed moisture separated, to minimize fuel cost. - Increased auxiliary fuel usage for low L.E.L. fume streams.

THERMAL OXIDIZER DESIGN AND ENGINEERING DATA

COMMON ABBREVIATIONS USED:

BTU	British thermal units	L.E.L.	Lower explosive limit
BTUH	BTU per hour	MBTUH	Thousand BTUH
CF	Cubic feet	MMBTUH	Million BTUH
CFH	CF per hour	N.F.P.A.	National Fire Protection Assoc.
CFM	CF per minute	PPM	Parts per million
CFS	CF per second	SCF	Standard CF
I.R.I.	Industrial Risk Insurers	SCFH	SCF per hour
F.M.	Factory Mutual Insurance Assoc.	SCFM	SCF per minute
GPH	Gallons per hour	Therm	100,000 BTU
U.E.L.	Upper explosive limit	t	Temperature

STANDARD VOLUME:

The volume of gas or air measured at 29.92 inches of mercury pressure, and 60°F. To convert any volume of gas or air (at a given temperature and atmospheric pressure) to standard volume, the following formula is used:

$$\text{Standard cubic feet (SCF)} = \frac{CF \times (460 + 60)}{(460 + t_1)}$$

Where: CF is the know volume
t_1 is the actual temperature °F

To convert a known actual volume to standard volume, multiply the known volume by the following factor:

t_1	Factor	t_1	Factor	t_1	Factor	t_1	Factor
0°	1.13	300°	.685	800°	.412	1,300°	.295
32°	1.06	400°	.605	900°	.382	1,400°	.279
60°	1.00	500°	.542	1,000°	.356	1,500°	.266
100°	0.93	600°	.491	1,100°	.333	1,600°	.252
200°	0.79	700°	.448	1,200°	.313	1,700°	.241

To convert SCF to actual volume, divide the SCF by the above factors.

LOWER EXPLOSIVE LIMIT (L.E.L.)

The point at which a mixture of vapor and air is rendered barely explosive. N.F.P.A. Standard 86A establishes the maximum safe limit of vapor concentration at 25% of L.E.L. At the safe

limit, approximately 10,000 SCF of air is required for every gallon of solvent evaporated. To determine the minimum safe exhaust rate the following formula may be used:

$$\text{Exhaust SCFM} = \frac{\text{GPH} \times 10{,}000}{60}$$

Where: GPH is the actual evaporation of solvent expressed as gallons per hour.

When the solvent concentration is known in PPM, the following conversion table may be used:

L.E.L. - %	2.5	5.0	7.5	10.0	12.5	15.0	17.5	20.0	22.5	25.0
Gal. per 10,000 SCF	.1	.2	.3	.4	.5	.6	.7	.8	.9	1.0
PPM (Gasoline)	350	700	1,050	1,400	1,750	2,100	2,450	2,800	3,150	3,500
PPM (Methane)	1,250	2,500	3,750	5,000	6,250	7,500	8,750	10,000	11,250	12,500

HEAT REQUIREMENTS

The heat required to raise the temperature of a known volume of air can be determined from the following formula:

$$\text{BTUH} = \text{SCFM} \times (t_2 - t_1) \times 1.1$$

Where: t_2 is the final temperature in ° F.
t_1 is the initial temperature in ° F.

BASIC HEATING DATA

- 1 BTU (British Thermal Unit) = heat required to raise 1 lb. of water 1°F
- Specific heat of water = 1 BTU
- Specific heat of air = 0.24 BTU
- 1 cubic foot of air @ 32°F = 0.085 lb.
- 1 cubic foot of air @ 60°F = 0.075 lb.
- 1 BTU will heat 1 cubic foot of air 55°F
- 1 gallon (U.S.) of water = 8.33 lbs.
- 1 gallon (U.S.) of water = 231 cubic inches @ 39.2°F
- 1 cubic foot of water = 7.48 gallons
- 1 cubic foot of water = 62.418 lbs. @ 39.2°F
- Natural gas = 18,000 BTU/lb. or 1,000 BTU/ft³
- Propane = 21,500 BTU/lb. or 2,500 BTU/ft³
- Gasoline = 17,857 BTU/lb. or 4,921 BTU/ft³
- 1 gallon of LP gas = 36.6 ft³
- 1 gallon of LP gas = 4.25 lbs
- 1 gallon of gasoline = 125,000 BTU
- 1 gallon of propane = 91,375 BTU

GASOLINE LOWER EXPLOSIVE LIMIT		
% LEL	PPMV	LEL % (by volumn)
.01	1.4	.00014
.02	2.8	.00028
.03	4.2	.00042
.04	5.6	.00056
.05	7.0	.0007
.06	8.4	.00084
.07	9.8	.00098
.08	11.2	.00112
.09	12.6	.00126
.1	14	.0014
.2	28	.0028
.3	42	.0042
.4	56	.0056
.5	70	.007
.6	84	.0084
.7	98	.0098
.8	112	.0112
.9	126	.0126
1	140	.014
2	280	.028
3	420	.042
4	560	.056
5	700	.070
6	840	.084
7	980	.098
8	1120	.112
9	1260	.126
10	1400	.140
11	1540	.154
12	1680	.168
13	1820	.182
14	1960	.196

GASOLINE LOWER EXPLOSIVE LIMIT		
% LEL	PPMV	LEL % (by volumn)
15	2100	.210
16	2240	.224
17	2380	.238
18	2520	.252
19	2660	.266
20	2800	.280
21	2940	.294
22	3080	.308
23	3220	.322
24	3360	.336
25	3500	.350
28.6	4000	.40
32.1	4500	.45
35.7	5000	.50
39.3	5500	.55
42.9	6000	.60
46.4	6500	.65
50.0	7000	.7
53.6	7500	.75
57.1	8000	.8
60.7	8500	.85
64.3	9000	.9
67.9	9500	.95
71.4	10000	1.0
75.0	10500	1.05
78.6	11000	1.1
82.1	11500	1.15
85.7	12000	1.2
89.3	12500	1.25
92.9	13000	1.3
96.4	13500	1.35
100.0	14000	1.4

Above table calculated as follows:

$$\text{LEL} = 1.4\% = \frac{1.4}{100} \times 10^6 = \frac{14{,}000 \text{ PPMV @ } 100\% \text{ LEL}}{4} = 3500 \text{ PPMV @ } 25\% \text{ LEL}$$

GASOLINE EXPLOSIVE RANGE	
PPMV	**ER% (by volumn)**
14,000	1.40
14,500	1.45
15,000	1.50
15,500	1.55
16,000	1.60
16,500	1.65
17,000	1.70
17,500	1.75
18,000	1.80
18,500	1.85
19,000	1.90
19,500	1.95
20,000	2.00

GENERAL PROPERTIES OF GASOLINE FROM NFPA 86

- Molecular Weight — Mix
- Flash Point — -45°F
- Ignition Temperature — 495°F
- Lower Explosive Limit % by volumn — 1.4%
- Upper Explosive Limit % by volumn — 7.6%
- Specific Gravity (water = 1) — 0.8
- Vapor Density (air=1) — 3.4
- Boiling Point — 100-400°F
- Pounds per Gallon — 7.0
- Cubic Feet of Vapor per gallon liquid — 25.4
- Cubic Feet of Vapor per pound liquid — 3.63
- Approximate cubic feet of air rendered barely explosive per gallon — 1790

APPENDIX B

CALIBRATION PROCEDURES FOR MONITORING INSTRUMENTATION

HYDROCARBON ANALYZER

INSTRUCTION MANUAL
TRACE-TECHTOR
PORTABLE HYDROCARBON VAPOR TESTER

GEM GASTECH ENVIRONMENTAL MONITORS

DIVISION OF GAS TECH INC
8445 Central Avenue, Newark, CA 94560
Phone (510) 745-8700 FAX (510) 794-6201

WARNING

EXPLOSIVE GAS MIXTURES CAN MAIM, DISFIGURE, AND KILL. TOXIC VAPORS CAN CAUSE IMPAIRMENT OF HEALTH. IT IS ESSENTIAL THAT USERS OF THIS INSTRUMENT READ, UNDERSTAND, AND FOLLOW THE INSTRUCTIONS FOR OPERATION AND MAINTENANCE, AND THE PRECAUTIONS CONTAINED IN THIS MANUAL TO INSURE THAT THE INSTRUMENT IS USED IN A PROPER AND SAFE MANNER.

THE SENSOR USED IN THIS INSTRUMENT REQUIRES OXYGEN TO OPERATE. THIS INSTRUMENT IS INTENDED FOR MONITOR WELL TESTING, INTERSTITIAL SPACE TESTING, SOIL VAPOR ANALYSIS AND OTHER APPLICATIONS OF HYDROCARBON GAS OR VAPOR DETECTION IN AIR. DO NOT USE TO CHECK HYDROCARBON VAPOR LEVELS IN VESSELS THAT HAVE BEEN PURGED, WITH CO_2 OR OTHER INERT GAS, WITHOUT THE USE OF A DILUTION FITTING OR OTHER METHOD OF INTRODUCING OXYGEN INTO THE SAMPLE. LIKEWISE, USE OF THE INSTRUMENT IN OXYGEN ENRICHED MIXTURES IS BEYOND THE NORMAL SCOPE OF ITS INTENDED APPLICATION.

THIS DEVICE IS SAFE FOR TESTING MOST MIXTURES OF COMBUSTIBLE GAS IN AIR. IT IS CERTIFIED BY THE MANUFACTURER TO BE INTRINSICALLY SAFE IN CLASS I, DIVISION 1, GROUP C AND D ENVIRONMENTS.

VERSIONS OF THIS INSTRUMENT WHICH HAVE "NOT FOR METHANE USE" PRINTED ON THE METER DIAL DO NOT RESPOND TO METHANE OR NATURAL GAS. THESE INSTRUMENTS MUST NOT BE USED FOR DETECTION OF METHANE OR NATURAL GAS.

EXPLOSIVE MIXTURES OF ACETYLENE OR HYDROGEN IN AIR (GROUP A AND B ATMOSPHERES) ARE UNSUITABLE ENVIRONMENTS FOR PERSONNEL AND FOR ELECTRICALLY OPERATED INSTRUMENTS. THIS INSTRUMENT WAS NOT DESIGNED FOR USE UNDER SUCH CONDITIONS AND IS NOT CERTIFIED INTRINSICALLY SAFE FOR GROUP A AND B ATMOSPHERES.

DO NOT SAMPLE OR TEST OXYGEN-ACETYLENE MIXTURES AS FOUND IN OXY-ACETYLENE WELDING AND CUTTING EQUIPMENT. DO NOT USE FOR DETECTION OF TOXIC GASES OTHER THAN ORGANIC VAPORS IN THE TOXIC RANGE.

TRACE-TECHTOR WITH METHANE RESPONSE SWITCH

I. INTRODUCTION

This instrument is a standard Trace-Techtor with an added methane response switch. It is a toggle switch located on the top rear of the instrument. The switch changes the operating voltage of the sensor, which affects the response of the instrument to various gases. In the "FULL GAS RESPONSE" position, the sensor has full response to methane (CH_4). In the "NO METHANE RESPONSE" position, the sensor does not respond to methane, and response to certain other gases is also reduced or eliminated.

II. OPERATION

Set up, turn on, and warm up your instrument as described in the following instruction manual.

When to use the FULL GAS RESPONSE position:

When using the Trace-Techtor as a general hydrocarbon indicator, or when response to methane is desired.

When to use the NO METHANE RESPONSE position:

To detect hexane, BTX, and other petroleum-based hydrocarbons in environments where methane is or may be present, but where methane readings are not desired.

Note:

When switching between the FULL GAS and NO METHANE RESPONSE positions, allow two minutes for the sensor to stabilize, then re-zero in fresh air. It may also be necessary to adjust the Coarse Zero.

III. CALIBRATION

This unit was factory calibrated on hexane, with the switch in the NO METHANE RESPONSE position. When used in the FULL GAS RESPONSE position, the readings will be about 10% higher than NO METHANE RESPONSE readings.

For greatest accuracy, calibrate the Trace-Techtor on the gas (or vapor) to be detected, with the methane response switch in the desired position.

SPECIFICATIONS
GASTECH ENVIRONMENTAL MONITORS
TRACE-TECHTOR

			Standard	(Optional)
Serial No:	DT061	Ranges:	0-100 ppm 0-1000 ppm 0-10,000 ppm	0-500 0-5000 0-50,000
Sensor Type:	Catalytic	ALARMS:	100 ppm 1000 ppm 2000 ppm	500 2000 10,000
Calibration:	Hexane			

CONTENTS

I. INTRODUCTION

The Trace-Techtor is a portable instrument for detection of hydrocarbon vapors over a broad range. It includes the following features:

- Rugged water-resistant case
- Sample-drawing configuration for testing confined spaces
- Audible alarms for
  - Low battery charge
  - Low flow rate (also lights LED on control panel)
  - High level of hydrocarbon vapor
- Three ranges of detection
- High-stability catalytic combustion sensor

An excellent application of the Trace-Techtor is to determine concentrations of petroleum-based hydrocarbon vapors in industrial and environmental operations. It can be useful for testing UST monitoring wells, soil samples, fugitive emissions, and many other applications where total petroleum hydrocarbon vapor levels need to be detected.

The Trace-Techtor is typically calibrated to hexane, which provides readings representative of total petroleum hydrocarbons. The standard unit is designed to have no response to methane (natural gas), to avoid unwanted and confusing readings from this gas. If methane response is desired, the Trace-Techtor can be supplied in a version that will respond to methane. Units which say "NOT FOR METHANE USE" on the lower right hand side of the meter dial do not respond to methane.

The "FULL RESPONSE" version of the Trace-Techtor is a good instrument to use for fugitive emissions testing, or as a general purpose hydrocarbon gas or vapor monitor. This version does respond to natural gas (methane) and therefore does not say "NOT FOR METHANE USE" on the meter dial. Standard calibration is hexane unless specified otherwise when ordered.

II. DESCRIPTION

A. Housing

The Trace-Techtor has a fiberglass case which is durable, shock resistant, and water resistant. The lower half contains the battery, sensor, and sample drawing system; the upper half contains all of the electronic circuitry. A large handle makes the Trace-Techtor easy to carry and pick up. The lip of the upper case overlaps the lower, to shed water. Upper half is clamped to lower by a knurled screw.

B. Combustible Gas Sensor

The combustible gas sensor is installed in an anodized aluminum reaction chamber by means of a threaded ring, and sealed by an o-ring gasket. The sample enters the chamber from the lower front, flows over the detector, and then exits the chamber.

The active detector element is coated with a platinum catalyst. An identical but non-catalytic reference element is mounted in the same environment to stabilize the measurement and compensate for effects of non-combustible gases, temperature variation, etc. Elements are protected by a sintered stainless steel flame arrestor, which prevents outward propagation of flame should an explosive atmosphere be sampled. Flame arrestor also acts as a diffuser to isolate elements from flow fluctuations.

Detector assembly connects to the circuit board at three screw terminals, accessible when upper half of housing is removed.

C. Meter

Hydrocarbon concentrations are displayed on a meter, visible through a window on the top face of the instrument case. The standard meter readout has a detection range of 0-100 ppm. When the selector switch is in the ppm range, meter readings are the actual gas concentrations. When the selector switch is in the PPM x 10 range, add one zero to the meter reading to get the actual PPM concentration. In the PPM x 100 range, add two zeroes to the meter reading to get the actual concentration.

A mark on the scale, "BATT CK" represents the minimum permissible battery voltage, as an indication of the state of charge of the battery.

D. Controls and Indicators

There are only two controls that are used during normal operation of the instrument—the selector switch and the zero adjustment. The selector switch turns the instrument on and off, selects the desired range, and tests the battery condition. The zero adjustment is used to adjust the meter to read zero in fresh air.

Additional internal potentiometer controls for span, coarse zero, and alarm settings are accessible on the circuit board and are described in later sections of this manual.

A red indicator light labeled "LOW FLOW" is located near the center of the control panel. If the sample flow ever drops below an acceptable level, this light will be lit and a steady audible alarm will sound. This function can be tested by blocking the sample probe inlet momentarily with your finger after the unit is warmed up.

E. Recorder Output

Recorder output jacks are provided to connect to a recorder or data logging device, if desired. The output is 0-1.0 VDC, with 1.0 VDC corresponding to full-scale meter deflection on any of the three ranges available.

F. Buzzer

The buzzer is mounted inside the instrument, and it sounds a steady or pulsed tone for the following conditions:

STEADY	PULSED
Low Battery	Vapor Alarm
Low Flow	
Improperly zeroed sensor	
Defective or disconnected sensor	

The pulsed vapor alarms may be disabled by the alarm cutout switch, which is a dip switch located directly behind the three alarm potentiometers on the circuit board. To disable, push switch #1 away from the #1 marking on the circuit board to the side of the switch labeled "ALM OFF". The steady tone alarms cannot be silenced since they are an indication that something is not working properly.

G. Batteries

The battery pack, consisting of seven 3.5 ampere-hour nickel-cadmium cells in series, is secured within lower half of case. The cells are sealed as a unit, either with threaded bushings in bottom for clamping to instrument case, or with holes all the way through to accommodate 3" long screws and a hold-down bar. Power output (red and black) leads extend from front end of pack, and terminate in a plastic plug connector which mates with a connector wired to the main circuit board. A third orange wire is also present but has no function on this model. A similar connector at rear connects to the charger socket, so that battery may be unplugged at both ends for convenient removal. Current limiting resistors sealed into the pack limit maximum current that can be drawn on short circuit. Battery pack will power the instrument for approximately 10 hours. A "polyfuse", which operates as a fuse but which recovers when the overload is removed, is also sealed within the pack, and serves as an added protection against short circuit or overload. Some versions of battery pack contain a replaceable one amp fuse instead of a "polyfuse". To replace fuse, remove red fuseholder with screwdriver and replace with 1 amp 3AG fuse.

H. Circuit Board

All circuit components are arranged on two epoxy glass printed circuit boards. The main board includes the power supply, the amplifier and alarm circuits, and associated controls. A second board (the switch board), is installed above the main board. The switch board is primarily related to the selector switch and is connected to the main board by three socketed ribbon cables. This board is inaccessible while the instrument is assembled, and it contains no user adjustments.

1. Five miniature adjustment potentiometers are provided on the underside of the main circuit card, available for user adjustment when the case is opened, by use of a small screwdriver.

a) PPM SPN, located near the front of the board, is used to adjust the PPM span or sensitivity, so that the instrument reads properly on a known gas sample. See CALIBRATION in section V. A. of this manual.

b) CRS ZER, located next to the PPM SPN potentiometer near the front of the board, is a coarse zero adjustment which is used if the sensor offset is out of range of the external zero adjustment. See ZERO ADJUSTMENT in section V.B. of this manual.

c) ALM (PPM x 1, PPM x 10, PPM x 100) adjustments are used to adjust the alarm settings in each of the gas ranges. See ALARM ADJUSTMENT in section V.C.2. in this manual.

2. Two miniature switches are also available. These are:

a) ALM ADJ switch, located in the center of the circuit board, is used when checking or adjusting alarm levels. See Alarm Level Verification and Adjustment in section V.C. of this manual.

b) Alarm cutout switch, labeled "ALM OFF" on one side and 1234 on the other, is located directly behind the three alarm potentiometers. This is a small four-pole dip switch. Only poles 1 and 2 are used in this version of the instrument. The pulsing audible vapor alarm is active when the small lever in position 1 is pushed towards the "1" imprinted onto the circuit board. The vapor alarms will be disabled if the lever is pushed away from the "1", to the far side of the switch labeled "ALM OFF" towards the instrument control panel. Pole 2 must remain in the far side position at all times for this instrument version.

WARNING

DO NOT LEAVE SWITCH 1 IN THE DISABLED POSITION IF AN AUDIBLE ALARM IS DESIRED.

I. Sample System

Sample system consists of the components in flow path:

1. Probe is a 10" long 1/4" OD plastic tube with a dust filter chamber at the upper end, forming a handle. This filter chamber is transparent plastic, so the filter condition is easily visible. To replace filter, unscrew filter chamber where it connects to the knurled base.

2. Hose is a 5' flexible polyurethane tube. It has a male quick-connect coupling on one end to match inlet fitting of instrument. The opposite end has a threaded fitting to connect the probe.

3. Hydrophobic filter attaches directly to the front of the instrument with a quick connect fitting. It should always be used if there is any danger of sucking liquid into the unit. The hydrophobic filter stops water-based liquids, and also doubles as an additional dust filter. The hydrophobic filter is a disposable item. If it gets filled with water it can be removed, the water shaken out, and the filter can be re-used. If it gets clogged with dust or hydrocarbon liquids are sucked into it, the filter must be replaced. **Since the filter will not stop gasoline or other hydrocarbon liquids, care must be taken not to suck these liquids into the unit, since they can damage or contaminate flow components.**

4. Inlet fitting is a quick-connect female coupling on front of instrument. To release, pull back on the knurled outer ring and pull hose or hydrophobic filter out of the fitting.

5. Internal filter is a 0.2 micron dust filter and also is hydrophobic, which prevents it from passing dust or water that may damage the pump, flow switch, or sensor.

6. Pump is a DC motor driven diaphragm type. It operates directly from the battery whenever power switch is on.

7. Reaction chamber, is an anodized aluminum block that holds the detector in flow path of sample. Flexible tubes connect chamber to other internal flow components.

8. Flow switch is located on the upper side of the circuit board, and sample flow is routed to it with a tube to the upper case. The flow switch has no user adjustable parts and will trigger the circuitry to sound a continuous low flow alarm if the flow rate ever drops below about 0.25 cc/minute (0.5 scfh). To verify flow switch operation, temporarily block probe inlet with finger and alarm should sound. Alarm will clear when blockage is removed and flow resumes.

J. Charger

The battery charger plugs into a polarized socket in the rear of the case. Charger provides a high current charge to the battery pack for a 16 hour period, and then cuts back to a sustaining charge. An amber light shows that the battery is receiving a charge. When complete, a green light shows that the battery is fully charged and ready for use.

K. Continuous Operation

Instrument can be operated continuously from a 12 volt DC source, such as a 12 volt vehicle battery, by use of a Continuous Operation Adapter. This is a power cord with with a mating plug to fit the charger socket. When connected to instrument and to a 12 volt source, it will carry the load and tend to recharge the battery. It may also be used as a DC charger.

Adapter is furnished with a cigarette lighter plug to fit any negative-grounded vehicle with 12 volt battery. Order part number 47-1501.

An adapter for operation from 115V AC is also available. Order part number 49-2037.

WARNING

THE INTRINSIC SAFETY RATING OF THE TRACETECHTOR DOES NOT APPLY WHILE BEING OPERATED FROM AN EXTERNAL POWER SOURCE, OR WHILE CHARGING.

III. OPERATION

A. Start Up

1. Attach hydrophobic filter, hose and probe to the inlet fitting on front of instrument.

2. Turn rotary switch to BATT CK. position and allow a 5 minute warm-up. Meter reading should be above the BATT CK. mark on the meter. If close to or below this mark, recharge battery before use.

3. Alarms heard during warm-up should be investigated. If pulsed alarm sounds, turn selector switch to PPM x 100 range and zero meter reading with external zero adjustment. If a steady alarm sounds, check for the following:

   a) Low battery. Turn selector switch to the BATT CK. position, and verify that meter reading is above the BATT CK. mark on the meter. If not, recharge battery before use.

   b) Below zero reading. Turn selector switch to PPM x 100 range and note if meter reading is below zero. If so, re-zero with external zero adjustment. If out of range of external adjustment, use internal coarse zero adjustment (see section V.B. of this manual).

   c) Defective sensor. If unit cannot be zeroed, sensor may be open or need replacement. Replace sensor and try again.

   d) Low flow. If the LOW FLOW light on side panel is lit, the flow is too low for the instrument to operate properly. Possible causes for a low flow condition are as follows:

      1) Clogged external filter or sample line. Disconnect the external hydrophobic filter and see if flow alarm silences. If it does, clear the hydrophobic filter of any water present by disconnecting it from the hose and shaking out any liquid. Also check that the hose or probe does not contain any dirt or other blockage. Replace filter if needed.

      2) Clogged internal filter. Remove and check the internal hydrophobic filter for water or dust clogging. Replace if required.

      3) Dirty or malfunctioning pump. If filter and tubing are all clear then pump may need to be cleaned, rebuilt, or replaced.

      4) If a non-water based liquid has been sucked into the unit recently, it is possible that the flow switch is damaged. To check flow switch connect a flow meter to the inlet and verify flow is less than 0.25 cc/minute (0.5 scfh). If flow switch is damaged, unit should be repaired before further use.

4. Test that flow system is fully functional by placing finger over inlet and verify that low flow alarm activates. Inlet should be checked with all sampling accessories connected (hose, probe, and hydrophobic filter), and finger placed over the probe tip. Allow a few seconds for flow alarm to activate when blocking inlet.

5. Adjust zero. After a five minute warm-up, or when reading in PPM range has stabilized, adjust the external zero knob to obtain a "0" reading. This must be done with selector switch in the PPM range, and with the probe sampling from a gas free location. If impossible to adjust the zero within the range of the external zero adjust potentiometer, adjust internal coarse zero adjustment (see section V.B. of this manual.).

6. Turn selector switch to desired range and hold hose inlet at point to be tested. Watch meter and note highest reading obtained. If meter reads over full scale, then move selector switch to the next position to change range to a less sensitive one. If reading rises above the alarm set point, a pulsed audible alarm will start, and will continue as long as reading remains above alarm point. After completing readings, purge instrument with fresh air before turning off.

Note

Because of the very high sensitivity of this instrument, the meter will tend to drift until sensor is thoroughly warmed up. Always let it run for 5 minutes or more, whenever possible, before operating on the PPM and PPM x 10 ranges. Take readings immediately after zeroing, and observe maximum deflection when sampling. It may be necessary to re-zero in fresh air periodically if using the instrument for many tests or for longer term testing throughout the day.

IV. INTERPRETATION OF GAS OR VAPOR READINGS

The PPM range is a very sensitive range, obtained by amplification of the signal from the catalytic element. Sensitivity is set for a direct reading in PPM of the gas for which the instrument is calibrated.

Even though the sensing element is compensated to minimize the effect of non-combustible gases, a residual effect is still observable in the sensitive ranges. The instrument may need to be re-zeroed if exposed to a gross change in humidity, or to a change in background level of CO_2 or other inert gas.

Most hydrocarbon gases or vapors will cause a response on the meter, but may not be direct reading. A hexane calibration provides a conservative reading representative of total petroleum hydrocarbon vapors present. If comparing these readings to another type of meter such as an FID or PID, you will find that the readings can be either higher or lower depending on several factors, such as the constituents of the hydrocarbon vapors, type of filters or lamps used, and gas used to calibrate the instruments. In general, the readings are a good indication of the level of hydrocarbon vapor contamination of the space being tested. When absolute levels are needed, samples must be tested in a qualified laboratory.

Soil contamination by hydrocarbon liquids can be tested by measuring the head space in a closed container half-full of soil. This test with any portable gas sensing instrument should be used only as a crude field indication of whether or not the soil is contaminated, and a soil sample should be sent to a laboratory for a more accurate determination of the contamination level. Any field gas detection instrument cannot be expected to provide the same reading as a laboratory tested soil sample, because they are not measuring the same thing. The gas or vapor detector can only measure hydrocarbons that have volatized or "evaporated" into a vapor state. Heavy hydrocarbons such as diesel or fuel oil do not fully evaporate at normal temperatures, so they will produce only relatively low levels of vapor (as compared to gasoline). A laboratory tested sample of diesel contaminated soil generally will indicate a much higher level of total hydrocarbons than a field vapor test may reveal, because the chemical extraction methods used for the laboratory test can also pick up the heavy hydrocarbons. Likewise, recent gasoline spills may reveal a higher field vapor reading than a laboratory soil sample test will produce.

V. CALIBRATION AND ADJUSTMENT

A. Calibration

Calibration of the Trace-Techtor should be checked periodically to assure proper response. Frequency of calibration depends on frequency and type of use the instrument receives. There is no set frequency of calibration that is correct for all users, so it is recommended that the unit be check fairly frequently at first (perhaps weekly) until a reasonable calibration need pattern is developed for your usage. For example, if the meter is used only once a month, then even monthly checks are not likely to be needed. The other extreme would be an instrument that is used constantly every day, and where the data accuracy is critical. Such frequent use in a critical application might demand the calibration be checked daily. Hexane is the recommended calibration gas, since it provides a conservative response representative of total petroleum hydrocarbon vapors present.

If the sensor is damaged or replaced, the unit should be recalibrated.

To calibrate:

1. Turn instrument on and allow at least a five minute warm up period. Verify battery is charged.
2. Open instrument case by loosening captive screw at front. Lift upper half of case slightly and move it 1/4" forward to disengage rear clamp, then separate the two halves. Locate the potentiometer on the front corner of the circuit board marked PPM SPN. This is the span adjustment.
3. Attach hose, probe, and hydrophobic filter to the instrument as it would be in normal operation.
4. Turn to PPM range and zero the meter using the external ZERO adjustment knob. If zero cannot be adjusted with the external adjustment, use the internal coarse zero adjustment. (See Section V. B.)
5. Attach upper end of flowmeter to the probe with the short piece of tubing included in the calibration kit. Note flowmeter reading.
6. Attach valve to cylinder and flowmeter to valve with the remaining tubing. Open valve just enough so that flow is the same as observed in step 5.
7. Watch meter and note highest reading. The desired reading is the PPM value marked on the calibration gas cylinder. (Selector switch should be in the appropriate position to read the concentration marked on the cylinder.) If the reading does not match the cylinder value, turn PPM SPN adjustment to give desired reading.

   Calibration kits and replacement cylinders are available from Gastech Environmental Monitors. The recommended cylinder is part number 81-0007E, which is a cylinder of nominal 40% LEL hexane marked with its PPM value, nominally 4400 PPM.

   Calibrate the unit with a concentration in excess of 1000 ppm, to minimize any calibration error that may occur due to humidity effects caused by the dry air which comes out of a compressed gas cylinder.
8. If zero cannot be adjusted, or if reading cannot be set high enough, replace detector.

B. Zero Adjustment

This instrument contains both an external fine zero adjustment and an internal coarse zero adjustment. Generally the external adjustment is all that is needed, but when replacing sensor or as sensor ages, it may become necessary to adjust the internal coarse zero. This potentiometer is accessible with the instrument opened and is located on the front of the circuit board labeled CRS ZER. Adjust as follows:

1. Turn instrument on and allow at least a five minute warm-up period.
2. Turn the external zero adjustment to the center of its adjustment range. This is a 10 turn adjustment, so count 5 turns from one end of its range. (First turn it fully clockwise and then back it off 5 full turns counterclockwise.)
3. Turn selector switch to PPM range.
4. Turn internal CRS ZER adjustment to bring the meter to a zero reading. Turning the adjustment clockwise increases the reading.
5. If unable to adjust meter to zero with the CRS ZER adjustment, sensor wires may be loose or sensor may need replacement

C. Alarm Level Verification and Adjustment

The Trace-Techtor contains individually adjustable gas or vapor alarms for each of the three ranges. These alarms are inactive for the first 30 seconds following turn on. See the Specifications at the front of this manual for alarm setting for this instrument.

Note

2000 ppm for hexane is roughly the same as 20% LEL hexane. Both versions of this instrument have a 2000 ppm alarm to alert the user that the concentration is approaching a flammable condition.

WARNING

ON THE 50,000 PPM UNIT, THE 10,000 PPM ALARM POINT INDICATES THE SAMPLE MAY BE TO A FLAMMABLE LEVEL ALREADY. USE EXTREME CAUTION WHEN SAMPLING SUCH AREAS TO AVOID POSSIBLE IGNITION OF THE TEST SPACE. ANY POSSIBLE IGNITION SOURCE, SUCH AS SPARKS, MATCHES, TORCHES, CIGARETTES, VEHICLES, ETC. MUST NOT BE USED NEAR A FLAMMABLE AREA.

The Trace-Techtor is designed to be intrinsically safe for use in Class I, Div. 1, Group C and D hazardous atmospheres, so if used properly it cannot be a source of ignition in these atmospheres.

1. Alarm Verification

Alarm levels can be checked with the ALM ADJ switch. It is located in the center of the circuit board, accessible when the instrument is open. To check alarm levels:

a) Separate top and bottom halves of instrument housing by loosening the large knurled screw near the front of the housing.

b) Turn instrument on and allow to warm-up.

c) Move selector switch to PPM range, and then press and hold the ALM ADJ switch.

d) Observe meter reading. Meter reading will read the level at which the alarm point is set.

e) Turn the selector switch to PPM x 10 and PPM x 100, and repeat the above (press ALM ADJ switch and observe meter reading) for these ranges.

2. Alarm Adjustment

Alarm levels are adjustable with the ALM ADJ switch and the ALM potentiometers. Alarm levels are factory-set at the levels shown in Specifications, but can be field adjusted as follows:

a) Follow steps a through d of the preceding Alarm Verification section.

b) While observing meter reading of alarm set point for PPM range, turn the adjustment potentiometer marked PPM x 1 located directly behind the ALM ADJ switch. Turning this adjustment will move the meter dial to a new alarm setting. Stop turning when meter displays the desired alarm level setting.

c) Repeat step b for PPM x 10 and PPM x 100 ranges; move the selector switch to those ranges and turn their respective alarm adjustment potentiometers to display the desired settings.

3. Alarm Cutout

An alarm cutout switch is provided in the event the instrument will be used as a survey tool only and no gas level alarms are desired. The alarm cutout switch is unlabeled and is located directly behind the three alarm adjustment potentiometers. This is a small four pole switch which utilizes only poles 1 and 2. The pulsing audible vapor alarm is active when the small lever in position 1 is pushed near the "1" imprinted onto the circuit card. The vapor alarms will be disabled if the lever is pushed away from the "1" to the far side of the switch labeled "ALM OFF", towards the instrument control panel. Pole "2" must remain in the ALM OFF position at all times for this instrument version.

WARNING

DO NOT LEAVE THE SWITCH IN THE DISABLED POSITION IF AUDIBLE VAPOR ALARMS ARE DESIRED.

STANDARD WARRANTY

GAS DETECTION INSTRUMENTS

We warrant gas alarm equipment manufactured and sold by us to be free from defects in materials, workmanship and performance for a period of one year from date of shipment from Gas Tech Inc. Any parts found defective within that period will be repaired or replaced, at our option, free of charge, f.o.b. factory. This warranty does not apply to those items which by their nature are subject to deterioration or consumption in normal service, and which must be cleaned, repaired or replaced on a routine basis. Such items may include:

a) Lamp bulbs and fuses

b) Pump diaphragms and valves

c) Absorbent cartridges

d) Filter elements

e) Batteries

f) Most catalytic and electrochemical sensors are covered by a separate warranty of 12 or 24 months.

Warranty is voided by abuse including rough handling, mechanical damage, and alteration or repair procedures not in accordance with instruction manual. This warranty indicates the full extent of our liability, and we are not responsible for removal or replacement costs, local repair costs, transportation costs, or contingent expenses incurred without our prior approval.

Gas Tech Inc.'s obligation under this warranty shall be limited to repairing or replacing, and returning any product which Gas Tech Inc. Material Review Board examination shall disclose to its satisfaction to have been defective. To receive warranty consideration, all products must be returned to Gas Tech Inc. at its manufacturing facilities with transportation charges prepaid.

This warranty is expressly in lieu of any and all other warranties and representations, expressed or implied, and all other obligations or liabilities on the part of Gas Tech Inc. including but not limited to, the warranty of fitness for a particular purpose. In no event shall Gas Tech Inc. be liable for direct, incidental or consequential loss or damage of any kind connected with the use of its products or failure of its product to function or operate properly.

This warranty covers instruments and parts sold (to users) only by authorized distributors, dealers and representatives as appointed by Gas Tech Inc.

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VI. MAINTENANCE

A. Batteries

1. To check battery voltage, turn the selector switch to BATT. Recharge before voltage reads minimum. To charge:

   a) Turn selector switch to BATT position and note meter reading.

   b) Plug charger into power source and then into the socket on the rear of the Trace-Techtor. The meter reading should rise slightly as soon as charger is connected. If it does not, verify that AC outlet is active. If outlet is active but meter does not rise when charger is attached, charger may be defective.

   c) If meter reading does rise, turn instrument off and leave on charge for 16 hours.

   Note

   Do not attempt to charge while instrument is turned on.

   Charger provides a dual rate, timed charge. The amber LED lights when the instrument is charging. After 16 hours the green LED on the charger will light, indicating that charging cycle is complete.

2. If sufficient voltage cannot be obtained after charging, open instrument and :

   a) Check voltage output with a voltmeter, between red and black wires (unplug connector to gain access to pins). Voltage should be about 8.5 volts.

   b) If battery voltage is too low, and cannot be brought up by overnight charging, battery probably needs replacement. To remove, take out the two screws holding it to bottom of case, and unplug black and orange wire connector and charging end.

   c) If battery has no output and is the fused version, replace fuse. Remove existing fuse by unscrewing the red fuse holder on the battery with a screwdriver. Replace only with 1 AMP 3AG type fuse.

B. Combustible Detector

1. Sensor assembly may require replacement if:

   a) Meter cannot be set to zero within range of internal coarse zero potentiometer.

   b) Meter cannot be set to desired level within range of SPAN adjust.

2. To Replace Detector:

   a) Open instrument case.

   b) Disconnect the red, green and white wires at terminals on main circuit board, noting color coding.

   c) Unscrew knurled retaining cap at reaction chamber.

d) Pull out original detector and install new one. Be sure that o-ring is in place, under flange of detector.

e) Connect wires to terminals, turn power on, zero and calibrate new sensor after warm up.

C. Meter

If meter is damaged it can be removed for repair or replacement as follows:

1. With upper half of instrument removed from lower half and inverted, remove three screws holding circuit board to case.
2. Gently lift circuit board with meter out of case. Circuit board will remain attached to case by three ribbon cables.
3. Remove two nuts holding meter to circuit board, then remove meter.
4. Re-install new meter in reverse order of the above steps.

D. Circuit Board

Main circuit board can be removed by following the above steps 1-3 for meter removal and adding these additional steps:

1. Remove three connecting ribbon cables by unplugging from sockets on main board. Prying loose from sockets carefully with a small screwdriver can aid this step.
2. Remove tubing to bottom case at the quick disconnect fittings located in the bottom case. To remove, push the red flange into the fitting while pulling tube with other hand. Take note of which tube goes where.
3. Return defective circuit board to the factory for repair, or purchase new circuit card for replacement.

Note

When returning to factory for repair, please be sure problem has been narrowed down to the main circuit board, otherwise it is better to send in the complete top case assembly or the entire instrument for checkout.

E. Filters

There are three filtering stages used in the Trace-Techtor. They should all be maintained in good condition because their function is to protect other internal components from damage or unnecessary maintenance.

1. Probe filter is a cotton ball located in the clear plastic portion of the probe. It captures dust and other debris to prevent it from entering the hose. It is not a moisture trap. Periodically inspect to verify that this cotton ball is clean. To replace, unscrew probe body from probe base, remove dirty cotton ball, insert a new cotton ball and re-assemble. Cotton balls may be purchased from Gastech Environmental Monitors or any drug store.

2. External hydrophobic filter attaches directly to the front of the instrument with a quick connect fitting, and the hose attaches to the hydrophobic filter. This filter prevents water-based liquids from entering the instrument and possibly damaging the sensor or other internal components. It also further filters dust particles from the gas stream.

   This disposable filter should be replaced it if collects excessive amounts of dust, if hydrocarbon liquid is sucked into it, or if it is physically damaged. If water is sucked into it, remove the filter, shake the water out, and then re-install filter.

3. Internal hydrophobic filter is located in the lower portion of the instrument and is accessible when the instrument is open. The purpose of this filter is to provide one last filtering stage for both water and dust before the sample flow passes on to the pump, sensor, and flow switch.

   This filter can be replaced by disconnecting it from the yellow tubing sections and re-installing a new one. When installing new one, be sure the side of the filter marked "INLET" is facing towards the front of the unit and is connected to the hose leading to the inlet fitting.

CAUTION

Gasoline or other hydrocarbon based liquids can cause damage to hose, filters, and internal components.

F. Pump

Pump used is a DC motor driven diaphragm type. It should have long life, (several years in normal operation) but it may lose efficiency if dirt or liquid is drawn in and collects under the valves. Verify proper pump operation periodically by taking a sample and observing time for initial gas response to occur. This should be within 5 seconds for a 5' hose. It may also be checked with the flowmeter provided as a calibration accessory. Normal pump flow is generally about 2.0 SCFH.

If pump needs servicing, remove it by unscrewing two small screws holding it in the bottom of the case. Pump can be returned for repair on an exchange basis or it can be disassembled and cleaned. Replacement pump head assemblies are also available.

VII. PRECAUTIONS AND NOTES ON OPERATION

A. Heated Samples

When sampling spaces that are warmer than the instrument (hot tanks), condensation can occur as the sample passes through the cooler sample line. Water vapor condensed in this way can block the flame arrestor and interfere with pump operation, unless a hydrophobic filter is used.

If heated hydrocarbon vapors of the heavier hydrocarbons (flash point 90 degrees Fahrenheit or above) are present, they may also condense in the sample line and fail to reach the filament. Thus an erroneous low reading may be obtained.

B. Filament Poisoning

Certain substances have the property of desensitizing the catalytic surface of the platinum filament. These substances are termed "catalyst poisons" and can result in reduced sensitivity or in failure to give a reading on samples containing combustible gas. The most commonly encountered catalyst poisons are the silicone vapors, and samples containing such vapors even in small proportions should be avoided.

Occasional calibration checks on known gas samples are desirable, especially if the possibility exists of exposure to silicones.

C. Other Gases and Vapors

The instrument is designed and calibrated specifically for hexane unless specified differently in the original order. It can be recalibrated and used on other gases and vapors, by proper use of the calibration control while sampling a known gas-air mixture.

Note

The Trace-Techtor cannot be used for methane or natural gas detection unless specifically provided for that use by the factory.

D. Oxygen Deficient Mixtures

Samples which do not have the normal proportion of oxygen may tend to read low because there is not enough oxygen to react with all combustible gas present in the sample. As a general rule, samples containing 10% oxygen or more have enough oxygen to give a full reading on any combustible gas sample up to 10,000 PPM. For lower concentrations of flammable gas, lower levels of oxygen are required for full response. If oxygen deficiency is suspected of a test space, a dilution fitting (Part No. 80-0403) should be used in order to get an accurate measurement.

E. Arson Investigation

Flammable liquids (gasoline, kerosene or paint solvent) are often used in starting intentional fires. Investigation of such fires can be greatly aided if the presence and location of such liquids can be determined at the site, as soon as possible after the fire is extinguished. The Trace-Techtor can be of great assistance in making this determination.

In testing for residual flammable liquids, look for places where the liquid could have been trapped and where it might remain even after the fire. Naturally, if the entire structure has been consumed there is little likelihood of any liquid or vapors remaining. Conversely, the earlier the fire has been extinguished, the greater the chance of finding significant amounts of liquid remaining.

To check for residual volatile liquids, set the instrument up in accordance with the preceding instructions and, allow it to run for at least 5 minutes. Then turn to PPM range and balance zero carefully immediately before taking the test.

Hold end of probe at point where vapors may be present, and watch meter carefully for any sign of a deflection. Check at joints or cracks between boards, for example, under baseboards or plates in contact with flooring. Pry boards up to form a small crack where hose or probe may be inserted. Check also under unburned portions of rug or upholstery, or any point where liquid might logically have soaked in and remained.

If a positive indication is obtained, trace it to the point of maximum reading. This is the point where samples should be taken for further lab analysis.

VIII. PARTS LIST

Stock No.	Description
07-6010	O-Ring Seal, hose (probe end)
07-6115	O-Ring Seal, combustible detector
30-0018	Pump, Gilian
30-0018E	Pump, Gilian, exchange
30-0021	Repair kit for Gilian Pump
33-0153	Filter, internal, hydrophobic
33-1031	Filter for probe, pkg of 24 cotton balls
47-1501	12 VDC Adapter/Charger
49-1571	Battery Pack, encapsulated with Ni-Cad batteries
49-2037	115 VAC Continuous Operation Adapter
49-2133	Battery Charger, 115 volts, dual-rate time controlled
49-2034	Battery Charger, 230 volts, for Ni-Cad batteries (single rate)
49-2134	Battery Charger, 230 volts, dual rate time controlled (user to provide AC plug)
49-8051	Battery Pack, Ni-Cad, replaceable cell type
50-5801E-A2	Meter, 0-100 PPM scale (No CH_4)
50-5801E-A4	Meter, 0-500 PPM scale (No CH_4)
61-0120TT	Detector Ass'y Catalytic, selected for Trace-Techtor
80-0150	10" Probe
80-0155	Probe, 30", aluminum
80-0224	Filter, external, hydrophobic w/ quick disconnect ftgs.
80-0403	Dilution fitting, 50/50
80-0800E-5	Hose, Polyurethane, inlet 5'
80-0800E-10	Hose, Polyurethane, inlet 10'
80-0800E-15	Hose, Polyurethane, inlet 15'
80-0800E-20	Hose, Polyurethane, inlet 20'
81-0007E	Spare cylinder of 4400 PPM hexane
81-0012E	Cylinder of 25,000 ppm methane in air
81-0086E	Cylinder of 5000 ppm methane in air
81-0221E-2	Calibration Kit for Trace-Techtor, w/2 cyl. of 4400 PPM hexane

SERVICE POLICY

GasTech Inc. maintains an instrument service facility at the factory. Some GasTech distributors also have repair facilities; however, **GasTech assumes no liability for service performed by other than GasTech personnel.** Should your instrument require non-warranty repair, you may contact the distributor from which it was purchased, or you may contact GasTech directly.

If GasTech is to do the repair work for you, you may send the instrument, prepaid to GasTech Inc. 8445 Central Avenue, Newark, CA 94560, Attn: Service Department. Always include your address, purchase order number, shipping and billing information and a description of the defect as you perceive it. If you wish to set a limit to the authorized repair cost, state a "not to exceed" figure. If you must have a price quotation before you can authorize the repair cost, so state, but understand that this involves extra cost and extra handling delay. GasTech's policy is to perform all needed repairs to restore the instrument to full operating condition, including reactivation of all out-of-warranty electrochemical cells.

To expedite the repairs operation, it is preferable to call in advance to GasTech Instrument Service, (510) 794-7015, obtain a Return Authorization Number (RA#), describe the nature of the problem and provide a purchase order number.

If this is the first time you are dealing directly with the factory, you will be asked to provide credit references or prepay, or authorize COD shipment.

Pack the instrument and all its accessories (preferably in its original packing). Enclose your Purchase Order, shipping and billing information, RA#, and any special instructions.

Rev. 9/91

O_2/CO_2 METER

INSTRUCTION MANUAL

GASTECHTOR

CARBON DIOXIDE/OXYGEN INDICATOR

MODEL 3252OX

SERIALS: L 0213

CO_2 DETECTION RANGE: 0-5% CO_2

OXYGEN DETECTION RANGE: 0-25% O_2

ALARM SETTINGS:
CO_2: 0.5% CO_2 (Rising)
O_2: 19.5% O_2 (Falling)
O_2: 25% O_2 (Rising)

CONTENTS

Made By:

GASTECH INC.
8445 CENTRAL AVENUE
NEWARK, CALIFORNIA 94560 USA
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FAX: (415) 794-6210
TELEX: 334-462

WARNING

Carbon dioxide is a colorless, odorless and tasteless gas that can produce a debilitating effect on humans, including impaired breathing. This gas is heavier than air and it seeks the lowest levels, displacing normal air. Where carbon dioxide is known to exist in locations such as manholes, tanks and tunnels, a test for excess carbon dioxide or sufficient oxygen content should be made before personnel enter the area. Entry into an oxygen (air) depleted space can cause immediate unconsciousness, followed soon by death by suffocation if resuscitation is not carried out promptly after loss of consciousness.

INSTRUCTION MANUAL

GasTechtor Portable Carbon Dioxide/Oxygen Indicator

Model 32520X

I. INTRODUCTION

The Model 32520X GasTechtor is a portable gas detection instrument designed to determine carbon dioxide and oxygen content of the air around various industrial processes. It reads carbon dioxide over the range 0-5% CO_2, actuating a characteristic alarm whenever reading exceeds a preset level, and oxygen over the range of 0-25% O_2, actuating an alarm when O_2 reading falls below a preset level.

Instrument is ruggedly constructed to withstand rough handling in industrial environments.

Samples of the atmosphere under test are drawn through a hose by means of a built-in pump and analyzed for CO_2 in a simplified NDIR (Non-Dispersive Infrared) cell and then for oxygen in an electrochemical cell. Solid-state amplifiers are used to amplify indications of the elements to give adequate voltage to drive the meter and the alarm circuits.

Power for the instrument is provided by a built-in rechargeable battery pack. An extension hose and probe permits withdrawal of sample from the space under test. The audible alarm sounds whenever CO_2 concentration exceeds, or O_2 concentration falls below, preset levels. An audible signal is also given in case of malfunction or a dead battery.

II. DESCRIPTION, DETAILED

A. Housing

The Model 32520X is housed in a fiberglass case which is durable, shock-resistant and protected against entry of water. The lower half, containing the batteries, oxygen sample chamber and sampling system, has no openings near the bottom and hence can safely be placed in mud or water up to 3 cm depth without hazard to the internal components.

The upper half contains all of the electronic circuitry plus the infrared cell for CO_2 detection, and is provided with a substantial carrying handle. The lip of the upper case overlaps the lower to shed water. Upper half is clamped to lower by means of a heavy-duty knurled thumbscrew.

2. The oxygen potentiometers are:

   a. OXY ZERO, to balance the oxygen circuit for Zero output when the detector is surrounded by oxygen-free gas such as nitrogen. Potentiometer is forwardmost of the three.

   b. DWN ALM Threshold, to set the oxygen concentration at which the low oxygen alarm is actuated. This alarm is actuated by falling O_2 concentration. It is the center of the three potentiometers.

   c. UP ALM Threshold, to set the oxygen concentration at which the high oxygen alarm is actuated. This alarm is initially set at 25% O_2 concentration. Potentiometer is located at the rear corner of the board.

I. Charger

A separate battery charger is provided, which plugs into socket in rear of case. This charger is the No. 49-2133 (49-2134 for 220-240V AC) dual-rate timed charger, which provides a full charge over a 16 hour period, then automatically cuts back to a sustaining rate. An amber light shows that battery is receiving a charge; when complete, the green light indicates that the battery is ready to use.

J. Sample system

Sample system consists of the flow path, from probe to sample inlet to pump to oxygen chamber to CO_2 reaction chamber. These components are further described below.

1. Probe, a 28" long, 1/4" OD stainless steel tube with transparent-bodied filter housing in handle. The cotton-ball filter element is readily replaced by unscrewing the filter housing from the threaded base. Filter should be inspected frequently and replaced when it becomes discolored. Probe is cross-drilled 4" from the end, to prevent water from being drawn into the instrument.

2. Hose, a 5' polyethylene lined tube with threaded connectors at each end, to mate with the probe and the inlet fitting on instrument.

3. Inlet fitting, a threaded male coupling on front of instrument.

4. Filter, a transparent-bodied disposable assembly with 1/4" nipples on inlet and outlet. Filter removes dust and liquid water from incoming sample, thus preventing interfering particles from entering the sensors. It is installed inside instrument housing.

5. Pump is of the motor driven diaphragm type, with a brushless DC motor having no commutator or sparking contacts. It operates from an internal voltage regulator whenever power switch is on.

6. Infrared cell, a tubular chamber with inlet and outlet fittings to allow the filtered sample to pass through it. Windows at each end allow infrared energy to pass through while at the same time keeping the sample confined within the cell. The sample flow discharges from the CO_2 cell to the oxygen chamber.

7. Oxygen chamber is an anodized aluminum block having inlet and outlet fittings and containing a diffusion cavity into which the oxygen cell is clamped. Cell is held in place by a metal retaining strap and sealed with an O-ring. The flow discharges through an opening at front of instrument after it has passed through cell.

K. Continuous Operation

Instrument can be operated continuously from a 12 volt DC source, such as a 12 volt vehicle battery, by use of a Continuous Operation Adapter. This is a power cord with plug to fit charger socket. When connected to instrument and to a 12 volt source, it will carry the load and tend to recharge the battery. It may also be used as a DC charger.

Adapter is normally supplied with a cigarette lighter plug, which is polarized correctly for a grounded-negative vehicle. Order Part No. 47-1501. If a separate battery is to be used, order an adapter with plus and minus spring clips, and be sure to observe polarity. An adapter for operation from 115V AC is also available. Order Part No. 49-2037.

B. Carbon Dioxide Sensor

Gas detection by the infrared method is based on the principle that every gas absorbs infrared energy of a characteristic frequency. In this instrument a broad-band infrared source (a heated filament) emits energy which is filtered to produce a narrow range of frequencies characteristic of CO_2, and passed through an enclosed chamber containing the gas sample to be analyzed. Any carbon dioxide in the sample selectively absorbs energy of that frequency, resulting in reduced infrared energy reaching the solid state sensor. This change in energy can be detected, amplified and used as an indication of CO_2 concentration, displayed on a meter and arranged to sound a alarm at a preset level.

Calibration and alarm settings are adjustable, using the potentiometers marked SPAN and ALARM respectively. Span can be set while a known gas sample is admitted to instrument. Alarm can be set as described in Section IV.B., calibration and adjustment.

C. Oxygen Sensor

The oxygen sensor is an electrochemical cell in which gold and lead electrodes are immersed in an alkaline electrolyte, and covered by a permeable fluorocarbon membrane. Oxygen from the surrounding atmosphere diffuses through the membrane and enters into an electrochemical reaction whose rate is directly proportional to the partial pressure of oxygen, the end product of this reaction being lead oxide. The current generated by this reaction is amplified and used to drive the meter and the alarm circuit. The detector is clamped into a cavity in an anodized aluminum block, through which the sample flows after it leaves the pump. Oxygen cell connects to circuit board by a 7-pin plug connector.

D. Meter

Indications of the instrument are displayed on a meter, visible through a window on top face of instrument case. Meter has two sets of graduations and reads carbon dioxide or oxygen concentration directly, depending on whether range switch is in the CO_2 or O_2 position. A mark on scale, "BATT CK", represents the minimum permissible battery voltage, as an indication of state of charge of the battery.

E. Controls and Indicators

The six controls that are used in normal operation of the instrument are arranged on the left side of instrument as viewed from the rear. These controls are recessed to minimize possibility of accidental operation.

1. POWER switch, an alternate-action pushbutton switch which energizes circuit when pressed. An orange indicator dot is exposed when the switch is in the ON position, serving as a mechanical pilot light.

2. BATT. CK. switch, a momentary push button switch, when pressed connects meter as a voltmeter for battery condition check. Instrument must be in CO_2 range for battery check switch to function.

3. Range, an alternate-action push button switch which selects the range displayed on the meter, either carbon dioxide in the "OUT" position or oxygen in the "IN" position. A colored indicator dot shows when the switch is "IN".

4. CO_2 ZERO, a slotted-shaft potentiometer which is used to adjust circuit to read zero in the absence of carbon dioxide.

5. OXY CAL, a slotted-shaft potentiometer which is used to adjust circuit to display 21% on the meter when detector is surrounded by known normal air.

6. ALARM switch, which when pushed in will silence the audible tone. It is an alternate-action push button switch similar to the POWER switch. When in the IN (alarm off) position an orange indicator dot shows.

7. Alarm lights, red (CO_2) and amber (O_2), illuminate when the corresponding channel is in alarm condition. Alarm lights operate regardless of the position of the Range and Alarm Switches.

F. Buzzer

A solid-state electronic buzzer is mounted at the rear of instrument, behind perforations which permit transmission of sound. The buzzer gives a characteristic pulsed tone on alarm in either range (rising CO_2, falling O_2) with O_2 alarm giving an alternating long-short pulse signal and CO_2 giving a series of long pulses. A continuous tone sounds in case of malfunction, either low battery voltage or downscale drift of meter, in case of high oxygen reading or when both ranges indicate an alarm condition simultaneously.

G. Batteries

The battery pack, consisting of seven 3.5 ampere-hour nickel-cadmium cells in series, is secured within lower half of case. The cells are sealed as a unit, either with threaded bushings in bottom for clamping to instrument case, or with holes all the way through to accommodate 3"-long screws and a hold-down bar. Power output (red, orange and

black) leads extend from front end of pack, and terminate in a plastic plug connector which mates with a connector on the main circuit board. A similar connector at rear connects to the charger socket, so that battery may be unplugged at both ends for convenient removal. Current limiting resistors sealed into the pack limit maximum current that can be drawn on short circuit. Battery pack will power the instrument for approximately 6 hours. A protective fuse (type 3AG 1 amp) is installed in a recessed fuseholder set into top surface of pack, and serves as an added protection against short circuit or overload.

GasTechtor instruments may be supplied with the 49-8051 Battery Pack with replaceable cells. This design was developed for the convenience of replacing any cell that may fail, in lieu of having to replace an entire battery pack. This battery pack is permanently secured by two screws through the bottom of the case.

An optional pack (49-8052) designed specifically for disposable batteries is also available. This battery pack will take alkaline or carbon flashlight type cells. This pack does not have a charger connection.

H. Circuit Boards

All circuit components are arranged on two epoxy-glass printed circuit boards, the main CO_2 board and the smaller O_2 board located above it. The CO_2 board includes the power supply, the gas detection amplifier and alarm circuits and associated controls for CO detection. The O_2 board includes similar components for O_2 detection, except it uses power from the CO_2 board.

Six adjustment potentiometers, three for CO_2 on the CO_2 board and three for O_2 on the O_2 board, are provided on underside of circuit boards, available for user adjustment when case is opened. Oxygen potentiometers are circular in shape and clustered together in line near the rear of the O_2 board. Potentiometers for the CO_2 circuitry are square and are spread across the CO_2 board.

1. The CO_2 potentiometers are:

   a. SPAN, near center of board, to set sensitivity of CO_2 circuit to required value to produce a correct reading on a known calibrating sample.

   b. ALARM Threshold, at the front end of board, to set the gas concentration at which the CO_2 alarm is actuated.

   c. Coarse ZERO, at the rear end of board, to extend the range of the external ZERO for CO_2.

III. OPERATION

A. Normal Operation

To use instrument, carry out the following steps:

1. Connect probe and hose to fitting on front of instrument.

2. Press POWER switch to turn instrument on, with orange indicator dot showing. Meter will initially deflect upscale and pulsing alarm signal will sound. Audible hum of pump will be noticed.

3. With range select switch in CO_2 (OUT) position, press BATT CK button and note meter reading. If reading is below BATT CHECK mark on meter, turn off instrument and recharge batteries.

4. Allow to warm up in CO_2 range until meter stabilizes (about a minute). With probe inlet in a normal air location, turn CO_2 ZERO shaft to bring meter to halfway between 0 and the first increment on the CO_2 scale (approximately 0.05%).

5. Next, put range switch in OXY (IN) position. Verify that probe is in a normal-air location; then turn OXY CAL control to bring meter to 21% (CAL) indication.

6. Verify normal operations by breathing out through your mouth and letting the probe sample your expired breath.

   Oxygen reading should move downscale and activate the alarm at 19.5%. In CO_2 range, reading should come up to about 2.5%. Both alarm lights and a steady audible alarm tone should come on during this test.

7. To take a reading, select meter range with range switch either CO_2 or O_2. Place tip of probe at point to be tested, and watch meter. Any CO_2 or O_2 abnormality present will indicate on the scale, when in appropriate range. If reading exceeds CO_2 alarm setting (see cover) pulsed red light and audible alarm will commence and will continue until source of CO_2 is removed. If reading falls below oxygen alarm setting (normally 19.5%) pulsed amber light and audible alarm will commence, and will continue until normal oxygen content is restored.

   An atmosphere containing more than the normal 21% oxygen will produce an increased oxygen reading. A steady tone will sound when reading reaches or exceeds 25% O_2. Light does not accompany this high oxygen alarm.

8. Monitoring for carbon dioxide and for oxygen is continuous and simultaneous, independent of range switch position. If either condition goes off-normal, corresponding alarm light and audible signal will sound. If both abnormal gas conditions exist simultaneously, both lights will blink in their normal pattern but the buzzer will sound continuously.

B. Abnormal Indications

1. If battery voltage drops below the designed value (about 8 volts), the low battery alarm will sound. This is a continuous audible tone. To verify the cause of the alarm, press BATT CK switch and note that the meter reads below check mark. Instrument will operate for about 20 minutes after it goes into low battery alarm.

2. If CO_2 zero drifts or moves below 0 by 5% or more, the low limit alarm will sound. This is also a continuous tone, and the cause can be recognized by a glance at the meter. The following are possible causes for downscale meter movement:

   a. Incorrect zero adjustment

   b. Defect in infrared analysis cell.

3. Note that the instrument is equipped with a "live zero" in which the OFF or rest position of meter is about 5% of scale below the zero position. Thus a glance at the meter will show that the instrument is active. CO_2 Zero drift as far down as the OFF mark will actuate the malfunction alarm.

4. If oxygen cell output declines or deteriorates, as is likely toward the end of cell life, this will produce a reduced reading, and a low oxygen alarm.

5. If oxygen detector is unplugged, or if one of the wires connecting it internally is broken, reading will go to zero, and low oxygen alarm will sound.

6. The steady audible tone sounds when the oxygen reading exceeds 25%. This characteristic is provided to warn against the increased fire hazard due to excess oxygen. It also serves as a warning in case of oxygen cell failure in the high-output mode, which can occur occasionally. It further precludes accidental or intentional incorrect adjustment of the oxygen calibrate control to an abnormally high level above 25%.

IV. CALIBRATION AND ADJUSTMENT

A. Carbon Dioxide Calibration

The following steps should be carried out with the range switch in CO_2 OUT position.

To check and adjust calibration on a known gas sample:

1. Turn instrument on and allow it to warm up and stabilize, preferably for at least 5 minutes. Be sure batteries are charged sufficiently to read above the check mark, then adjust zero to give a reading of 0.05% (halfway between 0 and first mark on the upper scale) if setting is fresh air, or to 0.0 if detector is exposed to a known CO_2-free sample.

2. Open instrument case by loosening captive knurled screw at front. Lift upper half of case slightly, move 1/4" to rear to disengage rear clamp; then separate the two halves. Locate CO_2 SPAN potentiometer on underside of circuit board near middle.

3. Connect instrument inlet to a known calibrating gas sample. If the sample exists within a large container at atmospheric pressure, the hose inlet may be inserted into the container. Watch meter carefully, and when it reaches its maximum reading, adjust to match known CO_2 concentration of sample. To adjust, turn SPAN potentiometer using a small screwdriver. Clockwise rotation increases reading. This is a single-turn potentiometer.

4. If GasTech Calibration kit is to be used to introduce gas into the instrument, proceed as above but:

   a. Screw dispensing valve onto the calibrating gas cylinder and attach it to one branch of the plastic "Y" connector on the gas collecting bag. Attach the probe of the instrument to the other branch of the "Y" connector. Make attachments with the flexible plastic tubing provided in the kit.

   b. While instrument is operating, open dispensing valve until collecting bag remains partly distended.

   c. Make the SPAN adjustment as in Step 3 above.

5. If calibration cannot be completed successfully, replace infrared detector, (see MAINTENANCE, Section V.)

B. Carbon Dioxide Alarm Threshold

The reading at which the alarm is actuated can be set by use of the ALARM Threshold potentiometer. To set:

1. Turn ZERO to bring meter to desired alarm setting.

2. Turn ALARM Threshold potentiometer to the point where alarm just operates. Clockwise rotation will raise alarm setting. Verify setting by turning ZERO to bring meter into and out of alarm zone.

C. Oxygen Zero Adjustment

The following steps should be carried out with range switch in OXY IN position, to check and adjust zero on a known oxygen-free sample.

1. While instrument is still open, identify oxygen ZERO potentiometer, which is the forward-most of the three located at the rear of the oxygen circuit board.

2. Admit a known oxygen-free sample, such as nitrogen, argon or helium, to sample inlet.

3. Watch meter carefully. If reading does not go exactly to zero, adjust it by turning ZERO potentiometer. Counterclockwise rotation will decrease reading.

4. If zero adjust cannot be made, replace oxygen cell.

5. After zero adjustment has been completed, return probe inlet to normal atmospheric air. Readjust OXY CAL control as necessary to bring meter reading to 21%.

6. If reading cannot be set high enough, replace oxygen cell.

D. Oxygen Alarm Threshold

The readings at which the alarms are actuated can be set by use of the alarm threshold potentiometers. To set:

1. Turn OXY CAL control to bring meter needle down to desired alarm setting, for example 19.5%.

2. Locate DWN ALM threshold potentiometer, center of the group of three at the rear of circuit board.

3. Turn DWN ALM threshold potentiometer to the point where alarm just operates. Clockwise rotation will raise alarm setting. Verify setting by turning OXY CAL control to bring meter needle into and out of alarm zone.

4. High oxygen alarm is set by repeating steps 1 through 3 above, but adjust the UP ALM potentiometer located at the rear corner of the O_2 board. A setting of 25% is suggested.

5. To complete the oxygen circuit settings, turn the OXY CAL control as necessary to bring meter needle to the 21% position on the scale.

V. MAINTENANCE

A. Batteries

1. Check battery voltage periodically by pressing BATTERY CHECK switch. This check must be done while range switch is in CO_2 OUT position. Recharge before voltage reaches minimum.

   When connecting charger, always follow these steps:

   a. Confirm that the plug is inserted in the correct way, with the THIS SIDE UP label upwards. The socket is polarized, with the pins offset below the centerline, but can sometimes be forced on the wrong way, particularly if it has become worn with use.

   b. Verify that a charge is actually entering battery, by confirming that amber light is on. Leave connected until green light comes on, indicating that 16 hour charge is completed.

2. If sufficient voltage cannot be obtained after charging, open instrument and:

   a. Check battery voltage output with a voltmeter, between red and black wires (unplug connector to gain access to pins). Voltage should be about 8.5 volts.

   b. If no output voltage can be obtained, check battery fuse by unscrewing recessed cap, marked "FUSE", and removing fuse. It can be checked visually or with an ohmmeter. If burned out, replace with a new one, but be sure to attempt to identify the cause of the overload or short circuit. Fuse must be type 3AG-1A.

   c. If battery voltage is too low, and cannot be brought up by overnight charging, it probably needs replacement. To remove, take out the two screws holding it to bottom of case, and unplug black and orange wire connector at charging end.

3. If the replaceable cell battery pack has been installed and is found defective, open the pack and check the voltage of each individual cell with a voltmeter. To open remove two screws on the top of the pack with a 1/8" Allen wrench. The lid is spring loaded and may be held down by hand to ease the screw removal. Carefully remove the lid and the individual cells.

   a. The cells supplied are the Stock No. 49-1501 rechargeable D-size nickel-cadmium type, 3.5-4.0 AH, and when charged, measure about 1.35 volts. Discard and replace faulty cells.

b. Examine the battery cavity and carefully clean out all foreign substances. Reinsert the cells into the pack in accordance with the diagram on the lid. (Negative end to springs, button end to rivets.) Leave the proper space open for the fuse cartridge.

c. Place the lid onto the cells, press down firmly and insert screws. The convoluted case will assure cell alignment. Tighten the screws snugly, do not overtorque. It may be necessary to spring sides of instrument case apart slightly to clear battery lid.

d. Join all loose connectors, reassemble instrument and charge battery as required.

e. If normal operation from disposable batteries is desired, use the Stock No. 45-8052 battery pack instead of the 49-8051 pack. The spring-loaded top is held down by two knurled thumb screws. When replacing, tighten both screws at the same time to assure even compression of the springs and proper battery contact. Duracell* type disposable batteries are recommended for a proper fit.

This battery pack has no charger connection, so there is no danger of inadvertent charging of disposable cells. It can be used with rechargeable cells, but they must be charged separately.

B. CO_2 Coarse Zero

If CO_2 circuit cannot be set to zero within the span of the external ZERO control, then use the Coarse Zero control, marked ZERO, near edge of circuit board.

1. Set external ZERO shaft to the middle of its travel.

2. Adjust Coarse Zero control to bring meter to zero while testing a CO_2-free atmosphere. Clockwise rotation moves meter upscale.

C. Filters

1. The disposable plastic filter within housing is intended to remove dust particles and liquid droplets which might otherwise reach the sensors. Inspect it periodically, and replace it when the element becomes visibly dirty.

2. The probe handle contains a replaceable cotton-ball filter element and should be inspected frequently. Remove old cotton-ball by unscrewing end from housing and loosely inserting fresh cotton-balls as needed; do not pack tightly.

* Durcell is a trade name for Duracell, Inc., Bethel, CT 06801

D. Meter

If meter is damaged, it can be removed for repairs or replacement, as follows:

1. With upper half of instrument removed from lower half and inverted, loosen internal lock nuts from POWER and VOLT CK switch bushings.
2. Remove Zero Adj. potentiometer lock nut.
3. Remove face nuts from switch bushings and potentiometer
4. Remove three screws holding circuit board into case.
5. Remove two nuts from meter studs.
6. Pull circuit board out of case as far as connecting wires permit. *Zero adj. potentiometer will come free from its mounting hole, held to the circuit board by its wires.
7. Lift out meter.

E. If buzzer fails, it can be removed by first taking out circuit board (Steps D.1-D.6) and unsoldering red and black wires at alarm switch. Then remove retaining screws and nuts.

Note: Before replacement, first verify that buzzer is actually defective. Connect to a 6 volt battery (Red +, Black -). A good buzzer will give a steady tone.

F. Circuit Board

Main circuit board can be removed entirely from instrument by steps D.1-D.6, plus disconnection of pump and battery wires at connectors, and disconnection of wires from oxygen board at connectors.

Oxygen board can then be removed following removal of retaining nuts from remaining two switches and OXY CAL potentiometer, along with buzzer and the two threaded hex standoffs. *OXY CAL potentiomenter will come free from its mounting hole, held to the board by its wires.

G. Infrared Cell

To remove infrared cell, first complete steps D.1-D.7, then:

1. Disconnect inlet and outlet tubes from nipples.
2. Unsolder the three pins extending from cell header board at main circuit board.
3. Unsolder red and black wires, at circuit board. Cell can then be removed.
4. Cell is not field-repairable. Return to factory or order a new one.

*When replacing boards, each potentiometer must be installed before its respective board. Install potentiometers square with the instrument, with the wires extending toward the front. Be sure ground lug is in place on OXY CAL potentiometer.

H. Oxygen Cell

1. Oxygen Sensor assembly may require repair if:

   a. Meter cannot be set to desired level on air within range of OXY CAL Adjust.

   b. Meter cannot be set to zero on inert gas within range of ZERO potentiometer.

2. If oxygen cell requires repair, it should be sent to factory for reactivation, on an exchange basis. Alternatively, a complete new sensor can be ordered. To replace oxygen sensor:

   a. Open instrument case. Locate oxygen cell.

   b. Swing retainer clamp clockwise and remove it to release cell.

   c. Tilt cell upward and pull it out of case. Unplug cell wire at socket.

   d. Reinstall newly reactivated cell in same position. Before installing, remove protective seal from face of cell. Verify that cell is seated against its O-ring seal when installed.

   e. Oxygen cell is an electrochemical device similar to a battery which gradually depletes itself, regardless of usage of the cell. It requires periodic reactivation, consisting of replacement of the electrolyte and the membrane, plus cleaning and inspection of the electrodes. This is most economically done at the factory.

      New or reactivated cells are guaranteed usable for one year, and any cells returned for reactivation within that time period will be inspected and tested for operability. If found to have failed prematurely, they will be reactivated at a pro-rated cost. Cells are internally date-coded.

I. Pump

Pump used is a diaphragm type, driven by a DC motor. It should have long life, several years in normal operation, but it may lose efficiency if dirt is drawn in and collects under the valves. Verify proper pump operation periodically by taking a sample and observing time for gas response to occur. This should be within 5 seconds for a 3' hose.

If pump needs servicing, it can be removed by taking out the clamp retaining screw in bottom. Pump can be returned for repair on an exchange basis or it can be disassembled and cleaned. Replacement pump head assemblies are also available, as well as replacement valve sets and replacement diaphragms.

VI. PARTS LIST

Stock No.	Description
07-6216	O-ring, oxygen cell
14-3502	Retainer strap, oxygen cell
30-0017	Pump, rotary DC
30-0340	Pump head, replacement
30-0341	Pump diaphragm, replacement
30-0342	Pump valves, replacement, set of 2
33-0141	Filter, internal, Balston DFU-BQ
33-1031	Filter elements, probe
43-4140	Fuse, battery, 3AG 1A
45-8051	Battery pack, replaceable, rechargeable cell, less batteries
45-8052	Battery Pack, replaceable, disposable cell less batteries
49-1201	Battery, alkaline size D disposable
49-1501	Battery, Ni-Cad, rechargeable
49-1571	Battery Pack, Ni-Cad batteries
49-2133	Battery Charger, dual rate, time-controlled, 115 volts, for Ni-Cad batteries
49-2134	Battery Charger, dual rate, time-controlled, 230 volts, for Ni-Cad batteries
49-8051	Battery Pack, replaceable, rechargeable cell, with batteries
50-12XX	Meter, Dual range, CO_2 and oxygen, specify Job 4539
52-1005	Buzzer
57-8055M	Circuit board, oxygen, specify Job 4539
65-0601	Oxygen cell, new
65-0601E	Oxygen cell, reactivated
65-7001	Infrared cell, replacement
80-0006	Hose, Polyethylene-lined, 6'
80-0155M	Probe assembly, 28"

When ordering part, please specify Model 3252OX and Serial Number of instrument.

SERVICE POLICY

GasTech Inc. maintains an instrument service facility at the factory. Some GasTech distributors also have repair facilities; however, **GasTech assumes no liability for service performed by other than GasTech personnel.** Should your instrument require non-warranty repair, you may contact the distributor from which it was purchased, or you may contact GasTech directly.

If GasTech is to do the repair work for you, you may send the instrument, prepaid, to GasTech Inc., 8445 Central Avenue, Newark, CA 94560, Attn: Service Department. Always include your address, purchase order number, shipping and billing information and a description of the defect as you perceive it. If you wish to set a limit to the authorized repair cost, state a "not to exceed" figure. If you must have a price quotation before you can authorize the repair cost, so state, but understand that this involves extra cost and extra handling delay. GasTech's policy is to perform all needed repairs to restore the instrument to full operating condition, including reactivation of all out-of-warranty electrochemical cells.

To expedite the repairs operation, it is preferable to call in advance to GasTech Instrument Service, (415)794-7015, obtain a Return Authorization Number (PA#), describe the nature of the problem and provide a purchase order number.

If this is the first time you are dealing directly with the factory, you will be asked to provide credit references or prepay, or authorize COD shipment.

Pack the instrument and all its accessories (preferably in its original packing). Enclose your Purchase Order, shipping and billing information, RA#, and any special instructions.

Rev. 9/89

GasTech Inc.

Standard Warranty

Gas Detection Instruments

We warrant gas alarm equipment manufactured and sold by us to be free from defects in materials, workmanship and performance for a period of one year from date of shipment from GasTech Inc. Any parts found defective within that period will be repaired or replaced, at our option, free of charge, f.o.b. factory. This warranty does not apply to those items which by their nature are subject to deterioration or consumption in normal service, and which must be cleaned, repaired or replaced on a routine basis. Such items may include:

a) Lamp bulbs and fuses

b) Pump diaphragms and valves

c) Absorbent cartridges

d) Filter elements

e) Batteries

f) Most catalytic and electrochemical sensors are covered by a separate warranty of 12 or 24 months.

Warranty is voided by abuse including rough handling, mechanical damage, and alteration or repair procedures not in accordance with instruction manual. This warranty indicates the full extent of our liability, and we are not responsible for removal or replacement costs, local repair costs, transportation costs, or contingent expenses incurred without our prior approval.

GasTech Inc.'s obligation under this warranty shall be limited to repairing or replacing, and returning any product which GasTech Inc. Material Review Board examination shall disclose to its satisfaction to have been defective. To receive warranty consideration, all products must be returned to GasTech Inc. at its manufacturing facilities with transportation charges prepaid.

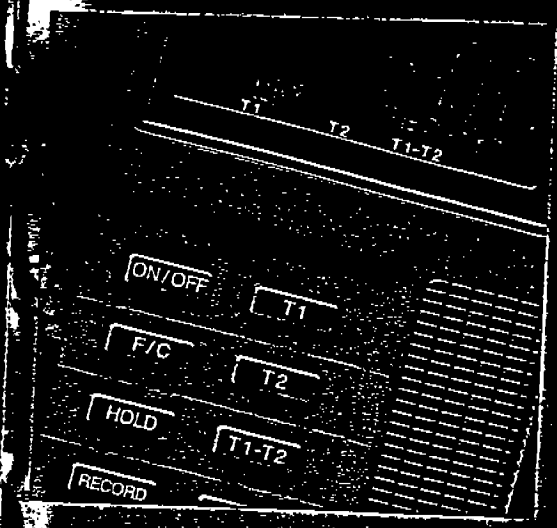
This warranty is expressly in lieu of any and all other warranties and representations, expressed or implied, and all other obligations or liabilities on the part of GasTech Inc. including but not limited to, the warranty of fitness for a particular purpose. In no event shall GasTech Inc. be liable for direct, incidental or consequential loss or damage of any kind connected with the use of its products or failure of its product to function or operate properly.

This warranty covers instruments and parts sold (to users) only by authorized distributors, dealers and representatives as appointed by Gas Tech.

Sls/Eng Rev. 1/90

TEMPERATURE METER

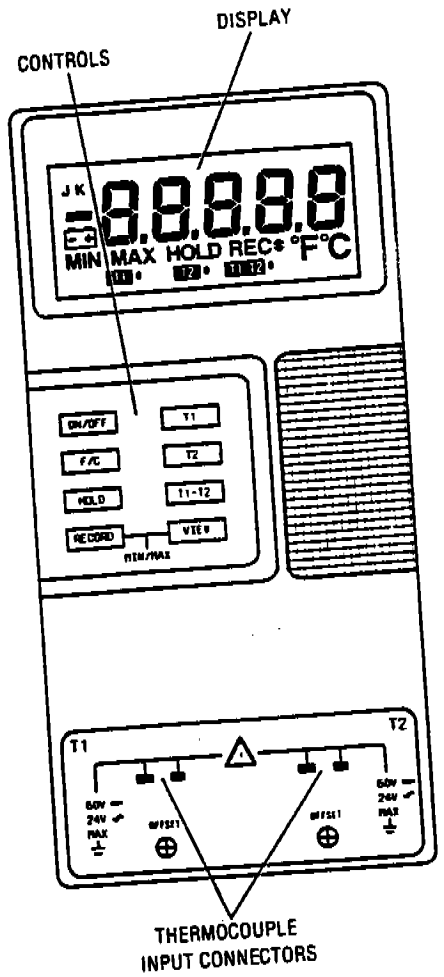
52 K/J THERMOMETER



OPERATOR'S MANUAL

P/N 764712
OCTOBER 1985
Rev. 3, 12/90

FLUKE®



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INTRODUCTION

This instrument is a microprocessor-based, digital thermometer designed to use external K-type or J-type thermocouples as temperature sensors. Temperature indication follows National Bureau of Standards and IEC 584 temperature/voltage tables for K-type and J-type thermocouples. Two K-type thermocouples are supplied with the thermometer.

It is recommended that you read the safety and operating instructions before using the thermometer.

NOTE

A quick operating guide is located on page 7 to get you started using the thermometer quickly.

SAFETY INFORMATION

WARNING

TO AVOID ELECTRICAL SHOCK, DO NOT USE THIS INSTRUMENT WHEN VOLTAGES AT THE MEASUREMENT SURFACE EXCEED 24V AC OR 60V DC.

WARNING

TO AVOID DAMAGE OR BURNS, DO NOT MAKE TEMPERATURE MEASUREMENTS IN MICROWAVE OVENS.

CAUTION

Repeated sharp flexing can break the thermocouple leads. To prolong lead life, avoid sharp bends in the leads, especially near the connectors.

This instrument has been designed and tested according to IEC Publication 348, Safety Requirements for Electronic Measuring Apparatus. This manual contains information and warnings that must be followed to ensure safe operation and to protect the meter.

The ⚠ symbol on the instrument indicates that the operator must refer to an explanation in this manual.

OPERATIONAL LIMITATIONS

The thermometer is designed to operate within the following conditions:

- THERMOCOUPLE MEASUREMENT RANGE

  K-type thermocouple: -200°C to 1370°C (-328°F to 2498°F) (See Appendix A.)

  J-type thermocouple: -200°C to 760°C (-328°F to 1400°F)

- INSTRUMENT ENVIRONMENT:

  Temperature: 0°C to 50°C (32°F to 122°F)

  Humidity: 0% to 90% (0°C to 35°C) (32°F to 95°F)

  0% to 70% (35°C to 50°C) (95°F to 122°F)

The thermometer displays an error indication (Figure 1) if the thermometer itself is subjected to temperatures outside the instrument environment range listed above. However, if the thermometer is initially at an ambient temperature of 20°C (68°F), it will typically provide accurate readings for 5 minutes down to an ambient temperature of -26°C (-15°F)

Figure 1. Error Indication

The thermometer is designed to provide accurate readings even when it is subjected to rapid ambient temperature changes (for example, when carried from a cold vehicle to a warm building). For an ambient temperature step change of up to 35°C (63°F), readings are within 1 degree of specified accuracy immediately, and within specified accuracy within 10 minutes.

Thermocouple limitations are discussed later in this manual. If you are using another manufacturer's thermocouple, consult the manufacturer's specifications for that thermocouple.

NOTE

Measurement errors may occur if voltages on the measurement surfaces result in

potentials greater than 1 V between the two thermocouples. When potential differences are anticipated between the thermocouples, electrically insulated thermocouples are recommended.

FEATURES

Display

Each item in the display is described below and keyed by number to the illustration inside the back cover of this manual.

(1) NUMERIC DISPLAY
The numeric display indicates the temperature of thermocouple T1, the temperature of thermocouple T2, or the temperature difference between the two thermocouples (T1-T2).

(2) °F°C TEMPERATURE SCALE ANNUNCIATOR
Either the °C or °F symbol is displayed, indicating whether temperature readings are displayed in degrees Celsius or degrees Fahrenheit.

(3) REC RECORD MODE ANNUNCIATOR
This symbol indicates that the thermometer is in RECORD mode. (See "RECORD Mode," later in this manual.)

(4) ⇕ STORED-DATA SYMBOL
This symbol indicates whether the readings stored in RECORD mode were taken from T1, T2, or T1-T2 input. (The stored-data symbol appears next to T1, T2, or T1-T2 on the display window.)

(5) T1 T2 T1-T2 INPUT SELECTION CURSOR
The input selection cursor indicates which input is selected for display: thermocouple T1, thermocouple T2, or the difference between the two thermocouples (T1-T2).

(6) MAX MAX ANNUNCIATOR
This symbol appears when the display shows the maximum reading stored while in RECORD mode.

(7) MIN MIN ANNUNCIATOR
This symbol appears when the display shows the minimum reading stored while in RECORD mode.

(8) LOW BATTERY ANNUNCIATOR
This symbol appears when approximately 50 hours of battery life remain. For proper operation, replace the battery as soon as possible. (Refer to "Battery Replacement," later in this manual.)

(9) JK THERMOCOUPLE TYPE ANNUNCIATOR
This symbol indicates which type of thermocouple (K or J) the thermometer is set up to use.

NOTE

For readings to be correct, be sure that the displayed thermocouple type matches the type of thermocouple you are using.

(10) HOLD HOLD MODE ANNUNCIATOR
This symbol indicates that the thermometer is in HOLD mode. (See "HOLD Mode," later in this manual.)

Controls

The thermometer's controls are briefly described below and keyed by number to the illustration inside the back cover of this manual.

(11) ON/OFF
The ON/OFF key turns the thermometer on or off.

(12) F/C
The F/C key switches between the Celsius (°C) and Fahrenheit (°F) scales on the display.

(13) HOLD
Pressing the HOLD key selects HOLD mode. (See "HOLD Mode," later in this manual.) If pressed during power-up, the HOLD key changes the selection of thermocouple type.

(14) RECORD
Pressing the RECORD key selects RECORD mode. (See "RECORD Mode," later in this manual.)

(15) T1
The T1 key selects thermocouple T1 as the input. When pressed during power-up, the T1 key changes the display resolution.

(16) T2
The T2 key selects thermocouple T2 as the input. When pressed during power-up, the T2 key selects SCAN mode. (See "SCAN Mode," later in this manual.)

(17) T1-T2
The T1-T2 key selects differential temperature measurement. This causes the thermometer to measure the temperature of T1 and T2 and display the difference (T1 minus T2). To use this feature, you must connect two thermocouples to the thermometer.

(18) VIEW
This key displays the MIN and MAX readings stored in RECORD mode. (See "RECORD Mode," later in this manual.)

(19) OFFSET
The OFFSET controls allow you to optimize measurement accuracy for a particular thermocouple (or pair of thermocouples) at a particular temperature. (**IMPORTANT:** Before adjusting these controls, read "Offset Adjustment," later in this manual.)

Alternate Control Functions

The T1, T2, and HOLD keys have alternate functions when held down during power-up. The T1 key changes the display resolution, the T2 key selects the SCAN mode, and the HOLD key changes the selection of thermocouple type. For reference, these alternate functions are indicated on the back of the instrument.

To select an alternate function, turn the thermometer off. Then, while holding down the T1, T2 or HOLD key, turn the thermometer on. Release the T1, T2, or HOLD key 2 to 3 seconds later.

Any combination of these three keys can be held down during power-up to select combinations of alternate functions. For example, by holding down the T1 and T2 keys with your thumb at power-up, you can change the display resolution and also select SCAN mode.

Open Thermocouple Indication/Error Indication

The error indication (Figure 1) is displayed if any of the following conditions occur:

1. If no thermocouple is plugged into the selected input.
2. If the thermocouple connected to the selected input is broken or open-circuited.
3. If the thermometer itself is subjected to temperatures outside its specified environmental range.
4. If an attempt is made to display MIN/MAX readings before MIN/MAX readings have been recorded.

While the error indication is displayed, the annunciators still indicate which features have been selected (thermocouple type, temperature scale, etc.).

QUICK OPERATING GUIDE

The following procedure is intended to familiarize you quickly with the thermometer's operation. Start with both thermocouples disconnected from the thermometer.

1. Press the ON/OFF key. The self-test display appears briefly (see Figure 2). The display then shows the error indication (Figure 1), indicating that no thermocouple is plugged into the selected input. If the thermometer should fail the self-test, the self-test display will flash several times.

Figure 2. Self-Test Display

At power-up, the thermometer is set up to measure temperatures from the T1 input connector with K-type thermocouples. (To set up the thermometer

for J-type thermocouples, see "Selecting the Thermocouple Type.") The thermometer uses the same temperature scale (°C or °F) that was in use when the thermometer was last turned off.

2. Insert a K-type thermocouple into the T1 input connector. The thermometer will display the temperature of the T1 thermocouple (see Figure 3).

Figure 3. Example T1 Temperature Reading

3. Insert a second K-type thermocouple into the T2 input connector.

4. Press the T2 key to select and display the temperature of the T2 thermocouple.

5. Press the T1-T2 key to select and display the differential temperature (the temperature of T1 minus the temperature of T2) (see Figure 4).

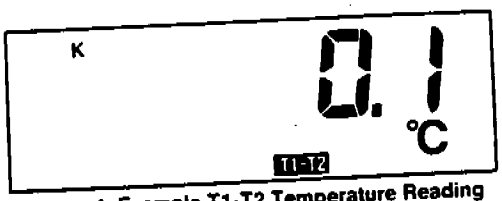


Figure 4. Example T1-T2 Temperature Reading

6. Press the RECORD key. The thermometer is now in RECORD mode, and the RECORD symbol is displayed (see Figure 5). In addition, the stored-data symbol (↕) appears next to T1-T2, indicating that MIN/MAX readings are being recorded for T1-T2.

7. Press the T1 key or T2 key to view the temperature of T1 or T2 while still recording the MIN/MAX values of T1-T2.

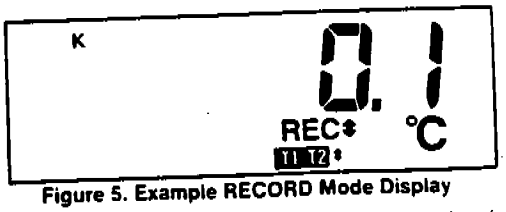


Figure 5. Example RECORD Mode Display

8. Press the VIEW key to display the MAX value of T1-T2. Press the VIEW key again to display the MIN value of T1-T2. Repeatedly pressing the VIEW key toggles between the MAX and MIN displays.

9. Press the T1 key to cancel the MIN/MAX display and to display the temperature of T1. The thermometer continues to update the MIN/MAX values for T1-T2.

10. Press the HOLD key to stop all temperature measurements. The T1, T2, T1-T2, and MIN/MAX values last measured can still be viewed. Press the HOLD key again to continue measurements.

11. Press the RECORD key. The REC annunciator will turn off, indicating that RECORD mode is off.

12. Press the VIEW key. Note that the last MIN/MAX readings are still retained. The stored-data symbol (↕) is still on, indicating which input the MIN/MAX readings were taken from (in this case, T1-T2).

13. Press the RECORD key again, so that the REC annunciator reappears. This resets the MIN/MAX readings and causes the thermometer to begin recording MIN/MAX readings again. If another input has been selected, recording begins on that input.

OPERATING INSTRUCTIONS

The following paragraphs describe the thermometer's operation in detail.

Power-Up

When the thermometer is turned ON, all display segments appear while the thermometer performs a brief self-test (see Figure 2). If the thermometer should fail the self-test, the display will flash several times, and the thermometer will attempt to resume normal operation. If this occurs, contact the nearest Service Center.

After about 3 seconds, the thermometer displays the first temperature reading. If no thermocouple is plugged into the selected input, the thermometer displays the error indication (Figure 1).

Connecting the Thermocouples

The thermometer is used with one or two thermocouples. The thermocouples plug into the T1 and T2 input connectors. Either K-type or J-type thermocouples can be used. Only one type of thermocouple can be used at a time.

For readings to be correct, the thermometer must be set for the type of thermocouples you are using. The setting is indicated on the display by a K or a J.

The thermometer is set at the factory to default to K-type thermocouples. This is the correct setting for the thermocouples included with the thermometer.

To set the thermometer for J-type thermocouples, see "Selecting the Thermocouple Type."

Selecting the Temperature Scale

Readings are displayed in either degrees Celsius (°C) or degrees Fahrenheit (°F). When the thermometer is turned on, it is set to the temperature scale that was in use when the thermometer was last turned off. To change the temperature scale, press the F/C key.

Single-Thermocouple Temperature Measurement

The thermometer displays the temperature of the thermocouple that is connected to the selected input. Press the T2 key to display the temperature of the thermocouple connected to the T2 input. Press the T1 key to display the temperature of the thermocouple connected to the T1 input. The input selection cursor indicates which input is selected.

If the selected thermocouple is unplugged or open-circuited, the thermometer displays the error indication (Figure 1)

Differential Temperature Measurement

Differential temperature measurement is selected by pressing the T1-T2 key. This causes the thermometer to display the temperature difference between the two thermocouples (the temperature of thermocouple T1 minus the temperature of thermocouple T2). The selection is indicated by the input selection cursor.

If either thermocouple is unplugged or open-circuited, the thermometer displays the error indication (Figure 1). To return to single-thermocouple temperature measurement, press the T1 or T2 key.

NOTE

Measurement errors may occur if voltages on the measurement surfaces result in potentials greater than 1 V between the two thermocouples. When potential differences are anticipated between the thermocouples, electrically insulated thermocouples are recommended.

NOTE

If the temperature at the measurement surfaces changes faster than 4° C (7° F) per minute, the thermometer may display a temperature difference even when the two thermocouples are at the same temperature. This occurs because the thermometer does not measure T1 and T2 simultaneously.

Because the thermometer rounds off all measurements before they are displayed, the value displayed for T1-T2 may not always correspond exactly to the difference of the values displayed for T1 and T2.

For example,

Input	Actual Temperature	Displayed Temperature
T1:	25.14°C	25.1°C
T2:	25.05°C	25.1°C
T1-T2:	0.09°C	0.1°C

In this case, the thermometer rounds off both T1 and T2 to 25.1°C, but still displays the actual temperature difference for T1-T2 (rounded to the nearest tenth of a degree).

RECORD Mode

In RECORD mode, the thermometer continually records and updates the maximum and minimum readings from T1, T2, or T1-T2. When recording on T1 or T2, the thermometer records the maximum and minimum readings on that input. When recording on T1-T2, the thermometer records the maximum and minimum difference between the two inputs. MIN/MAX readings can be stored from only one input at a time.

To select RECORD mode, first select the desired input (T1, T2, or T1-T2), then press the RECORD key. The thermometer then records and updates the minimum and maximum values for that input. The stored-data symbol (⇕) appears on the display next to T1, T2, or T1-T2 to indicate which input is being recorded (see Figure 5). (The stored-data symbol remains displayed until the thermometer is turned off.) The other inputs can be displayed, but recording continues on the input indicated by the stored-data symbol (⇕) until RECORD mode is cancelled by pressing the RECORD key again.

The stored MIN/MAX readings remain available until RECORD mode is selected again or the instrument is turned off. To restart the MIN/MAX recording, press the RECORD key twice.

NOTE

MIN/MAX readings are erased when recording is restarted or when the thermometer is turned off.

To view the stored maximum reading, press the VIEW key once (the MAX annunciator will appear). To view the stored minimum reading, press the VIEW key again (the MIN annunciator will appear). Additional presses of the VIEW key toggle between the MIN and MAX displays. The stored-data symbol (⇕) indicates which input the MIN/MAX readings were recorded from. To cancel the MIN/MAX display, press the T1, T2, or T1-T2 keys.

Pressing the VIEW key does not stop measurement activity; it merely displays the MIN/MAX readings. Using the VIEW key

while in RECORD mode provides a continuously updated display of the minimum or maximum temperatures.

If you attempt to display MIN/MAX readings before MIN/MAX data has been recorded, the thermometer displays the error indication (Figure 1).

HOLD Mode

Pressing the HOLD key selects HOLD mode. When HOLD mode is selected, the thermometer stores the present T1, T2, and T1-T2 readings and stops all further measurements. Each of these readings can still be displayed by pressing the respective key. The MIN/MAX values can also be displayed by pressing the VIEW key. Additionally, all other keys can still be used.

Pressing the HOLD key again cancels HOLD mode, causing the thermometer to resume taking measurements.

SCAN Mode

When SCAN mode is selected, the display continuously cycles between T1, T2, and T1-T2 temperature readings. To select SCAN mode, first turn the thermometer off. Then, while keeping the T2 key pressed, press the ON/OFF key. After 2 to 3 seconds, release the T2 key. The thermometer will then be in SCAN mode.

To leave SCAN mode, turn the thermometer OFF and then ON again. (Remember: Previously recorded MIN/MAX readings are erased when the thermometer is turned off.)

Selecting the Thermocouple Type

The thermometer accepts either K-type or J-type thermocouples. The thermometer is set at the factory to default to K-type thermocouples at power-up.

To select the alternate type of thermocouple, first turn the thermometer OFF. Then, while keeping the HOLD key pressed, press the ON/OFF key. After 2 to 3 seconds, release the HOLD key. The thermocouple type annunciator will indicate that the alternate thermocouple type has been selected.

NOTE

For readings to be correct, be sure that the displayed thermocouple type matches the type of thermocouple you are using.

To change the default thermocouple type, the case must be opened as described in the Battery Replacement procedure, later in this manual. Jumper W1 (see Figure 4) determines the default selection. When W1 is installed, the default selection is set for K-type thermocouples. When W1 is cut, the default selection is set for J-type thermocouples. REFER TO A QUALIFIED TECHNICIAN TO HAVE THIS MODIFICATION PERFORMED. K-type thermocouples can still be selected by pressing the HOLD key at powerup.

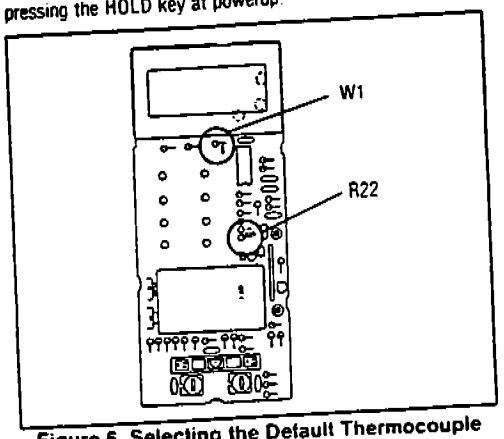


Figure 6. Selecting the Default Thermocouple Type and Resolution

Selecting the Display Resolution

The thermometer allows two choices of display resolution:

High resolution: 0.1°C (0.2°F)
Low resolution: 1.0°C (1.0°F)

The thermometer is set at the factory to default to high resolution when it is turned on. To select the alternate display resolution, turn the thermometer OFF. Then, while keeping the T1 key pressed, press the ON/OFF key. After 2 to 3 seconds, release the T1 key. The alternate resolution remains selected until the instrument is turned off.

To change the default resolution, the case must be opened as described in the Battery Replacement procedure. Jumper R22

(see Figure 6) determines the default selection. When R22 is installed, the default is high resolution. When R22 is cut, the default is low resolution. REFER TO A QUALIFIED TECHNICIAN TO HAVE THIS MODIFICATION PERFORMED

OFFSET ADJUSTMENT

The OFFSET controls are set at the factory to allow for the variations found in standard thermocouples. By adjusting the OFFSET controls, you can optimize measurement accuracy for a particular thermocouple (or pair of thermocouples) at a particular temperature.

NOTE

To return the OFFSET control to its factory setting, refer to the thermocouple input calibration procedure located on page 3-7 in the 51/52 Service Manual (P/N 768234). The OFFSET controls should be adjusted only when planning to make long-term measurements at a single temperature using a particular thermocouple or pair of thermocouples. The OFFSET controls do not need to be adjusted to obtain the accuracy specified for the thermometer and thermocouples.

By leaving one of the OFFSET controls untouched, you will be able to return the OFFSET controls to their factory setting. If both OFFSET controls are adjusted, you will still be able to return the OFFSET controls close to their factory setting. (See "Resetting the OFFSET Controls," below.)

The OFFSET controls are adjusted using a small screwdriver TO ENGAGE EITHER CONTROL, PRESS DOWNWARD GENTLY AS YOU TURN THE SCREWDRIVER. When the limit of their rotation is reached, the OFFSET controls slip with a ratchet-like feeling. Each OFFSET control has a range of approximately ±3°C (±5°F).

Adjusting for T1 or T2 Measurements

To adjust the OFFSET controls for optimum T1 or T2 measurements with a particular thermocouple at a particular temperature, perform the following procedure:

1. Connect the thermocouple to the T1 or T2 input connector and turn the thermometer ON. (If using T2, press the T2 key.)
2. Place the thermocouple in a known, stable temperature environment at or near the temperature you wish to measure, and allow the readings to stabilize.
3. Slowly adjust the OFFSET control that corresponds to the selected input (i.e., T1 or T2) so that the thermometer reading matches the temperature of the known environment. Leave sufficient time between adjustments to allow for measurement lag.
4. The calibration of the thermometer-thermocouple combination is now optimized for measurements near the temperature measured in step 2. (Note: It is recommended that you mark down which OFFSET control has been adjusted.)

Adjusting for T1-T2 Measurements

To adjust the OFFSET controls for optimum differential temperature readings with a particular pair of thermocouples at a particular temperature, perform the following procedure:

1. Connect the thermocouples to the input connectors.
2. Turn the thermometer ON and select T1-T2.
3. Place both thermocouples in a stable temperature environment at or near the temperature you wish to measure, and allow the readings to stabilize.
4. Slowly adjust either one (but not both) of the OFFSET controls until the thermometer reads zero. Leave sufficient time between adjustments to allow for measurement lag.
5. The thermometer-thermocouple combination is now optimized for differential temperature measurement near the temperature used in step 3.

Resetting the OFFSET Controls

To return the OFFSET controls to (or close to) their factory

setting without having to recalibrate the thermometer, perform either of the two following procedures.

Procedure 1 (This procedure is preferred but will only work if one of the OFFSET controls was left at its factory setting):

1. Connect a thermocouple in good working order to the input which has NOT been adjusted.
2. Place the thermocouple in an ice-water bath (or other stable temperature environment) and allow the readings to stabilize.

NOTE

To create an ice-water bath, add crushed ice to a styrofoam cup (or other insulated container), fill the cup with water to the top of the ice, and stir during measurement.

3. Write down the temperature reading.
4. Immediately connect the SAME thermocouple to the other input without disturbing the position of the thermocouple in the temperature environment.
5. Slowly adjust the corresponding OFFSET control to obtain the reading recorded in step 3.

Procedure 2:

1. Connect a thermocouple that is in good working order to the input that is to be adjusted.
2. Place the thermocouple in an ice-water bath and allow the readings to stabilize.
3. Slowly adjust the corresponding OFFSET control until the thermometer reads 0°C (32°F).

INTERNAL CALIBRATION

The thermometer should be calibrated once a year to ensure its accuracy is within specifications. To calibrate the thermometer, refer to the Service Center nearest you or to the Service Manual listed on page 32.

MEASUREMENT TECHNIQUES

The following paragraphs present several suggestions for getting the best accuracy from your temperature measurements.

Choosing a Thermocouple Probe

The thermocouples shipped with your thermometer are bead thermocouples, which are designed for general-purpose use. For optimum accuracy, use the style of probe that is appropriate for each type of application. Use an immersion probe for liquid or gel measurements, an air probe for air measurements, a surface probe for surface measurements, etc.

Thermocouple Connectors

Thermocouple connectors are made from the same materials as thermocouple wires. To avoid error, it is important to use a thermocouple connector whose materials matches the thermocouple you are using. The thermocouples included with the thermometer have the correct type of connector already installed.

When attaching a miniature thermocouple plug to a K-type or J-type thermocouple, ensure that the thermocouple connector type matches the thermocouple type. The correct connections are shown in Table 1.

Reducing Thermal Error

In surface temperature measurements, error can result if there is a poor thermal connection between the thermocouple and the material being measured. Here are some suggestions for reducing thermal error:

- Ensure that there is a good connection between the thermocouple and the surface you are measuring. You can do this several ways:
  1. Clean the surface you are measuring.
  2. Use adequate mounting pressure.
  3. Use a thermal conducting compound (such as silicone grease) between the thermocouple and the surface you are measuring. (Use thermal epoxy if you want a permanent connection.)
- When you are measuring above-ambient temperatures, adjust the connection of the thermocouple to the surface until you get the highest temperature reading. Use any of the suggestions given above to do so.
- Similarly, when you are measuring below-ambient temperatures, adjust the connection of the thermocouple

to the surface until you get the lowest temperature reading. Use any of the suggestions given above to do so

- When measuring near-ambient temperatures, take the reading when the thermometer's display is most stable.

Table 1. Thermocouple Connections

K TYPE (Yellow connector body)	POSITIVE (+) LEAD NON-magnetic Yellow insulation (if color coded) Chromium-nickel alloy (Chromel) Connects to narrow connector blade
	NEGATIVE (-) LEAD Magnetic Red insulation (if color coded) Aluminum-nickel alloy (Alumel) Connectes to wide connector blade
J TYPE (Black connector body)	POSITIVE (+) LEAD Magnetic White insulation (if color coded) Iron Connects to narrow connector blade
	NEGATIVE (-) LEAD NON-magnetic Red insulation (if color coded) Copper-nickel alloy (Constantan) Connects to wide connector blade
NOTE: These color codes are USA standards. Color codes may vary by country.	

Other Sources of Error

Excessive voltage potentials at the measurement surface can cause incorrect readings and/or instrument damage. Use caution when making temperature measurements in the presence of live circuits. To avoid incorrect or noisy readings, do not exceed the 1V maximum allowed voltage potential between T1 and T2.

Strong low-frequency and radio-frequency fields can also cause incorrect temperature readings.

THERMOCOUPLE LIMITATIONS

Thermocouple performance is subject to environmental and electrical limitations, as well as to the inherent accuracy

limitations of the thermocouples themselves. The limitations for K-type and J-type thermocouples are summarized in Table 2. Appendix A lists the specifications for the thermocouples included with the thermometer.

Table 2. Thermocouple Characteristics

PARAMETER	J-TYPE THERMOCOUPLES
Temperature Range	-200°C to +760°C -328°F to 1400°F
Environmental Limitations	Alloy is brittle below 0°C. OK for reducing or oxidizing atmospheres or in vacuum. Not OK for sulfurous atmospheres above 500°C
Color Codes	See Table 1.
Initial Tolerances	Standard: ±2.2°C or 0.75%* (±3.6°F or 0.75%*) Special: ±1.1°C or 0.38%* (±1.98°F or 0.38%*)
PARAMETER	**K-TYPE THERMOCOUPLES**
Temperature Range	-270°C to +1370°C -454°F to 2498°F
Environmental Limitations	OK for clean, oxidizing or inert gas atmospheres. Not OK for vacuum at high temperatures. Corrodes in low-temperature, oxygen-poor atmospheres
Color Codes	See Table 1.
Initial Tolerances	Standard: ±2.2°C or 0.75%* (±3.6°F or 0.75%*) Special: ±1.1°C or 0.38%* (±1.98°F or 0.38%*)

* whichever is greater

OPERATOR MAINTENANCE

WARNING

TO AVOID POSSIBLE ELECTRICAL SHOCK, DISCONNECT THE THERMOCOUPLE CONNECTORS FROM THE THERMOMETER BEFORE REMOVING THE COVER.

Battery Replacement

The thermometer is powered by a single 9V battery (NEDA 1604A, IEC 6LR61). Referring to Figure 7, use the following procedure to replace the battery:

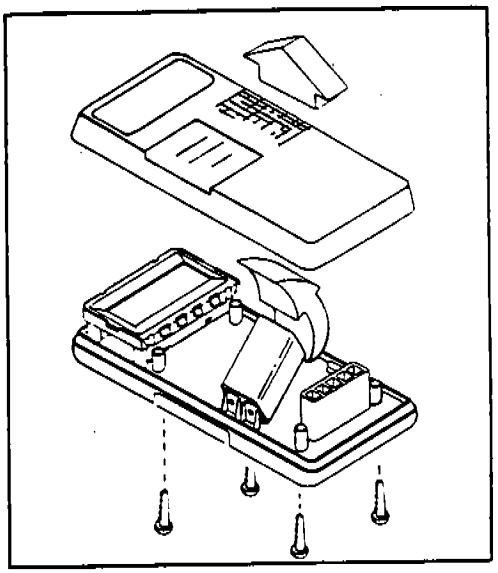


Figure 7. Battery Replacement

1. Remove the four case screws with a #2 Phillips screwdriver and separate the case halves by pulling them straight apart.
2. Disengage the battery from the battery contacts by prying the battery away from the clips.

3. Install a fresh battery by squeezing the battery against the battery contacts. Make sure that the battery is fully seated in the contacts.

4. Reassemble the case halves.

5. Install the four case screws with a #2 Phillips screw driver, taking care to tighten the screws only finger tight (6-7 in-lbs).

Proper Care of Thermocouples

To maintain a thermocouple in good condition, observe the following precautions.

- AVOID EXCESS BENDING
  Bending changes the thermoelectric characteristics to some extent, especially where the wire is subjected to high thermal gradients. Bending can also break the wire. If it is necessary to bend the wire, give the bend a large radius. Be careful not to bend the wire sharply, especially where it exits the connector.

- DON'T OVERHEAT THE THERMOCOUPLE
  Usually, the first thing to fail on a thermocouple assembly is its insulation, handle, or other supporting material. Almost always, the wire can withstand more heat than its insulation can. See the manufacturer's specifications for the maximum temperature of any thermocouple assembly.

  The wire itself can lose its accuracy if it is allowed to operate for extended periods of time near the high limit of its specifications. This is due to annealing and contamination of the wire's composition.

- AVOID CHEMICAL REACTIONS THAT CAN DAMAGE THE THERMOCOUPLE
  The presence of various gasses and fluids at particular temperatures can contaminate, etch, or chemically combine with the thermocouple wire. Such conditions can affect its accuracy. The manufacturer's publications will show what to watch out for.

INSTRUMENT SPECIFICATIONS

Instrument specifications are shown in Table 3.

Table 3. Instrument Specifications

NBS CONFORMITY

The thermometer conforms to the temperature/voltage tables of the National Bureau of Standards and to the IEC 584 standards for K-type and J-type thermocouples

ELECTRICAL

Measurement Range:

K-type thermocouple	-200°C to +1370°C (-328°F to +2498°F)
J-type thermocouple	-200°C to +760°C (-328°F to +1400°F)

Resolution:

High 0.1°C or 0.2°F
Low 1°C or 1°F

Accuracy:

Accuracy is specified for operating temperatures over the range of 18°C to 28°C (64°F to 82°F), for 1 year, not including thermocouple error (see "Thermocouple Limitations")

For single-thermocouple measurements, accuracy is

K-type thermocouple	±(0.1% of reading + 0.7°C) (±[0.1% of reading + 1.3°F])
J-type thermocouple	±(0.1% of reading + 0.8°C) (±[0.1% of reading + 1.4°F])

For T1-T2 measurements, accuracy is typically better than

K-type thermocouples

±(0.1% of T1-T2 reading + 1.0°C)
(±[0.1% of T1-T2 reading + 1.8°F])

J-type thermocouples

±(0.1% of T1-T2 reading + 1.2°C)
(±[0.1% of T1-T2 reading + 2.2°F])

Temperature Coefficient (for ambient temperatures from 0°C to 18°C and 28°C to 50°C [32°F to 64°F and 82°F to 122°F])

Table 3. Instrument Specifications (cont)

For each °C (°F) ambient below 18°C (64°F) or above 28°C (82°F), add to the accuracy specifications

0.01% of reading + 0.03°C
(0.01% of reading + 0.03°F)

Input Protection:
60V dc or 24V rms ac maximum input voltage on any combination of input pins

Maximum Differential Common Mode Voltage (Maximum voltage between T1 and T2 during measurement): 1 volt

Reading Rate:

One thermocouple plugged in: 1 second per reading
Two thermocouples plugged in: 1.7 seconds per reading

ENVIRONMENTAL

Ambient Operating Range:
0°C to 50°C (32°F to 122°F)
Will operate to -26°C (-15°F) for 5 minutes when taken from a 20°C (68°F) environment

Storage Temperature: -40°C to 60°C (-40°F to 140°F)

Humidity:

0% to 90% (0°C to 35°C) (32°F to 95°F)
0% to 70% (35°C to 50°C) (95°F to 122°F)

RF Fields: Strong low-frequency and radio-frequency fields may produce erroneous readings.

GENERAL

Weight: 280 gm (10 oz)

External Dimensions: 2.84 cm x 7.49 cm x 16.64 cm (1.12 in x 2.95 in x 6.55 in)

Battery: Standard 9V battery (NEDA 1604, 6F22, or 006P)

Battery life: 1200 hours. Low battery indicator appears when less than 50 hours of battery life remain

Table 3. Instrument Specifications (cont)

Input Connector: Accepts standard miniature thermocouple connectors (flat blades spaced 7.9 mm or 0.312 inch, center to center).

Protection: Class III as defined in IEC 348, Safety Requirements for Electronic Apparatus

Accessories:
80PK-1 K-Type Bead Termocouple (included)
80PK-2(A) K-Type Immersion/General Purpose Probe
80PK-3 K-Type Surface Probe
80PK-4(A) K-Type Air Probe
80PK-5 K-Type Piercing Probe
80PK-6(A) K-Type Exposed Junction Probe
C50 Soft Case
(See authorized Fluke distributors for other accessories, thermocouple probes and connectors.)

SERVICE CENTER REPAIR

If the thermometer fails, forward it, postage paid, to one of the Fluke Service Centers listed at the back of this manual. Include a description of the difficulty, and pack the instrument securely; Fluke shall assume NO responsibility for damage in transit.

IN WARRANTY: Instruments covered by the limited warranty will be promptly repaired or replaced, at Fluke's option, and returned, all at no charge. See the registration card for warranty terms.

OUT OF WARRANTY (USA AND CANADA): The instrument will be repaired and returned for a fixed fee. (Repairs needed because of abuse or accidental damage will be quoted.) Contact the nearest Service Center for current prices. Include a check, money order, or purchase order with the instrument.

OUT OF WARRANTY (OUTSIDE USA AND CANADA): Service programs may vary by country. Contact the nearest Service Center for information.

Appendix A

These specifications apply to the thermocouples included with the thermometer.

Thermocouple Specifications

Type: K (Chromel vs Alumel)

Operational Range: -40°C to 260°C (-40°F to 500°F) continuous

NOTE

Operational limitations are due primarily to the thermal limitations of the thermocouple's insulation.

Initial Tolerances (with respect to NBS tables):

±1.1°C (2°F) over the range of 0°C to 260°C (32°F to 500°F)

(Typically within 1.1°C or 2°F of NBS tables over the range of -40°C to 0°C or -40°F to 32°F)

Output: 25°C (77°F) corresponds to 1.00 mV (internal reference junction at 0°C)

Seebeck Coefficient: 40.50 μV/°C at 25°C (22.5 μV/°F at 77°F)

Measurement Time (Time Constant): 2 seconds (for air at room temperature at one atmosphere of pressure moving with a velocity of 65 ft/sec)

Maximum Safe Contact Voltage: 24V ac rms or 60V dc

Maximum Temperature of Bead: 260°C (500°F)

SERVICE CENTERS (cont)

China
Fluke International Corp
P.O. Box 9085
Beijing
Tel: 86 01 512-3436

Colombia
Sistemas E Instrumentacion, Ltda
Carrera 21 No. 39A-21, Of. 101
Ap. Aereo 29583
Bogota
Tel: 57 287-5424

Denmark
Philips Elektronik Systemer A/S
Strandlodsvej 4B
DK-2300
Copenhagen
Tel: 45 32 882531

Ecuador
Proteco Coasin Cia., Ltda
P.O. Box 228-A
Ave. 12 de Octubre
2285 y Orellana
Quito
Tel: 593 2 529684

Egypt
Philips Egypt
10, Abdel Rahman el Rafei st.
el. Mohandessin
P.O. Box 242
Dokki Cairo
Tel. 20-2-490922

England
Philips Scientific
Test & Measuring Division
Colonial Way
Watford
Hertfordshire WD2 4TT
Tel: 44 923-240511

Federal Republic of Germany
Philips GmbH Service VSF
Unternehmensbereich Electronik
fuer Wissenschaft und Industrie
Oskar-Messter-Strasse 18
D-8045 Ismaning
49 (0)89 9605 261

Finland
OY PHILIPS
AB Central Service
Sinikalliontie 1-3
P.O. Box 11
SF-02631 ESPOO
Tel. 358-0-52572

France
S.A. Philips Industrielle
et Comerciale.
Science et Industry
105 Rue de Paris BP 62
93002 Bobigny, Cedex
Tel. 33-1-4942-8040

Greece
Philips S.A. Hellenique
15, 25th March Street
177 78 Tavros
10210 Athens
Tel: 30 1 4894911

Hong Kong
Schmidt & Co (H.K.) Ltd
18/FL., Great Eagle Centre
23 Harbour Road
Wanchai
Tel: 852 5 8330222

India
Hinditron Services Pvt. Inc
33/44A Raj Mahal Villas Extn
8th Main Road
Bangalore 560 080
Tel: 91 812 363139

Hinditron Services Pvt. Ltd
1st Floor, 17-B,
Mahal Industrial Estate
Mahakali Road, Andheri East
Bombay 400 093
Tel: 91 22 6300043

Hinditron Services Pvt. Ltd.
15 Community Centre
Panchshila Park
New Delhi 110 017
Tel: 011-6433675

Field Service Center
Hinditron Services Pvt. Ltd.
Emerald Complex 1-7-264
5th Floor
114 Sarojini Devi Road
Secunderabad 500 003
Tel: 08 42-821117

Israel
R.D.T. Electronics
Engineering, Ltd
P.O. Box 43137
Tel Aviv 61430
Tel: 972 3 483211

Italy
Philips S.p.A
Sezione I&E T&M
Viale Elvezia 2
20052 Monza
Tel: 39-39-363-5315

Japan
John Fluke Mfg. Co., Inc
Japan Branch
Sumitomo Higashi
Shinbashi Bldg
1-1-11 Hamamatsucho
Minato-ku
Tokyo 105
Tel: 81 3 434-0181

Korea
Myoung Corporation
Yeo Eui Do P.O. Box 14
Seoul 150
Tel: 82 2 784-9942

Malaysia
Mecomb Malaysia Sdn. Bhd.
P.O. Box 24
46700 Petaling Jaya
Selangor
Tel: 60 3 774-3422

SERVICE CENTERS (cont)

Mexico
Mexel Servicios en Computacion
Instrumentacion y Periericos
Blvd. Adolfo Lopez Mateos No. 163
Col. Mixcoac
Mexico D.F.
Tel: 52-5-563-5411

Netherlands
Philips Nederland
Test & Meetapparaten Div
Postbus 115
5000 AC Tilburg
Tel: 31-13-352455

New Zealand
Philips Customer Support
Scientific & Industrial
2 Wagener Place
Mt. Albert
Auckland
Tel: 64 9 894-160

Norway
Norsk A/S Philips
I&E Service
Sandstuveien 70
Postboks 1 Manglerud
N 0680 OSLO 6
Tel: 47-2-680200

Pakistan
International
Operations (PAK) Ltd.
505 Muhammadi House
I.I. Chundrigar Road
P.O. Box 5323
Karachi
Tel: 92 21 221127, 239052

Peru
Importaciones &
Representaciones
Electronicas S.A.
Avad Franklin D. Roosevelt 105
Lima 1
Tel: 51 14 288650

Philippines
Spark Electronics Corp
P.O. Box 610, Greenhills
Metro Manila 1502
Tel: 63-2-700-621

Portugal
Philips Portuguese S.A.
I&E Division
Estrada de Outurela-Carnaxide
2795 Linda-A-Velha
Tel: 418 00 71

Singapore
Rank O'Connor's Singapore Pte Ltd
98 Pasir Panjang Road
Singapore 0511
Tel: 65 4737944

South Africa
South African Philips (Pty) Ltd
Service Department
195 Main Rd
Martindale, Johannesburg 2092
Tel. 27 11 470-5255

Spain
Philips Iberica Sae
Depto. Tecnico Instrumentacion
c/Martinez Villergas 2
28027 Madrid
Tel. 34 1 4042200

Sweden
Philips Kistaindustrier AB
I&E Technical Customer Support
Borgarfjordsgatan 16
S 164 93 Kista
Tel. 46-8-703-1000

Switzerland
Philips A.G.
Technischer Kundendienst
Postfach 670
Allmendstrasse 140
CH-8027 Zurich
Tel 41 1 488 29 63

Taiwan, R.O.C.
Schmidt Electronics Corp
5th Floor, Cathay Min Sheng
Commercial Building
344 Min Sheng East Road
Taipei
Tel: 886 2 501-3466

Thailand
Measuretronix Ltd
2102 31 Ramkamhaeng Rd
Bangkok 10240
Tel 66 2 375-2733, 375-2734

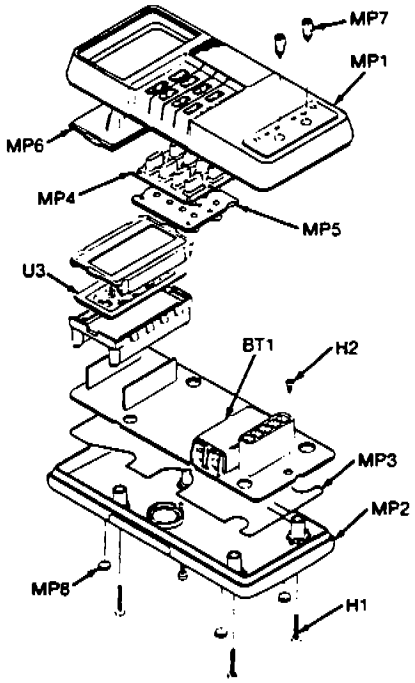
Turkey
Turk Philips Ticaret A.S.
Inonu Caddesi 78-80
Posta Kutusu 504-Beyoglu
Istanbul
Tel. 90 1 1435891

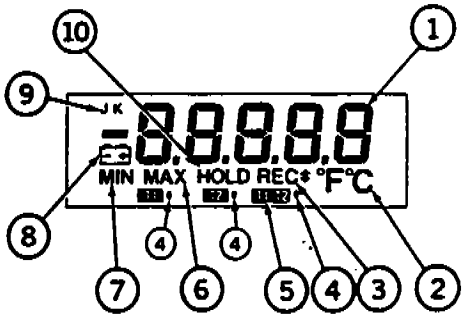
Uruguay
Coasin Uruguaya S.A.
Casilla de Correo 1400
Libertad 2525
Montevideo
Tel 598-2-789015

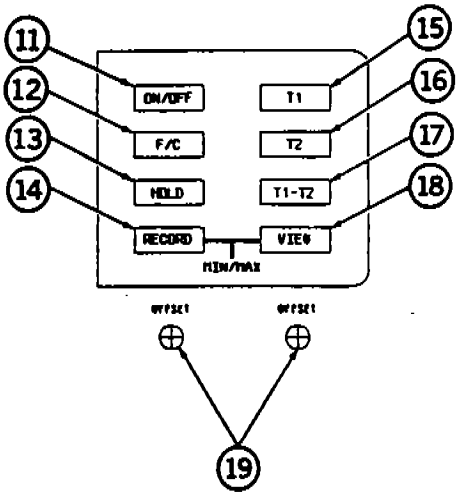
Venezuela
Coasin C.A.
Calle 9 Con Calle 4, Edif. Edinurbi
Apartado de Correos Nr-70-136
Los Ruices
Caracas 1070-A
Tel. 58 2 241-0309, 241-1248

REPLACEMENT PARTS

ITEM	DESCRIPTION	FLUKE PART NO.	QTY
BT1	BATTERY, 9V (NEDA 1604A, IEC 6LR61)	822270	1
U3	LIQUID CRYSTAL DISPLAY	741314	1
MP1	CASE, TOP	749515	1
MP2	CASE, BOTTOM	749523	1
MP3	SHIELD, BOTTOM	761924	1
MP4	SWITCH PAD, MOMENTARY	744623	1
MP5	SUPPORT, SWITCH	749044	1
MP6	LCD WINDOW	749531	1
MP7	TRIM SHAFT	749556	2
MP8	FOOT, NON-SKID	640565	4
H1	SCREW, CASE BOTTOM	733410	4
H2	SCREW, PCB MOUNTING	519116	1
	TYPE-K THERMOCOUPLE PROBE		2
	OPERATOR'S MANUAL	764712	1
	SERVICE MANUAL KIT	802413	-







See page 4

APPENDIX C

CHECKLISTS AND DATA SHEETS

Checklist for System Shakedown

Site: _____

Date: _____ Operator's Initials: _____

Equipment	Check if Okay	Comments
Liquid Ring Pump		
Aqueous Effluent Transfer Pump		
Annunciator Panel		
Equalizing Tank		
Heat Exchanger		
Dehumidifier		
Blower		
Off-Gas Treatment System		
Vapor Flow Meter		
Water Flow Meter		
Emergency Shut Off Float Switches		
Analytical Field Instrumentation - GasTechtor O_2/CO_2 Analyzer - TraceTechtor Hydrocarbon Analyzer - Oil/Water Interface Probe - Magnehelic Boards - Thermocouple Thermometer		

Initial Oil / Water Levels

Well ID	Depth to LNAPL (ft)	Depth to Groundwater (ft)	LNAPL Thickness (ft)

BATTELLE		SOIL GAS SURVEY INFORMATION			DATE: _____	
METERS (SERIAL NUMBERS): O_2 _____ CO_2 _____ TPH _____					SITE: _____	
POINT #	DEPTH (ft. & tenths) (e.g., 10.2')	READINGS			PUMP PRESS (in Hg. Vac.)	Recorded by: _____
		O_2 (%)	CO_2 (%)	TPH (ppm)		Comments

Extraction Well Vacuum

Well ID	Extraction Well Vacuum (in. H_2O) versus time (dd/mo/yr)					
	/ /	/ /	/ /	/ /	/ /	/ /

Operational Data

Date / Time	Run Time	Seal Water Temp (°C)	Dehumidifier Temperature (°C)		Pump Head Vacuum (in. Hg)	Equalizing Tank Pressure (in. H_2O)
			Inlet Airstream	Outlet Airstream		

Off-Gas Analysis Record Sheet

Date/Time	Hour Meter	Reading			Stack Temperature (°C)	Carbon Pressure (in. H_2O)		Flow Rate (scfm)	Comments
		O_2 (%)	CO_2 (%)	TPH (ppm)		Inlet	Outlet		

Groundwater Recovery Data

Date/Time	Run Time	Meter Reading (gal)	Groundwater Recovered in Time Period (gal)

Fuel Recovery Data

Date/Time	Run Time	LNAPL Thickness (prior to emptying 20,000-gallon tank)	Change in LNAPL Thickness Since Last Reading	LNAPL Thickness (after emptying 20,000-gallon tank)

Record Sheet for Oil / Water Levels

Date/Time	Well ID:			Well ID:			Well ID:		
	Depth to LNAPL (ft)	Depth to Ground-water (ft)	LNAPL Thickness (ft)	Depth to LNAPL (ft)	Depth to Ground-water (ft)	LNAPL Thickness (ft)	Depth to LNAPL (ft)	Depth to Ground-water (ft)	LNAPL Thickness (ft)

Record Sheet for In Situ Respiration Test

Site : _____ Monitoring Point : _____

Shutdown Date : _____ O_2/CO_2 Meter No. : _____ TPH Meter No. : _____

Shutdown Time : _____ Recorded by : _____

Date	Time	O_2 (%)	CO_2 (%)	TPH (ppm)	Temperature (°C)	Comments

Battelle
Columbus Laboratories

CHAIN OF CUSTODY RECORD

Form No. _____

Proj. No.	Project Title

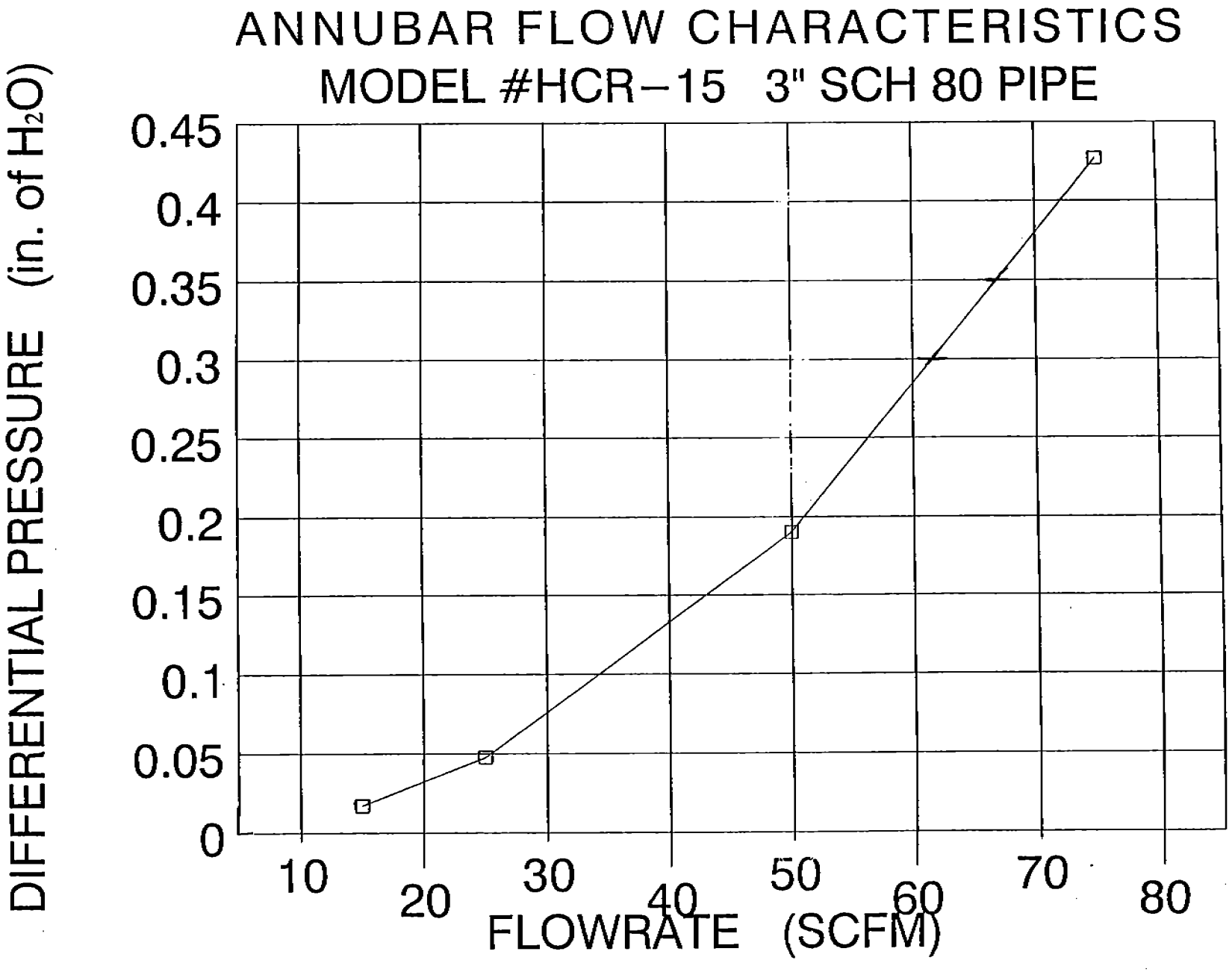
SAMPLERS: (Signature)

DATE	TIME	SAMPLE I.D.	SAMPLE TYPE (√)	Container No.	Number of Containers	Remarks

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

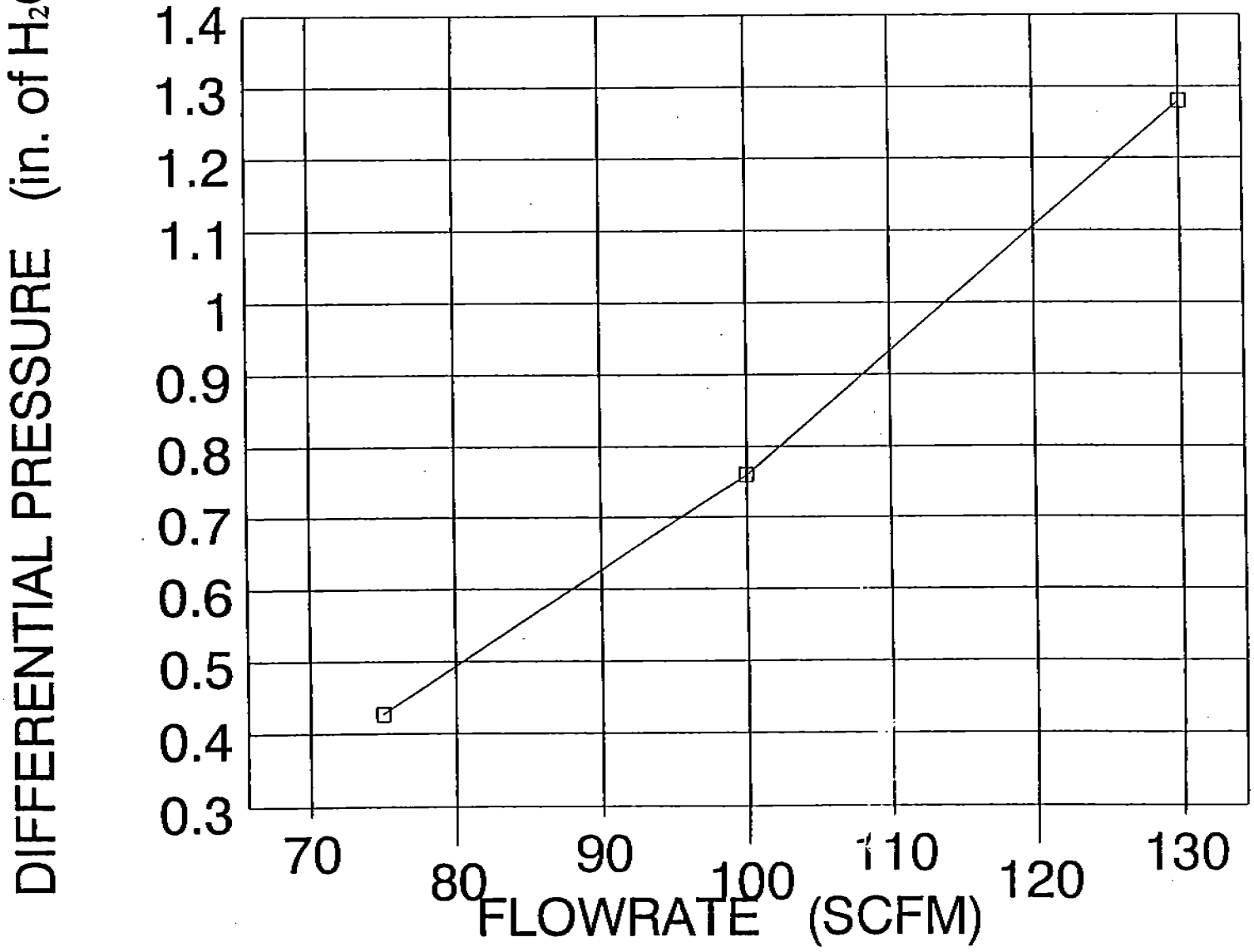
APPENDIX D

ANNUBAR FLOW CHARACTERISTICS


ANNUBAR FLOW CHARACTERISTICS
MODEL #HCR–15 3" SCH 80 PIPE
DIFFERENTIAL PRESSURE (in. of H_2O)
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
10
20
30
40
50
60
70
80
FLOWRATE (SCFM)

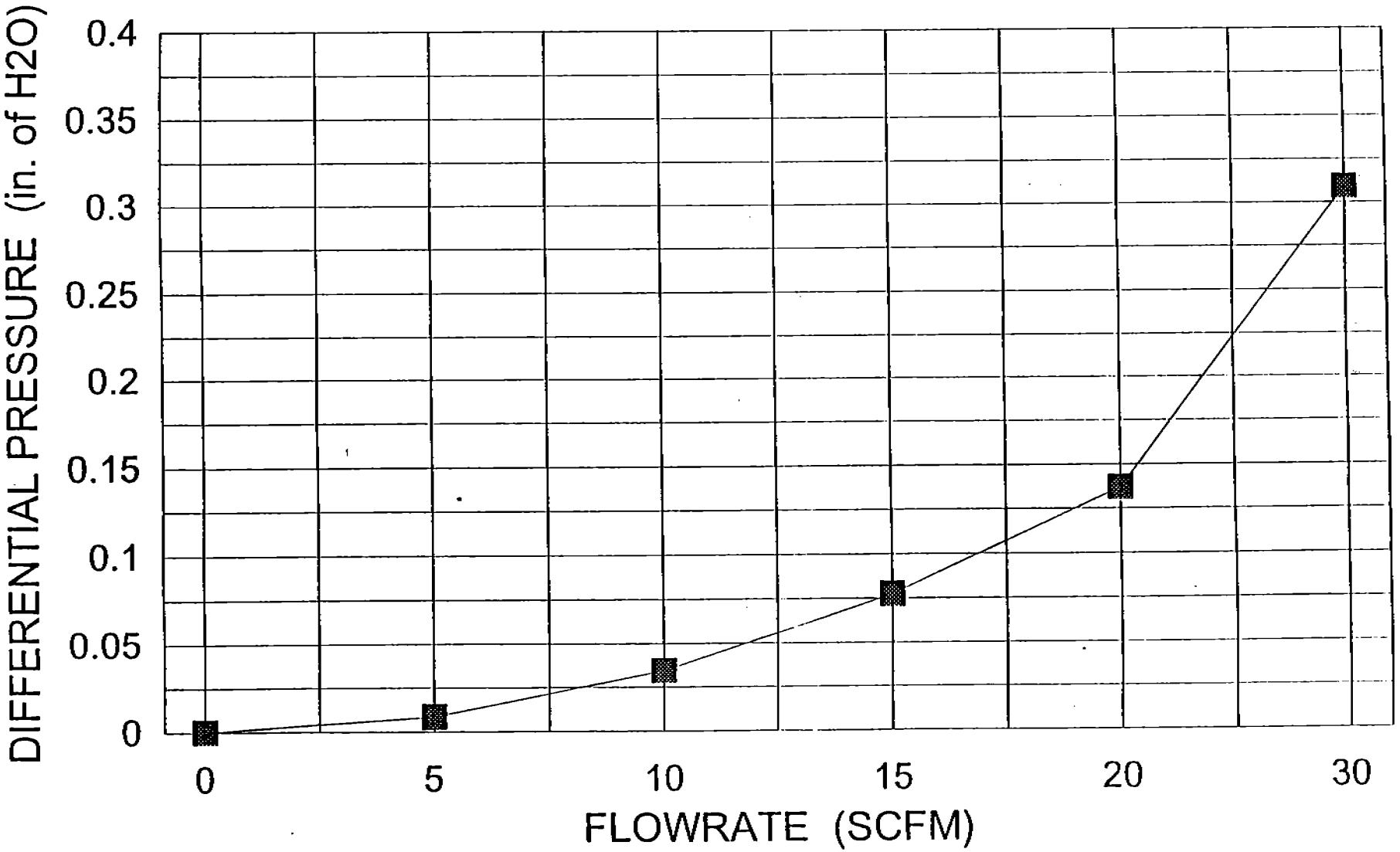
ANNUBAR FLOW CHARACTERISTICS

MODEL #HCR–15 3" SCH 80 PIPE



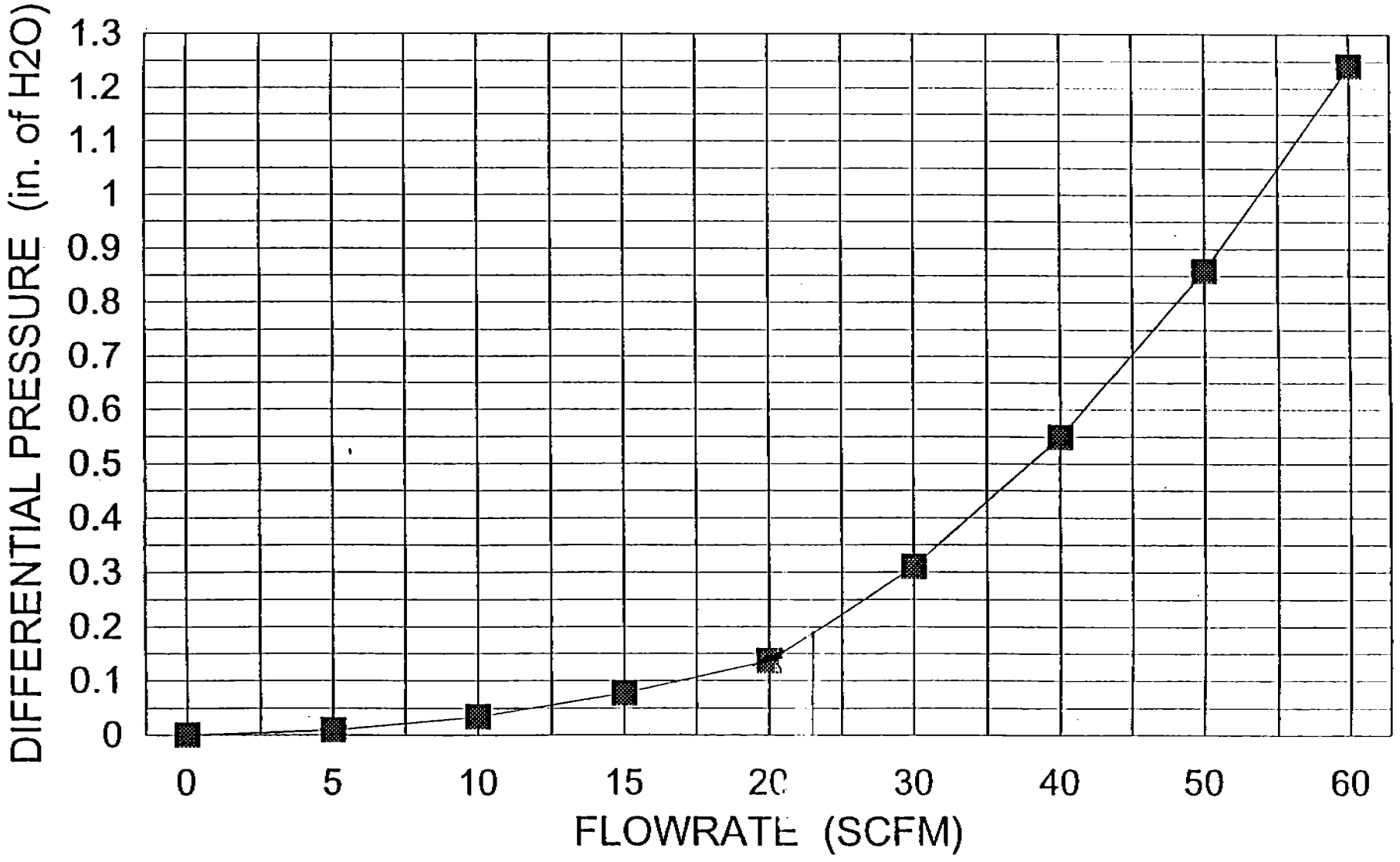
ANNUBAR FLOW CHARACTERISTICS

MODEL #HCR-15 2" SCH 40 PIPE



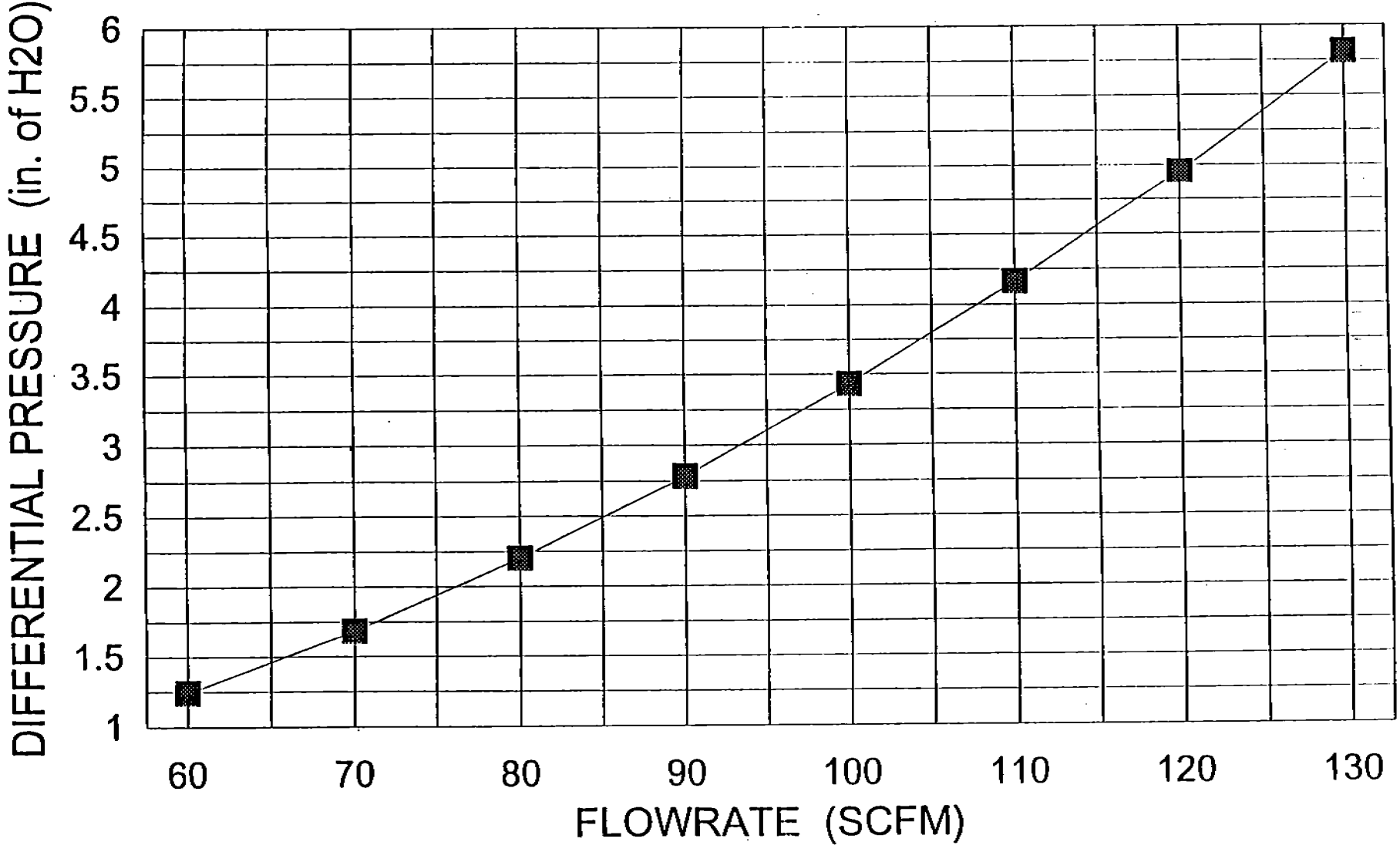
ANNUBAR FLOW CHARACTERISTICS

MODEL #HCR-15 2" SCH 40 PIPE



ANNUBAR FLOW CHARACTERISTICS

MODEL #HCR-15 2" SCH 40 PIPE



APPENDIX E

RESPIRATION TEST DATA CALCULATION AND WORKSHEET

The respiration test is performed to obtain data for calculating the total petroleum hydrocarbon (TPH) degradation rates in the vadose zone. In the respiration test, O_2 levels are measured in soil gas sampled from the monitoring points installed in the vicinity of bioslurper extraction wells. Readings generally are taken until the oxygen concentrations drop below 5%, or until the O_2 concentration no longer decreases. If O_2 decreases rapidly, more frequent readings will be necessary than if O_2 decreases slowly. To determine the oxygen utilization rate, oxygen percent is plotted against time. The slope of this line is referred to as the oxygen utilization rate and is reported as change of oxygen percent per day.

If low oxygen levels become a limiting factor for biodegradation, the slope of the line will level off and will no longer be indicative of oxygen consumption relative to TPH degradation. In this case, only the linear portion of the curve, generally limited to data points at or above 12% O_2, will be used to calculate biodegradation rates.

The stoichiometric relationship between oxygen consumption and TPH degradation using hexane as a representative compound is shown in Equation 1:

$$C_6H_{14} + 9.5O_2 \rightarrow 6CO_2 + 7H_2O \quad (1)$$

Using this equation, the biodegradation rate in terms of milligrams of hexane-equivalent per kilogram of soil per day can be estimated.

The first step in this calculation (Equation 2) is to convert the percentage of O_2 in soil gas to the actual amount in the form of mg O_2/kg of soil. Properties of both oxygen and soil consistency are used to calculate this value. One mole of air at a temperature of 293 K would occupy a volume of 24.04 L. Assuming a soil-gas oxygen concentration such as that of ambient air (20.9%), only 5.02 L of the 24.04 L/mole soil gas would be occupied by O_2.

$$24.04 \text{ L/mole of soil gas} \times 20.9\% \ O_2 = 5.02 \text{ L of } O_2\text{/mole of soil gas} \quad (2)$$

This value would vary according to the reported oxygen concentration. As shown in Equation 3, for example, an oxygen concentration of 15% would result in 3.61 L O_2/mole of soil gas instead of 5.02 L O_2/mole of soil gas.

$$24.04 \text{ L/mole of soil gas} \times 15\% \ O_2 = 3.61 \text{ L of } O_2\text{/mole of soil gas} \quad (3)$$

To determine the mass of the 5.02 L O_2/mole of soil gas, the density of O_2 must be used. Because 1 mole of O_2 would have a mass of 32 g and occupy a volume of 24.04 L, the density of O_2 would be 1,300 mg/L (Equations 4 and 5).

$$32 \text{ g} \div 24.04 \text{ L of } O_2 = 1.331 \text{ g/L of } O_2 \quad (4)$$

$$1.331 \text{ g/L of } O_2 \times 1000 \text{ mg/g} = 1{,}331 \text{ mg/L of } O_2 \quad (5)$$

This value multiplied by 5.02 L/mole soil gas would yield 6,682 mg O_2/mole soil gas (Equation 6) or 278.0 mg O_2/L soil gas (Equation 7).

$$1{,}331 \text{ mg/L of } O_2 \times 5.02 \text{ L of } O_2\text{/mole of soil gas} = 6{,}682 \text{ mg } O_2\text{/mole of soil gas} \quad (6)$$

$$6{,}682 \text{ mg } O_2\text{/mole of soil gas} \div 24.04 \text{ L/mole of soil gas} = 278.0 \text{ mg } O_2\text{/L soil gas} \quad (7)$$

Once this relationship has been established, it must be determined what quantity of oxygen would exist in the void volume of 1 kg of soil. Assuming a soil density of 1,400 kg/m^3, Equation 8 shows that 1 kg of soil would occupy a volume of 0.702 L.

$$(1 \text{ m}^3\text{/}1{,}400 \text{ kg}) \times 1{,}000 \text{ L/m}^3 = 0.714 \text{ L/kg} \quad (8)$$

Assuming a void volume of 25% in the soil, the volume of 1 kg of soil that would be occupied by soil gas is 0.21 L (Equation 9).

$$0.714 \text{ L/kg} \times 25\% \text{ void volume} = 0.18 \text{ L soil gas/kg soil} \quad (9)$$

Using the conversion factor from Equation 7 of 278.0 mg O_2/L air, it can be calculated in Equation 10 that 50.04 mg of O_2 would be present in 1 kg of soil at an O_2 concentration of 20.9%.

$$0.18 \text{ L soil gas/kg soil} \times 278.0 \text{ mg } O_2\text{/L soil gas} = 50.04 \text{ mg } O_2\text{/kg soil} \quad (10)$$

Once the change in mass of O_2 has been calculated, Equation 1 can be used to determine the mass of hydrocarbons that theoretically would be degraded. The equation yields a hydrocarbon-to-oxygen mass ratio of 1:3.5 to oxidize hexane. Therefore, if a decrease of 50 mg O_2/kg soil were seen, then it could be assumed that 14.3 mg TPH/kg of soil had been degraded. As shown in Equation 11, the TPH degradation rate can be calculated from the O_2 degradation rate (mg O_2/kg·h) divided by 3.5, which is the O_2-to-hydrocarbon mass ratio described above.

$$50 \text{ mg } O_2\text{/kg} \div 3.5 \text{ mg } O_2\text{/mg TPH} = 14.3 \text{ mg TPH/kg of soil} \quad (11)$$

Figure D-1 is a completed example of a worksheet to convert respiration sampling data (%O_2 decrease with time) to the TPH degradation rate. Figure D-2 is a blank TPH degradation worksheet that can be copied and used on site.

TPH DEGRADATION RATE WORKSHEET

1. a) O_2 concentration reading at time of blower shutdown _____ %
   b) O_2 concentration reading nearest to and greater than 12% _____ %
   c) Change in O_2 concentration (Line 1a − Line 1b) _____ %
2. a) Elapsed time from shutdown to final O_2 reading _____ hr
3. Oxygen Utilization Rate
   a) Change in O_2 concentration/elapsed time (Line 1c/Line 2a) _____ %/hr
   b) Line 3a × 24 _____ %/day

Based on the oxygen utilization rate, use the following equation to calculate degradation rate:

$$K_B = \frac{-K_O A D_O C}{100}$$

where:

K_B = degradation rate (mg/kg-day)

K_O = oxygen utilization rate (%/day)

From Line 3b _____ %/day

4. A = volume of air/kg soil (L/kg)
   a) Density of soil (if unknown assume a bulk density of 1,400 kg/m^3) _____ kg/m^3
   b) Vol soil/kg soil: (1,000 L/m^3) ÷ Line 4a = _____ L/kg
   c) Vol air/kg soil: Line 4b × 0.25* = _____ L/kg
      * (assuming 25% soil porosity)
5. D_O = density of oxygen gas (mg/L)
   a) Size temperature: °C** + 273 = _____ K
      ** (assume 20°C if unknown)
   b) Volume per mole: 0.08205 × Line 5a = _____ L/mole
   c) Mass O_2 per liter: 32,000 mg/mole ÷ Line 5b _____ mg/L
6. C = mass ratio of hydrocarbon to oxygen required for mineralization (1/3.5) _____ 0.2857

TPH Degradation Rate = (Line 3b × Line 4c × Line 5c × Line 6) ÷ 100 _____ mg/kg-day

Figure E-1. TPH Degradation Rate Worksheet.

APPENDIX F

SITE HEALTH AND SAFETY PLAN

SITE HEALTH AND SAFETY PLAN

TO

PERFORM A BIOSLURPING PILOT-SCALE TEST AND DESIGN

AT

NAVAL STATION MAYPORT, FLORIDA

CONTRACT NO. N47408-95-D-0730
DELIVERY ORDER NO. 0011

JUNE 14, 1996

Battelle
505 King Avenue
Columbus, Ohio 43201

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TO

PERFORM A BIOSLURPING PILOT-SCALE TEST AND DESIGN

AT

NAVAL STATION MAYPORT, FLORIDA

1.0 INTRODUCTION

This Health and Safety Plan (HASP) is designed to address potential health and safety risks associated with the bioslurping project field activities to be performed at Naval Station (NAVSTA), Mayport, Florida. It has been developed to conform to applicable federal and state Occupational Safety and Health Regulations as defined by OSHA 1910.120. This HASP has been designed to ensure the health and safety of the field team through an integrated program of training, standard operating procedures, and careful site planning and operations. Refer to the site-specific Test Plan for a detailed description of the planned project activities.

A copy of this HASP will be on site during field activities. All site personnel and visitors will be required to read and understand the HASP prior to admission to the project site. During all project activities, the site Health and Safety Officer, or her/his designate, will be responsible for implementation of the HASP.

2.0 PROJECT DESCRIPTION

The objective of the bioslurper pilot-scale demonstration is to evaluate the potential for recovering free-phase light, nonaqueous-phase liquid (LNAPL) present at Solid Waste Management Unit (SWMU) 7 at NAVSTA Mayport, Florida. An initial evaluation of site variables will be conducted, followed by a bioslurper LNAPL recovery test. The intent of the field testing is to predict LNAPL recovery and to obtain site-specific performance data to design and cost a full-scale bioslurper system for recovery of free product and treatment of the contaminated site.

2.1 Site Investigation

Site characterization activities will consist of collecting data on the geologic and hydrologic characteristics of the site as well as data indicating the extent of contamination. The overall objective of the investigation is to collect sufficient site-specific data to design a full-scale bioslurper system to extract LNAPL and biodegrade hydrocarbons present in the unsaturated zone in the area of SWMU 7.

The site investigation activities will consist of the following tasks:

1. Advancement of soil borings. Soil samples for hydrocarbon analysis will be collected from the borings. The soil borings will be converted to soil gas monitoring points.

2. Performance of soil gas surveys. Soil gas samples will be collected and field analyses will be conducted for total petroleum hydrocarbons, oxygen, and carbon dioxide.

3. Performance of an air permeability test. Soil gas pressures and injection flowrates will be monitored during bioslurper activities.

4. An in situ respiration test will be conducted. Soil gas samples will be collected and field analyses will be conducted for total petroleum hydrocarbons, oxygen, carbon dioxide, and helium tracer.

5. Performance of baildown tests. Baildown tests will be performed to determine the LNAPL recharge rate in site monitoring wells.

2.2 Bioslurper Pilot Test

A pilot-scale bioslurper test will be performed for 2 weeks. A trailer-mounted bioslurper system will be installed for conducting field treatability testing. A brief startup test will be conducted to ensure

that the system is installed properly and operates safely. All system components will be checked for problems and/or malfunctions. After installation is complete and the bioslurper system is confirmed to be operating properly, the pilot-test will be initiated. LNAPL and water extraction rates will be closely monitored. Air permeability testing will be performed to determine the effective treatment area for the bioslurper system and to estimate scale-up requirements. Vadose zone hydrocarbon biodegradation rates will be established through in situ respiration testing. Discharge water and off-gas samples will be collected at regular intervals to determine mass loadings and treatment requirements.

2.3 Key Personnel and Responsibilities

G.B. Wickramanayake, Ph.D., P.E., is the program manager. Mr. Jeff Kittel, the project superintendent, is responsible for providing technical oversight for the field activities. Mr. Steve Rosansky, the project engineer, is responsible for providing management oversight for the field activities. Mr. Rosansky is responsible for the full implementation of this HASP. He (or appointed designee) will serve as the Health and Safety Officer during the field operations. The site supervisor/Health and Safety Officer will have a thorough knowledge of the site Health and Safety Plan as well as experience with hazard evaluation, risk assessment, monitoring equipment, and decontamination procedures. He will be responsible for ensuring that proper health and safety requirements are followed as specified in this HASP. He will have the authority to modify the HASP on site if site conditions require this response.

3.0 TRAINING REQUIREMENTS

Personnel working at field operations must recognize and understand the potential health and safety risks associated with the work at the site. All of Battelle's site employees will have completed the OSHA 40-hour hazardous waste site training course and applicable 8-hour annual updates. Copies of training certificates for site personnel will be maintained on site. In addition, all Battelle employees will have had a minimum of 2 weeks of field experience under the supervision of a trained supervisor. Personnel also will receive hazard communication training for the chemicals which they will be working with. All personnel entering the site shall read the HASP and sign a statement that they understand what is required of them under the HASP. A field health and safety meeting will be held prior to beginning fieldwork to discuss the HASP.

All visitors to the site, even if escorted, must receive a briefing on safety if exposure to hazardous chemicals in amounts above recommended guidelines is possible. Visitors not complying with the above requirements will not be allowed to enter the restricted work areas; however, they may observe site conditions from a safe distance. Personnel must receive hazard communication training for the chemicals they are exposed to in the workplace (29 CFR 1910.1200).

4.0 ANTICIPATED WEATHER CONDITIONS AND PRECAUTIONS

Performance of project activities will occur during the summer months. All personnel will be equipped with clothing/gear that is appropriate for the weather conditions.

Weather conditions will be closely observed and weather broadcasts will be monitored. Work shall cease in the event of heavy rain or high winds. Under no circumstance will work be continued if lightning is observed in the area. Personnel will leave the site and seek shelter until the storm subsides.

5.0 JOB HAZARD ANALYSIS AND CONTROL

Preparation of this HASP was based on the proposed scope of project activities to be undertaken at NAVSTA Mayport, Florida as well as on the available analytical data regarding the chemical contamination expected at the site.

5.1 Chemical Hazards

The soil and groundwater in the area of the site are contaminated with LNAPL that most closely resembles diesel fuel and mineral spirits. Material Safety Data Sheet (MSDS) for diesel fuel and mineral spirits are located in Appendix A. Diesel fuel is generally characterized as having low toxicity because of its high viscosity. Diesel fuel is considered by the National Institute for Occupational Safety and Health (NIOSH) to present no significant acute oral hazard. Inhalation of both mineral spirits and diesel vapors causes irritation to respiratory membranes, and at high concentrations can cause central nervous depression. Dermatitis may result from prolonged skin exposure to diesel, due to defatting of the skin.

The primary potential health hazards associated with exposure to the chemical substances identified are provided in Table 1. Applicable employee 8-hour permissible exposure limits (PELs) and threshold limit values (TLVs) also are indicated in Table 1. The PELs are defined by the United States Department of Labor, Occupational Safety and Health Administration (OSHA), in the Code of Federal Regulations (CFR), Title 29, Labor, Section 1910.1000, or other appropriate sections.

The TLVs listed are recommended by the American Conference of Governmental Industrial Hygienists (ACGIH). TLVs refer to airborne concentrations of substances and represent conditions to which it is believed nearly all workers may be repeatedly exposed, 8 hours per day, day after day, for a 40-year working lifetime, without adverse effect. Because of wide variation in individual susceptibility, however, a small percentage of workers may experience discomfort when exposed to chemical substances at concentrations equal to or below the TLVs. A still smaller percentage of persons may be affected more seriously from exposures at or below TLVs due to aggravation of a preexisting condition or the development of an occupational illness. TLVs are based on the best available information from industrial experience, from human and animal studies, and when possible from a combination of the three sources.

Table 1. Primary Health Hazards and Exposure Limits for Chemical Substances Expected at SWMU-7

Compound	Federal OSHA Exposure Limit (PEL) (ppmv)	ACGIH TLV (ppmv)	Primary Health Hazard
Total Petroleum Hydrocarbons	500	300	Dizziness, drowsiness, irritated eyes
Benzene	1	10	Irritated eyes and nose, headache, nausea, fatigue, carcinogenic
Toluene	200	100	Irritated eyes and nose, nausea, affects liver and central nervous system
Xylenes	100	100	Irritated eyes and nose, nausea, affects liver and central nervous system
Mineral Spirits	100	100	Irritated eyes and nose, nausea, dizziness, affects liver and central nervous system
Diesel Fuel	NA	NA	Irritated eyes and nose, nausea, dizziness, affects liver and central nervous system

NA= Not available.

The time-weighted average TLV (TLV-TWA) represents a time-weighted average exposure for an 8-hour day, 40-hour workweek. The majority of TLVs are expressed as TLV-TWAs. Certain substances have a skin notation following the TLV which implies that the overall exposure to a substance is enhanced by skin, mucous membrane, and/or eye exposure. Some substances have a ceiling value designated by the letter "C." Ceiling values should not be exceeded at any time during the workday.

5.2 Task-Specific Hazards

Investigations will be conducted to evaluate the following: geology, hydrogeology, bioactivity, and free-product availability. The project activities to be performed include a soil gas survey, installation of monitoring points and sampling of soil, baildown tests, soil gas permeability tests, in situ respiration tests, installation and operation of the pilot bioslurper system, and discharge water and off-gas collection.

5.2.1 Soil Gas Survey

A soil gas survey will be conducted to choose an optimum site for the soil gas monitoring points. Probes will be driven manually or with a power hammer at various points to locate the most contaminated areas. Possible hazards include objects striking feet and eyes, electrical shock, and exposure to organic vapors.

5.2.2 Soil Borings

The site investigation will involve the use of a manually driven hand auger to advance soil borings and to install monitoring points. Soil samples will be taken during this part of the investigation. Soil samples will be collected with brass sleeves inserted into a manually driven hand auger. Possible hazards include exposure to organic vapors or free-phase petroleum; objects striking feet; objects striking eyes; exposure to the elements; and possible fire, explosion, and/or electrocution as a result of rupturing a utility line.

5.2.3 Baildown Test

Baildown testing involves collecting LNAPL from the sampling wells using a bottom-filling bailer. The LNAPL is removed from the well and poured into a graduated cylinder to determine its volume. Possible hazards include exposure to free-phase petroleum and to organic vapors and/or fire.

5.2.4 Soil Gas Permeability and In Situ Respiration Testing

Activities conducted for the soil gas permeability and in situ respiration testing will include soil gas sampling and analysis and minor maintenance repairs. Possible hazards include exposure to organic vapors; objects striking feet; objects striking eyes; electrical shock; and possible fire or explosion.

5.2.5 Bioslurper Installation and Operation

The pilot-scale bioslurper system was designed to operate with minimal site support. The system includes a 7.5-hp 230-V explosion-proof liquid ring pump, an oil/water separator with 10-gpm flow

capacity, and a 225-gallon surge tank and pump for directing extracted LNAPL/groundwater to the base-supplied 40,000-gallon capacity temporary storage system. A conceptual diagram of the bioslurper pilot test system is shown in Figure 1. All field personnel are responsible for reading and understanding the operating manuals for each piece of equipment. Assembly of the bioslurper system includes making the necessary electrical connections, plumbing an existing monitoring well to the bioslurper system manifold, installing a slurper drop tube and well seal in an existing monitoring well, plumbing the bioslurper pump to the oil/water separator, and plumbing the discharge line to the base-supplied 40,000-gallon temporary storage system. The installation will be performed by field personnel. Required electrical work will be performed by a qualified electrical contractor. The primary hazards of installation include objects striking the head, feet, or eyes; electrical shock; and exposure to the elements.

The operation of the bioslurper system is described in detail in the Test Plan. The system will operate for approximately 14 days. The most likely time for an incident to occur is during sample collection. Personnel potentially could be exposed to free-phase petroleum and organic vapors. Safety switches have been installed to reduce the potential for spills due to equipment failure. These are discussed in detail in Section 5.4.

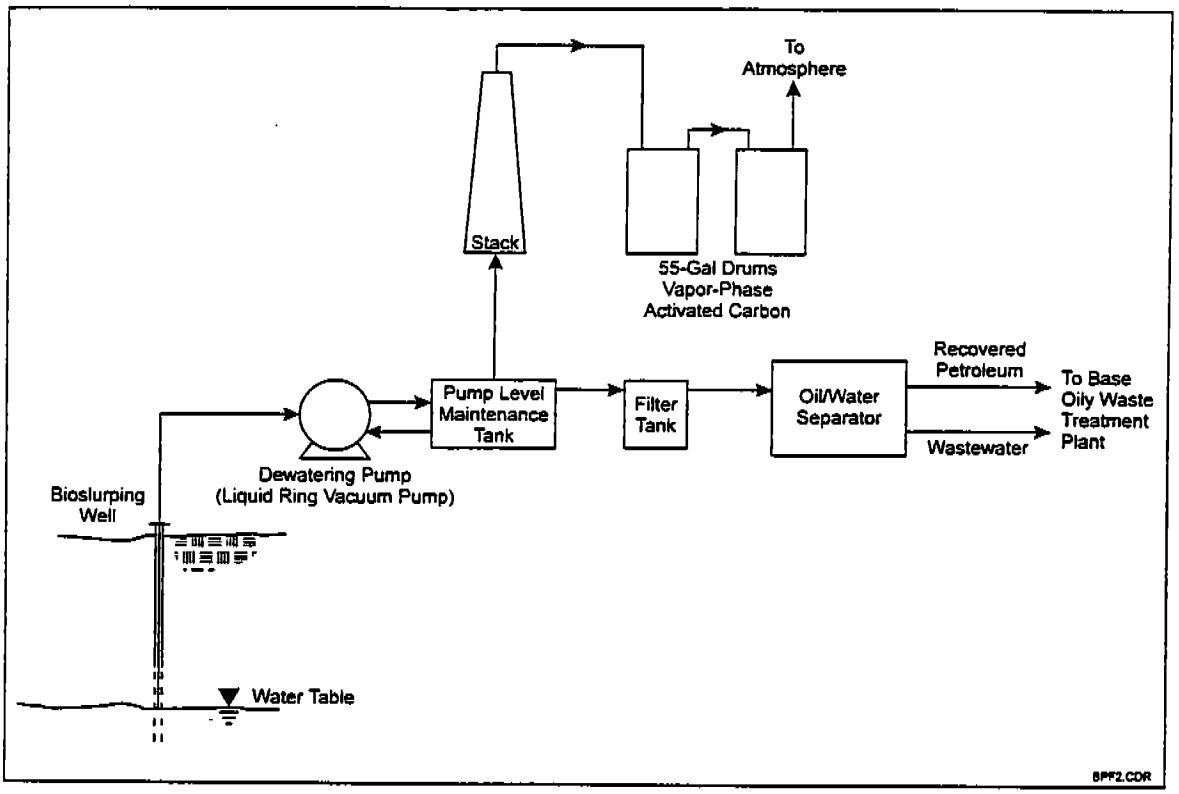

Figure 1. Diagram of the Bioslurper Pilot Test System.

5.2.6 Water and Off-Gas Sample Collection

Discharge water and offgas samples will be collected for sample analysis at various periods throughout the test program. Discharge water samples will be collected from the bioslurper oil/water separator discharge. Samples will be collected into airtight glass vials. Off-gas samples will be collected from the bioslurper stack using Summa™ canisters. Possible hazards include objects striking eyes; exposure to free-phase petroleum and organic vapors; and possible fire or explosion.

5.3 Primary Hazards and Controls

The potential hazards and required control measures for the proposed scope of the environmental project activities to be conducted at NAVSTA Mayport, Florida for the Bioslurping pilot-scale demonstration are summarized below.

- Flying particulate: Safety glasses will be worn by all site personnel.
- Objects striking head: Hard hats will be worn in the vicinity of overhead hazards (e.g., in the drilling rig area).
- Objects striking foot: Steel-toed boots will be worn.
- Slips, trips, and falls: Attempts will be made to minimize slips, trips, and falls by providing clear footing.
- Exposure to organic contaminants: Disposable gloves, coveralls, and boot covers will be worn when sampling contaminated soil and water.
- Exposure to free product: Exposure to free product will occur during sampling. Safety goggles, disposable gloves, coveralls, and boot covers will be worn during sampling.
- Exposure to organic vapors: Negative-pressure, NIOSH-approved cartridge respirators will be available to site personnel should conditions warrant.
- Severing a utility line: A severed utility line could result in fire, explosion, or electrocution. To prevent severed lines, an underground utility locating company will be subcontracted to locate and mark existing utility lines.
- Electrical shock: All major electrical work (e.g., wiring, control panel construction) will be performed by a qualified electrical contractor. Care will be taken to de-energize and ground electrical equipment prior to any necessary repair work. Before

undertaking repair work, the energy source will be either permanently disconnected or temporarily tagged and locked out to prevent the equipment from accidentally energizing. Tagging and locking out must meet OSHA 29 CFR 1910.147 Lockout/Tagout Program requirements.

- Fire: Open-flame ignition sources (e.g., smoking) will be restricted from the work area. Free-phase petroleum will be stored in appropriate containers. Signs indicating flammable liquids will be posted where appropriate. Appropriate fire extinguishers will be available to site personnel during drilling activities. A fire extinguisher will be permanently located on the site.

- Noise: The operation of pumps, drills, vehicles, aircraft, and other sources will create areas where excessive noise is present. The field personnel will identify areas with a high noise level. Earplugs/earmuffs will be worn as warranted. Areas with high noise level per OSHA 29 CFR Part 1910.95 must be signed with the appropriate warning.

5.4 Bioslurper System Controls

The bioslurping system was designed to operate maintenance-free for an extended period of time. However, there is always a possibility of equipment failure. The principal concern is a malfunction that would result in free product and/or contaminated water overflowing from any of the holding tanks. Equipment faults (kinked hose, clogged discharge port) or human error could potentially cause an overflow situation to occur. To prevent potential accidents, overflow float switches will be installed in both of the 20,000-gallon temporary storage tanks as well as inside the 225-gallon surge tank. These switches will shut down the liquid ring pump if any tank becomes full. Personnel will monitor the system on a daily basis. If personnel discover that the liquid ring pump has shut down, the reason for failure will be determined. The ring pump will then be restarted.

6.0 RISK ASSESSMENT SUMMARY

The project activities will involve minimal disturbance of contaminated soils. No risk to the communities at or near the site or to the environment is anticipated as a result of the project activities. Free-phase LNAPL collected during the pilot test will be quantified and pumped from the bioslurper process to the base-supplied 40,000-gallon capacity temporary storage system. The discharge stream will be subsequently pumped to and treated by the base Oily Water Treatment Plant. The source of exposure to the workers will be from organic vapors when drilling boreholes, installing monitoring points, emptying sample devices, and collecting samples. There is also an exposure risk of splashing LNAPL during baildown tests and during sample collection and transfer. The air permeability and in situ respiration tests are expected to vent minimal organic vapors and will be designed to discharge vapors away from the work area. The total organic vapor exposure as a result of project activities is not expected to approach the concentration limits of an 8-hour, time-weighted average as listed in Table 1 based on anticipated minimal work area exposure time.

7.0 MEDICAL PROGRAM

All Battelle field personnel undergo a pre-employment health screening and annual physical examinations. This medical surveillance program is overseen by a board-certified occupational medicine physician on staff at Battelle. Physical examinations include the following:

- Height, weight, temperature, pulse, and blood pressure
- Vision test
- Audiometric test
- Head, nose, and throat examination
- Blood and urine tests to check general liver, kidney, and multiple-system functions
- Pulmonary function test
- Electrocardiogram and chest x-ray (not annually, determined by doctor and by patient's job history).

Based on the risk assessment that exposure to organic contaminants (liquid and vapor phase) will be minimal, additional medical surveillance is not deemed necessary. Should any site personnel exhibit symptoms of overexposure to organic vapors (e.g., dizziness, nausea, irritated eyes and nose, etc.), they will be removed from the project site to fresh air. If the symptoms persist, the individual will be taken to Beaches Baptist Medical Center. The directions to Beaches Baptist Medical Center are as follows:

> From main gate at NAVSTA Mayport turn right on Mayport Rd. Follow Mayport Rd. to Atlantic Blvd. and turn left. Follow Atlantic Blvd. to Third St. and turn right. Follow Third St. to 13th Ave. South, then turn right. Beaches Baptist Medical Center is located on the left side of the street at 1350 13th Ave. South, Jacksonville Beach, Florida.

The location of the Base Medical/Dental Clinic is shown in Figure 2. The Base Clinic will be used for emergencies only. A first aid kit will be kept on site for nonemergency medical treatment such as cuts, scrapes, and other minor job-related injuries.

Copies of pertinent medical certificates will be maintained by Battelle Health Services. Medical emergency information and phone numbers are listed on the emergency information form in Appendix B. This form will be present on site in a location known to all field personnel.

9.0 GENERAL SAFETY

9.1 Housekeeping

The housekeeping procedures described in the following list relate to uncontaminated trash, debris, and rubbish. The following housekeeping rules will apply at the job site:

- Work areas must be kept clean and free from trash and debris; trash containers must be located throughout the job site.
- Excess scrap material and rubbish must be removed from the work area.
- All surplus materials must be returned to a designated area of the site at the completion of a job.
- Tools and materials must be put in toolboxs or returned to the toolroom after use to avoid creation of a hazard for others.
- Contaminated personal protective equipment, rags, and absorbent pads will be double-bagged and given to the Naval Station hazardous waste management coordinator for proper disposal.
- Personal protective equipment will be returned to the designated area at the end of the work period and will be placed in designated receptacles.
- Eating, drinking, use of tobacco products, chewing gum, etc., are permitted only in designated break areas.

9.2 Work Practices

The following work practices will be followed by all site workers or visitors:

- Whenever possible, workers will remain upwind of all activities that are expected to result in the potential release of airborne contaminants, including soil boring and sampling activities.
- No eating, drinking, or chewing of gum or tobacco, or smoking will be permitted in the work area.
- Any skin contact with contaminated or potentially contaminated surfaces, samples, or equipment shall be avoided.

- Removal of materials from protective clothing or equipment by blowing, shaking, or any other means that could disperse contaminated materials is prohibited.

- The hands and face must be thoroughly washed upon leaving the work area or engaging in any other activities.

- Whenever decontamination procedures for outer garments are in effect, the entire body should be thoroughly washed as soon as possible after the protective garment is removed.

- Because medicine can exaggerate the effects of exposure to toxic chemicals, prescribed drugs should be carefully administered.

- Personnel and equipment in the contaminated area should be limited to the numbers consistent with effective operations.

- Procedures for leaving a contaminated area must be explained before going to the site; decontamination procedures for work areas (Section 11.0) must be observed on the basis of prevailing site conditions.

9.3 Fire Prevention and Protection

9.3.1 Fire Prevention

The following rules will be enforced to prevent fires:

- Smoking will be prohibited at, or in the vicinity of, operations that may present a fire hazard; "No Smoking-Open Flame" markings will be conspicuously posted.

- Flammable and/or combustible liquids must be handled only in approved, properly labeled metal safety cans equipped with flash arresters and self-closing lids.

- Transfer of flammable liquids from one container to another will be done only when the containers are electrically interconnected (bonded).

- The motors of all equipment being fueled will be shut off during the fueling operations.

- Metal drums for storing flammable/combustible liquids will be equipped with self-closing safety faucets, vent bung fittings, and drip pans, and will be properly grounded; such containers will be stored outside buildings in an area approved by the site supervisor and the plant Fire Marshall whenever working within an operating facility. Such metal drums will be properly grounded and shall be labeled per 29 CFR 1910.1200.

- Electrical equipment installed in exclusion zones must meet requirements for Class 1, Division 1, Group B (National Electrical Manufacturers Association [NEMA] 7) per National Fire Protection Act (NFPA) 70.

9.3.2 Fire Protection

The following measures will be used to protect against fires:

- All vehicles will be equipped with a fire extinguisher of 5 ABC units or higher.
- At least one portable fire extinguisher of 20 ABC units will be located not less than 25 ft or more than 75 ft from any flammable liquid storage area.

9.4 Heat Stress

One of the most common types of stress that can affect field personnel is heat stress. Current thinking is that heat stress may be the most serious hazard to hazardous waste workers.

9.4.1 Causes and Preventative Measures

Heat stress usually results from protective clothing decreasing natural body ventilation and cooling; however, it may occur at any time work is being performed at elevated temperatures.

If the body's physiological processes fail to maintain a normal body temperature because of excessive heat, a number of physical reactions can occur ranging from mild (such as fatigue, irritability, anxiety, and decreased concentration, dexterity, or movement) to fatal. Because heat stress is one of the most common and potentially most serious illnesses that hazardous waste site workers encounter, regular monitoring and other preventative measures are vital. Site workers must learn to recognize and treat the various forms of heat stress.

The following procedures shall be followed to minimize the likelihood of heat stress:

- Suggest that workers drink 16 ounces of water before beginning work, such as in the morning or after lunch; provide disposable 4-ounce cups and water; urge workers to drink 1 to 2 gallons of water per day; provide a cool, preferably air-conditioned area for rest breaks; discourage the use of alcohol in nonworking hours, and discourage the intake of coffee during working hours; monitor for signs of heat stress; if an individual

has high blood pressure, she/he must be monitored more often and take precautions (i.e., drink more water).

- Acclimate workers to site work conditions by slowly increasing workloads, i.e., do not begin site work activities with extremely demanding activities.

- Ensure that adequate shelter is available to protect personnel against heat, as well as cold, rain, wind, etc., which can decrease physical efficiency and increase the probability of heat stress; if possible, set up the command post in the shade.

- Good hygienic standards must be maintained by frequent changes of clothing and. showering; clothing should be permitted to dry during rest periods; persons who notice skin problems should immediately consult the site supervisor.

9.4.2 Heatstroke

Heatstroke is a dangerous form of heat stress caused by a failure of the heat-regulating mechanisms of the body. The individual's temperature control system that causes sweating stops working correctly. The body temperature rises so high that brain damage and death will result if the person is not cooled quickly. Heatstroke is an acute illness which can be fatal if not promptly and properly managed.

- Symptoms: Red, hot, dry skin, although person may have been sweating earlier; nausea; dizziness; confusion; extremely high body temperature; rapid respiratory and pulse rate; unconsciousness or coma.

- Treatment: Heatstroke is a medical emergency and medical treatment should be obtained as quickly as possible. Heroic measures should be made to cool the person displaying heatstroke symptoms while transporting or waiting for transport to medical facilities. This can be accomplished by soaking with or immersion in cold water or ice.

9.4.3 Heat Exhaustion

Heat exhaustion is a response to heat characterized by fatigue, weakness, and collapse due to intake of water inadequate to compensate for loss of fluids through sweating. The symptoms of heat exhaustion and the treatment are described in the following paragraphs.

- Symptoms: Approximately normal body temperature; pale and clammy skin; profuse perspiration; tiredness, weakness; headache, perhaps cramps; nausea, dizziness, possible

vomiting; possible fainting, but the victim will probably regain consciousness as her/his head is lowered.

- Treatment: Heat exhaustion requires restoration of normal blood volume; small amounts of cool fluids should be given orally every few minutes; have the victim lie down and raise her/his feet from 8 to 12 inches; loosen the victim's clothing; apply cool, wet cloths and fan the victim or remove her/him to an air-conditioned room; if the victim vomits, do not give him any more fluids. Consult with a physician. After an attack of heat exhaustion, advise the victim not to return to work for several days and see that she/he is protected from exposure to abnormally warm temperatures.

9.4.4 Heat Cramps

Heat cramps are caused by perspiration that is not balanced by adequate fluid intake. Heat cramps often can be the first sign of a condition that can lead to heatstroke or heat exhaustion.

- Symptoms: Acute painful spasms of voluntary muscles, e.g., abdomen and extremities.
- Treatment: Remove victim to a cool area and loosen clothing. Have patient drink 1 to 2 cups of water immediately, and every 20 minutes thereafter, until symptoms subside. Total water consumption should be 1 to 2 gallons per day. Consult with physician.

9.4.5 Heat Rash

Heat rash is caused by continuous exposure to heat and humid air, and is aggravated by chafing clothes. The condition decreases the ability to tolerate heat.

- Symptoms: Mild red rash, especially in areas of the body in contact with protective gear.
- Treatment: Decrease amount of time in personal protective equipment and provide powder to help absorb moisture and decrease chafing.

9.4.6 Heat Stress Monitoring and Work Cycle Management

For strenuous field activities that are part of ongoing work site activities in hot weather, the following procedures may be used to monitor the body's physiological response to heat and to manage the work cycle. These procedures may be instituted when the temperature exceeds 70°F.

The heart rate (HR) should be measured by the radial pulse for 30 seconds as early as possible in the resting period. The HR at the beginning of the rest period should not exceed 110 beats/minute for most individuals. The maximum rate is based on an individual's base rate. Base rates vary across the population. If the HR is higher, the next work period should be shortened by 33%, while the length of the rest period stays the same. If the pulse rate still exceeds 110 beats/minute at the beginning of the next rest period, the following work cycle should be further shortened by 33%. The procedure is continued until the rate is maintained below 110 beats/minute.

9.5 Cold Weather Operations

It is not expected that cold weather conditions will be experienced at this site.

9.6 Biological Vectors

Black widow spiders, rattlesnakes, and scorpions are prevalent in northern Florida. Caution will be exercised when dealing with biological vectors. Areas with piping, well casings, pump housings, and tool chests will be routinely checked for biological vectors prior to the initiation of work in the area.

10.0 SITE CONTROL

The proposed project site is in an active area of NAVSTA Mayport, Florida. A map of the site is shown in Figure 3.

The Base security personnel control access to the site, limiting access to the project facilities to persons cleared for access to the area. Personnel identified as Base Safety Specialists shall have access to the site without advance notice provided they meet the requirements set forth in this HASP. An exclusion zone will be created to restrict unauthorized personnel from the immediate vicinity of the bioslurper system. This exclusion zone will be demarcated with caution tape.

11.0 DECONTAMINATION PROCEDURES

All disposable materials, including disposable coveralls, gloves, paper towels, etc., will be placed in appropriately marked containers (e.g., plastic bags) and disposed of in accordance with Base regulations. Sampling equipment will be decontaminated with a laboratory-grade detergent solution followed by a distilled water rinse.

12.0 WASTE DISPOSAL

Liquid and solid waste will be generated as a result of project activities. The only regulated substances expected to be encountered during project activities will be petroleum constituents of the contaminants at the site. Free product and contaminated water will be pumped to the 40,000-gallon-capacity temporary storage tank facility and subsequently pumped to the base Oily Water Treatment Plant. Soil cuttings will be placed within the sludge drying beds on the site. Contaminated personal protective equipment, rags, and absorbent pads will be double-bagged and given to the NAVSTA Mayport hazardous waste management coordinator for proper disposal.

13.0 EMERGENCY PROCEDURES

There are three primary scenarios for emergencies occurring during project activities:

- Personal injury requiring medical treatment
- An uncontrolled release of a dangerous substance (e.g., petroleum spill)
- A fire or explosion.

In the event of an emergency, the Base Environmental Director will be notified immediately. Emergency information (phone numbers, emergency care facilities, etc.) Is listed on the emergency Information Form in Appendix B. Base safety personnel are authorized to stop operations during situations of imminent danger to the life and health of any personnel, or damage to Navy property.

13.1 Personal Injury

Minor injuries (minor heat exhaustion, cuts, scrapes, etc.) will be treated on site. The site will be equipped with a first aid kit. In addition, a person who has had both cardiopulmonary resuscitation (CPR) and first aid training will be present on site. If the injury is thought to require additional medical attention, the injured individual will be transported to the Beaches Baptist Medical Center. In severe situations, the individual will be transported to the nearest available medical center by either a coworker or an ambulance. All personnel will be responsible for knowing the locations of the medical center.

All injuries will be recorded in a logbook. In the case of severe injuries, the project manager will be notified immediately.

13.2 Spills

Spills will be contained using absorbent pads and/or pillows. A supply of pads/pillows will be stored on site. In the event of a spill, pillows will be placed around the spill to contain it. The spill will be absorbed by placing pads on top of it. The materials used to contain the spill will be treated as hazardous waste and will be disposed of by Naval Station personnel. All spills will be documented and reported to the Base POC and to the Project Manager. Phone numbers for reporting spills are listed in Appendix B.

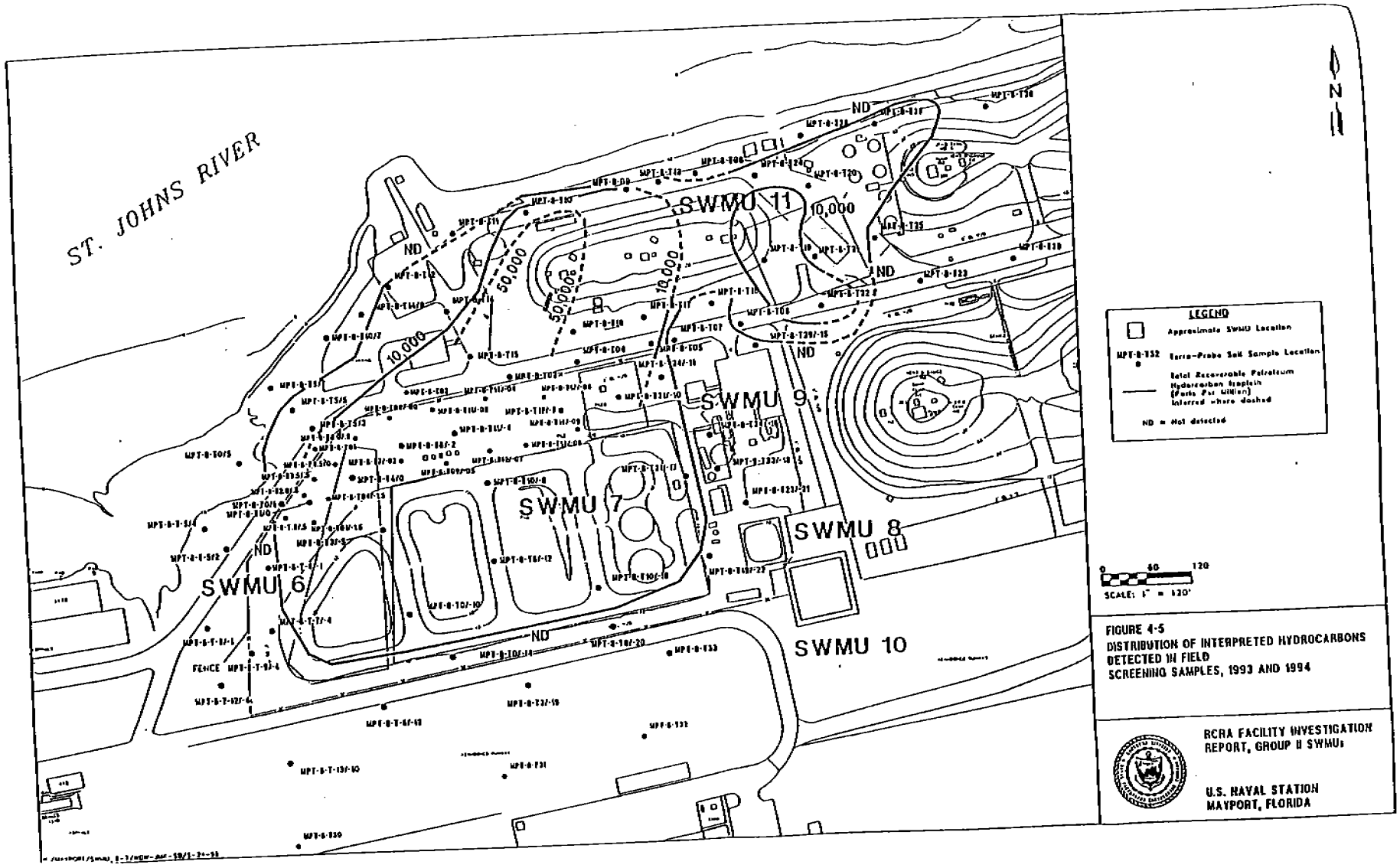

Figure 3. NAVSTA Mayport, Florida Site Map

13.3 Fire or Explosion

Minor fires will be extinguished by site personnel using fire extinguishers located on site. The reason for fire will be determined before continuing site activities. In the event of a large fire or explosion, the Naval Station Fire Department will be notified immediately. Base Safety personnel and the Project Manager will be notified in the event of a fire.

14.0 REFERENCES

Battelle, 1996. *Test Plan for Bioslurping Pilot-Scale Test and Design at Naval Station Mayport, Florida.* Prepared by Battelle Columbus Operations.

APPENDIX A

MATERIAL SAFETY DATA SHEETS FOR DIESEL FUEL AND MINERAL SPIRITS

MATERIAL SAFETY DATA SHEET

GULF OIL

DOCUMENT NUMBER Gulf 6,794

RECEIVED DEC 1 3 [illegible]

GULF OIL DIVISION
Cumberland Farms, Inc.
165 Flanders Road
Westboro, Massachusetts 01581

EMERGENCY: 800-424-930
Chemtre

COMPANY: 617-366-444

IMPORTANT: Read this MSDS before handling and disposing of this product and pass this information on to employees, customers, and users of this product. This product is considered a hazardous substance under the OSHA Hazard Communication Rule. (29CFR 1910.1200)

I. General

Trade Name: **#2 FUEL OIL/#2 DIESEL**

Other Names: Home Heating Oil; #2 Home Heating Oil; Heating Oil (Medium); Number Two; Diesel Fuel; Truck Diesel; Industria Diesel; #2 Utility

Chemical Family: PETROLEUM HYDROCARBONS

DOT Hazardous Materials Proper Shipping Name: FUEL OIL, #2 or FUEL OIL, diesel

Generic Name: PETROLEUM DISTILLATE FUEL

DOT Hazard Class: COMBUSTIBLE LIQUID

CAS No.: 68476-30-2

UN/NA ID No.: NA 1993

II. Summary of Hazards

WARNING

MAY CAUSE IRRITATION OR MORE SERIOUS SKIN DISORDERS!
AVOID PROLONGED OR REPEATED LIQUID, MIST AND VAPOR CONTACT WITH EYES, SKIN, AND RESPIRATORY TRACT. LONG-TERM TESTS SHOW THAT SIMILAR PETROLEU DISTILLATES HAVE PRODUCED SKIN TUMORS ON LABORATORY ANIMALS. WASH THOROUGHLY AFTER HANDLING.

MAY BE HARMFUL IF INHALED! (SEE SECTIONS IV. & V.)

CONTAINS PETROLEUM DISTILLATES!
IF SWALLOWED, DO NOT INDUCE VOMITING SINCE ASPIRATION INTO THE LUNGS WIL
CAUSE CHEMICAL PNEUMONIA. OBTAIN PROMPT MEDICAL ATTENTION.

MODERATELY COMBUSTIBLE! OSHA/NFPA CLASS-II OR IIIA COMBUSTIBLE LIQUID.

KEEP AWAY FROM HEAT, SPARKS, AND OPEN FLAME. AVOID THE "SWITCH LOADIN
HAZARD. (SEE SECTION XI.)

KEEP OUT OF REACH OF CHILDREN!

III. Fire and Explosion

Flash Point (Method): 123° to 150°F (D-93, Pensky-Martens Closed Cu
SEE "FIRE & EXPLOSION HAZARDS"

Auto-ignition Temperature (Method): > 495°F (E-659) BASED ON NFPA "FUEL OIL NO 1

Flammable Limits (% Vol. in Air) At Normal Atmospheric Temperature and Pressure: LOWER = ≈0.6 UPPER = ≈7.5 BASED ON NFPA "FUEL OIL NO.

Fire and Explosion Hazards: MODERATELY COMBUSTIBLE! WHEN HEATED ABOVE THE FLASH POINT, THIS MATERIAL WILL RELEASE FLAMMABLE VAPORS WHICH IF EXPOSED TO AN IGNITION SOURCE CAN BURN IN THE OPEN OR BE EXPLOSIVE IN CONFINED SPACES. MISTS OR SPRAYS MAY BE FLAMMABLE AT TEMPERATURES BELOW THE NORMAL FLASH POINT. FOR "SWITCH LOADING" PROCEDURES, SEE SECTION XI

Extinguishing Media: FOAM, DRY CHEMICAL, HALON, CARBON DIOXIDE AND WATER FOG.

Special Firefighting Procedures: FOR FIRES INVOLVING THIS MATERIAL, DO NOT ENTER ANY ENCLOSED OR CONFINED FIRE SPACE WITHOUT PROPER PROTECTIVE EQUIPMENT. THIS MAY INCLUDE SELF-CONTAINED BREATHING APPARATUS TO PROTECT AGAINST THE HAZARDOUS EFFECTS OF COMBUSTION PRODUCTS AND OXYGEN DEFICIENCIES. COOL TANKS AND CONTAINERS EXPOSED TO FIRE WITH WATER.

IV. Health Hazards

Summary of Acute Hazards: LIQUID, MIST, OR VAPOR CONTACT CAN IRRITATE EYES, SKIN, AND THE RESPIRATORY AND DIGESTIVE TRACTS. ASPIRATION INTO THE LUNGS WILL CAUSE CHEMICAL PNEUMONIA.

ROUTE OF EXPOSURE	SIGNS AND SYMPTOMS
Inhalation:	VAPORS AND MISTS FROM THIS MATERIAL CAN IRRITATE THE NOSE THROAT, AND LUNGS, AND CAN CAUSE SIGNS AND SYMPTOMS OFCENTRAL NERVOUS SYSTEM DEPRESSION, DEPENDING ON THE CONCENTRATION AND DURATION OF EXPOSURE.

Eye Contact: MILD EYE IRRITATION MAY RESULT FROM CONTACT WITH LIQUID, MIST, AND/OR VAPORS.

Skin Absorption: NO SIGNIFICANT SYSTEMIC EFFECTS ARE EXPECTED UNDER CONDITIONS OF ANTICIPATED USE.

Skin Irritation: THIS MATERIAL IS LIKELY TO BE A MODERATE SKIN IRRITANT. IRRITATION LEADING TO DERMATITIS MAY RESULT FROM PROLONGED OR REPEATED EXPOSURES. (SEE CHRONIC HAZARDS BELOW.)

Ingestion: THIS MATERIAL CAN IRRITATE THE MOUTH, THROAT AND STOMACH, AND CAUSE NAUSEA, VOMITING, DIARRHEA AND RESTLESSNESS. ASPIRATION INTO THE LUNGS WILL CAUSE CHEMICAL PNEUMONIA.

Summary of Chronic Hazards and Special Health Effects: THIS PRODUCT CONTAINS PETROLEUM DISTILLATES SIMILAR TO THOSE SHOWN TO PRODUCE SKIN TUMORS ON LABORATORY ANIMALS. AVOID PROLONGED OR REPEATED SKIN CONTACT. CAUTION IS RECOMMENDED FOR PRE-EXISTING CENTRAL NERVOUS SYSTEM DISEASE, SKIN DISORDERS, OR CHRONIC RESPIRATORY DISEASES SHOULD AVOID EXPOSURE TO THIS PRODUCT.

Primary Route(s): SKIN CONTACT AND INHALATION

V. Protective Equipment and Other Control Measures

Respiratory: THIS MATERIAL IS NOT EXPECTED TO PRESENT RESPIRATORY HAZARD BECAUSE OF ITS LOW VAPOR PRESSURE. BUT, IF EXCESSIVE MIST OR VAPORS RESULT FROM CONDITIONS OF USE, WEAR PROPER NIOSH/MSHA-APPROVED RESPIRATORY EQUIPMENT.

Eye: EYE PROTECTION SHOULD BE WORN WHENEVER THERE IS A LIKELIHOOD OF SPLASHING OR SPRAYING LIQUID. CONTACT LENSE SHOULD NOT BE WORN. SUITABLE EYE WASH WATER SHOULD BE AVAILABLE.

Skin: AVOID PROLONGED AND/OR REPEATED SKIN CONTACT. IF CONDITIONS OR FREQUENCY OF USE MAKE CONTACT SIGNIFICANT, CLEAN AND IMPERVIOUS PROTECTIVE CLOTHING SUCH AS GLOVES, APRON, BOOTS, AND FACIAL PROTECTION SHOULD BE WORN.

Engineering Controls: USE ADEQUATE VENTILATION TO KEEP VAPOR CONCENTRATIONS OF THIS MATERIAL BELOW APPLICABLE EXPOSURE LIMITS. (SEE SECTIONS VI. AND XI.)

Other Hygienic and Work Practices: USE GOOD PERSONAL HYGIENE PRACTICES. WASH HANDS BEFORE EATING, DRINKING, SMOKING, OR USE OF TOILET FACILITIES. IMMEDIATELY REMOVE SOILED CLOTHING AND WASH THOROUGHLY BEFORE REUSE. DISCARD CONTAMINATED LEATHER GOODS. RESPIRATOR USE SHOULD COMPLY WITH OSHA STANDARDS OR EQUIVALENT. SEE SECTION XI FOR ADDITIONAL INFORMATION.

VI. Occupational Exposure Limits

Substance	Source	Date	Type	Value/Units	Time
KEROSENE (DHEW PUBLICATION 77-192)	NIOSH	1977	PEL	100 MG/M3	10 HRS.
			STEL	1800 MG/M3	15 MIN.
STODDARD SOLVENT (SEE SECTION XI.)	ACGIH	1985	TWA	100 PPM	8 HRS.
			STEL	200 PPM	15 MIN.

VII. Emergency First Aid

Inhalation: IMMEDIATELY MOVE PERSONNEL TO AREA OF FRESH AIR. FOR RESPIRATORY DISTRESS, GIVE AIR, OXYGEN, OR ADMINISTER CPR (CARDIOPULMONARY RESUSCITATION), IF NECESSARY. OBTAIN MEDICAL ATTENTION IF BREATHING DIFFICULTIES CONTINUE.

Eye Contact: FLUSH WITH CLEAN-LOW PRESSURE WATER FOR AT LEAST 15 MINUTES. IF IRRITATION PERSISTS, OBTAIN MEDICAL ATTENTION.

Skin Contact: PROMPTLY REMOVE CONTAMINATED CLOTHING AND THOROUGHLY CLEAN BEFORE REUSE, BUT DISCARD CONTAMINATED LEATHER GOODS. THOROUGHLY WASH AFFECTED AREA WITH SOAP AND WATER.

Ingestion: DO NOT INDUCE VOMITING, SINCE ASPIRATION INTO THE LUNGS WILL CAUSE CHEMICAL PNEUMONIA. IF ASPIRATION OCCURS, PROMPTLY OBTAIN MEDICAL ATTENTION.

PERSONNEL WITH PRE-EXISTING SKIN DISORDERS, OR CHRONIC RESPIRATORY DISEASES SHOULD AVOID EXPOSURE TO THIS MATERIAL.

VIII. Spill and Disposal

Precautions if Material is Spilled or Released: CONTAIN SPILL. REMOVE ALL IGNITION SOURCES AND SAFELY STOP FLOW OF SPILL. SPILL MAY CREATE SLIPPING HAZARDS. PREVENT FROM ENTERING ALL WATER BODIES, IF POSSIBLE. EVACUATE ALL NON-ESSENTIAL PERSONNEL. IN URBAN AREAS, CLEANUP AS SOON AS POSSIBLE; IN NATURAL ENVIRONMENTS, CLEANUP ON ADVICE FROM ECOLOGISTS. THIS MATERIAL WILL FLOAT ON WATER. ABSORBENT MATERIAL AND PADS CAN BE USED. COMPLY WITH ALL APPLICABLE LAWS. SPILLS MAY NEED TO BE REPORTED TO THE NATIONAL RESPONSE CENTER (800/424-8802). THE SPILLED MATERIAL AND ANY WATER OR SOIL WHICH IT HAS CONTACTED MAY BE HAZARDOUS TO ANIMAL/AQUATIC LIFE.

Waste Disposal Method: MAXIMIZE PRODUCT RECOVERY FOR REUSE OR RECYCLING. UNUSED LIQUID PRODUCT IS LIKELY AN EPA "IGNITABLE HAZARDOUS WASTE" (D001). USE APPROVED TREATMENT, TRANSPORTERS, AND DISPOSAL SITES IN COMPLIANCE WITH ALL APPLICABLE LAWS. IF SPILL IS INTRODUCED INTO A WASTEWATER SYSTEM, THE CHEMICAL AND BIOLOGICAL OXYGEN DEMAND WILL LIKELY INCREASE. SPILL MATERIAL IS BIODEGRADABLE IF GRADUALLY EXPOSED TO MICROORGANISMS. POTENTIAL DISPOSAL METHODS INCLUDE INCINERATION AND LAND DISPOSAL, IF PERMITTED.

IX. Components

(This may not be a complete list of components)

Component Name	CAS No.	Carcinogen*	Composition amount (Vol.) (See Qualification on Page 4)
HYDROCARBONS WITH A BOILING POINT RANGE OF 325°F, TO 700°F.	--	N/A	≈100 PERCENT

Compositions given are typical values, not specifications.

* Listed By: 1=NTP; 2=IARC; 3=OSHA; 4-OTHER

X. Physical & Chemical Data

Boiling Point: 348° TO 680°F

Viscosity Units, Temp. (Method): ≈ 1 - 4 cSt. AT 100°F (D-445)

Dry Point: No Data Available

Freezing Point: ≈ -40°F

Vapor Pressure: (REID-PSIA at 100°F) < 0.1

Volatile Characteristics: SLIGHT

Specific Gravity (H_2O = 1 at 39.2°F): ≈ 0.85

Vapor Sp. Gr. (Air = 1.0 at 60° - 90°F): ≈ 7

Solubility in Water: NEGLIGIBLE

pH: Not Applicable

Hazardous Polymerization: NOT EXPECTED TO OCCUR

Other Chemical Reactivity: N/P

Stability: STABLE

Other Physical and Chemical Properties: SULFUR CONTENT = < 0.5 Wt %

Appearance and Odor: LIGHT YELLOW TO AMBER-COLORED LIQUID. KEROSENE ODOR.

Conditions to Avoid: HEAT AND IGNITION SOURCES.

Materials to Avoid: STRONG ACIDS, ALKALIES, AND OXIDIZERS SUCH AS LIQUID CHLORINE AND OXYGEN.

Hazardous Decomposition Products: BURNING OR EXCESSIVE HEATING MAY PRODUCE CARBON MONOXIDE AND OTHER HARMFUL GASES/VAPORS INCLUDING OXIDES AND/OR OTHER COMPOUNDS OF SULFUR.

XI. Additional Precautions

Handling, Storage and Decontamination Procedures: SPECIAL SLOW LOAD PROCEDURES FOR "SWITCH LOADING" MUST BE FOLLOWED TO AVOID THE STATIC IGNITION HAZARD THAT CAN EXIST WHEN THIS MATERIAL IS LOADED INTO TANKS PREVIOUSLY CONTAINING GASOLINE OR OTHER LOW FLASH POINT PRODUCTS. (SEE API. PUBLICATION 2003.) KEEP CONTAINERS CLOSED AND AWAY FROM HEAT AND IGNITION SOURCES! ALL ELECTRICAL EQUIPMENT IN AREAS WHERE PRODUCT IS STORED/HANDLED SHOULD BE INSTALLED IN ACCORDANCE WITH APPLICABLE REQUIREMENTS OF THE NATIONAL ELECTRICAL CODE, NFPA. DO NOT USE THIS PRODUCT AS A CLEANING AGENT. EMPTY CONTAINERS RETAIN SOME LIQUID AND VAPOR RESIDUES, AND HAZARD PRECAUTIONS MUST BE OBSERVED WHEN HANDLING EMPTY CONTAINERS.

WARNING: USE OF ANY HYDROCARBON FUEL IN SPACES WITHOUT ADEQUATE VENTILATION MAY RESULT IN GENERATION OF HAZARDOUS LEVELS OF COMBUSTION PRODUCTS AND INADEQUATE OXYGEN LEVELS FOR BREATHING.

General Comments: WARNING: USE OF THIS HEATING OIL AS FUEL IN NON-FLUE CONNECTED HEATING APPLIANCES CAN RESULT IN PERSONAL INJURY. PURCHASERS AND USERS SHOULD BE INFORMED OF THIS POTENTIAL HAZARD. SOME OSHA

PERMISSIBLE EXPOSURE LIMITS ARE NOT SHOWN IN SECTION VI, BECAUSE THEY ARE LESS RESTRICTIVE THAN THE ACGIH EXPOSURE LIMITS ALREADY LISTED. SINCE SPECIFIC EXPOSURE STANDARDS/CONTROL LIMITS HAVE NOT BEEN ESTABLISHED FOR THIS MATERIAL, THE EXPOSURE LIMITS SHOWN IN SECTION IV, ARE SUGGESTED AS MINIMUM CONTROL GUIDELINES.

MATERIALS SIMILAR TO SOME COMPONENTS IN THIS PRODUCT WERE FOUND TO BE MUTAGENIC IN "IN VITRO" AND "IN VIVO" TESTS. THE EXACT RELATIONSHIP BETWEEN THESE RESULTS AND POSSIBLE HUMAN EFFECTS IS NOT KNOWN.

"PETROLEUM DISTILLATE" -- 16 CFR 1500.14 (B) (3). USE SPECIAL FEDERAL LABELING IF INTENDED, OR PACKAGED, FOR USE IN THE HOUSEHOLD OR BY CHILDREN.

SOME OF THE INFORMATION PRESENTED AND CONCLUSIONS DRAWN HEREIN ARE FROM SOURCES OTHER THAN DIRECT TEST DATA ON THE MIXTURE ITSELF.

Disclaimer of Liability

The information on this MSDS was obtained from sources which we believe are reliable. HOWEVER, THE INFORMATION IS PROVIDED WITHOUT ANY WARRANTY, EXPRESS OR IMPLIED, REGARDING ITS CORRECTNESS.

The conditions or methods of handling, storage, use and disposal of the product are beyond our control and may be beyond our knowledge. FOR THIS AND OTHER REASONS, WE DO NOT ASSUME RESPONSIBILITY AND EXPRESSLY DISCLAIM LIABILITY FOR LOSS, DAMAGE OR EXPENSE ARISING OUT OF OR IN ANY WAY CONNECTED WITH THE HANDLING, STORAGE, USE OR DISPOSAL OF THE PRODUCT.

This MSDS was prepared and is to be used only for this product. If the product is used as a component in another product, this MSDS information may not be applicable.

MATERIAL SAFETY DATA SHEET

ASHLAND CHEMICAL, INC.
Subsidiar. Of Ashland Oil, Inc
P.O. BOX 2219
COLUMBUS, OHIO 43216
(614) 889-3333

24-HOUR Emergency Telephone
1(800) 274-5263
1(800) ASHLAND

RECEIVED JUN 2 0 1990

DOCUMENT NUMBER 513

000792

MINERAL SPIRITS ODORLESS

THIS MSDS COMPLIES WITH 29 CFR 1910.1200 (THE HAZARD COMMUNICATION STANDARD)

****

Product Name: MINERAL SPIRITS ODORLESS
CAS NUMBER: 64742-88-7

Data Sheet No: 0000594-004
Prepared: 05/31/89
Supersedes: 03/04/86

05 50 006 0859370-

BATTELLE MEMORIAL INSTITUTE
505 KING AVE
COLUMBUS OH 43201

PRODUCT: 2560000
INVOICE: 105755
INVOICE DATE: 05/22/90
TO: SAME

ATTN: PLANT MGR./SAFETY DIR.

SECTION I - PRODUCT IDENTIFICATION

General or Generic ID: ALIPHATIC HYDROCARBON

DOT Hazard Classification: COMBUSTIBLE (173.115)

SECTION II - COMPONENTS

IF PRESENT, IARC, NTP AND OSHA CARCINOGENS AND CHEMICALS SUBJECT TO THE REPORTING REQUIREMENTS OF SARA TITLE III SECTION 313 ARE IDENTIFIED IN THIS SECTION. SEE DEFINITION PAGE FOR CLARIFICATION

INGREDIENT	% (by WT)	PEL	TLV	Note
ALIPHATIC PETROLEUM DISTILLATES CAS #: 64742-88-7	100	100 PPM	100 PPM	(1)

Notes:

(1) NIOSH RECOMMENDS A LIMIT OF 350 MG/CUM - 8 HOUR TIME WEIGHTED AVERAGE, 1800 MG/CUM AS DETERMINED BY A 15 MINUTE SAMPLE.

SECTION III - PHYSICAL DATA

Boiling Point	for PRODUCT	340.00 - 400.00 Deg F (171.11 - 204.44 Deg C) @ 760.00 mm Hg
Vapor Pressure	for PRODUCT	2.00 mm Hg @ 68.00 Deg F (20.00 Deg C)
Specific Vapor Density	AIR = 1	4.9
Specific Gravity		.759 @ 60.00 Deg F (15.55 Deg C)
Percent Volatiles		100.00%
Evaporation Rate	(ETHER = 1)	70.00

SECTION IV - FIRE AND EXPLOSION INFORMATION

FLASH POINT 120.0 Deg F (48.9 Deg C)

EXPLOSIVE LIMIT (PRODUCT) LOWER - .7%

EXTINGUISHING MEDIA: REGULAR FOAM OR CARBON DIOXIDE OR DRY CHEMICAL

HAZARDOUS DECOMPOSITION PRODUCTS: MAY FORM TOXIC MATERIALS:, CARBON DIOXIDE AND CARBON MONOXIDE, VARIOUS HYDROCARBONS, ETC.

FIREFIGHTING PROCEDURES: WEAR SELF-CONTAINED BREATHING APPARATUS WITH A FULL FACEPIECE OPERATED IN THE POSITIVE PRESSURE DEMAND MODE WHEN FIGHTING FIRES.

SPECIAL FIRE & EXPLOSION HAZARDS: VAPORS ARE HEAVIER THAN AIR AND MAY TRAVEL ALONG THE GROUND OR BE MOVED BY VENTILATION AND IGNITED BY HEAT, PILOT LIGHTS, OTHER FLAMES AND IGNITION SOURCES AT LOCATIONS DISTANT FROM MATERIAL HANDLING POINT.

NEVER USE WELDING OR CUTTING TORCH ON OR NEAR DRUM (EVEN EMPTY) BECAUSE PRODUCT (EVEN JUST RESIDUE) CAN IGNITE EXPLOSIVELY.

NFPA CODES: HEALTH- 0 FLAMMABILITY- 2 REACTIVITY- 0

SECTION V - HEALTH HAZARD DATA

PERMISSIBLE EXPOSURE LEVEL 100 PPM

THRESHOLD LIMIT VALUE 100 PPM

EFFECTS OF ACUTE OVEREXPOSURE: FOR PRODUCT

EYES - CAN CAUSE SEVERE IRRITATION, REDNESS, TEARING, BLURRED VISION.
SKIN - PROLONGED OR REPEATED CONTACT CAN CAUSE MODERATE IRRITATION, DEFATTING, DERMATITIS.
BREATHING - EXCESSIVE INHALATION OF VAPORS CAN CAUSE NASAL AND RESPIRATORY IRRITATION, CENTRAL NERVOUS SYSTEM EFFECTS INCLUDING DIZZINESS, WEAKNESS, FATIGUE, NAUSEA, HEADACHE AND POSSIBLE UNCONSCIOUSNESS, AND EVEN DEATH.
SWALLOWING - CAN CAUSE GASTROINTESTINAL IRRITATION, NAUSEA, VOMITING, AND DIARRHEA. ASPIRATION OF MATERIAL INTO THE LUNGS CAN CAUSE CHEMICAL PNEUMONITIS WHICH CAN BE FATAL.

CONTINUED ON PAGE: 2

SECTION V-HEALTH HAZARD DATA (Continued)

FIRST AID:

IF ON SKIN: THOROUGHLY WASH EXPOSED AREA WITH SOAP AND WATER. REMOVE CONTAMINATED CLOTHING. LAUNDER CONTAMINATED CLOTHING BEFORE RE-USE.

IF IN EYES: FLUSH WITH LARGE AMOUNTS OF WATER, LIFTING UPPER AND LOWER LIDS OCCASIONALLY. GET MEDICAL ATTENTION.

IF SWALLOWED: DO NOT INDUCE VOMITING, KEEP PERSON WARM, QUIET, AND GET MEDICAL ATTENTION. ASPIRATION OF MATERIAL INTO THE LUNGS DUE TO VOMITING CAN CAUSE CHEMICAL PNEUMONITIS WHICH CAN BE FATAL.

IF BREATHED: IF AFFECTED, REMOVE INDIVIDUAL TO FRESH AIR. IF BREATHING IS DIFFICULT, ADMINISTER OXYGEN. IF BREATHING HAS STOPPED GIVE ARTIFICIAL RESPIRATION. KEEP PERSON WARM, QUIET AND GET MEDICAL ATTENTION.

PRIMARY ROUTE(S) OF ENTRY:

INHALATION, SKIN CONTACT

EFFECTS OF CHRONIC OVEREXPOSURE: FOR PRODUCT

OVEREXPOSURE TO THIS MATERIAL (OR ITS COMPONENTS) HAS BEEN SUGGESTED AS A CAUSE OF THE FOLLOWING EFFECTS IN HUMANS:, CENTRAL NERVOUS SYSTEM EFFECTS

SECTION VI-REACTIVITY DATA

HAZARDOUS POLYMERIZATION: CANNOT OCCUR

STABILITY: STABLE

INCOMPATIBILITY: AVOID CONTACT WITH:, STRONG OXIDIZING AGENTS.

SECTION VII-SPILL OR LEAK PROCEDURES

STEPS TO BE TAKEN IN CASE MATERIAL IS RELEASED OR SPILLED:

SMALL SPILL: ABSORB LIQUID ON PAPER, VERMICULITE, FLOOR ABSORBENT, OR OTHER ABSORBENT MATERIAL AND TRANSFER TO HOOD.

LARGE SPILL: ELIMINATE ALL IGNITION SOURCES (FLARES, FLAMES INCLUDING PILOT LIGHTS, ELECTRICAL SPARKS). PERSONS NOT WEARING PROTECTIVE EQUIPMENT SHOULD BE EXCLUDED FROM AREA OF SPILL UNTIL CLEAN-UP HAS BEEN COMPLETED. STOP SPILL AT SOURCE, DIKE AREA OF SPILL TO PREVENT SPREADING, PUMP LIQUID TO SALVAGE TANK. REMAINING LIQUID MAY BE TAKEN UP ON SAND, CLAY, EARTH, FLOOR ABSORBENT, OR OTHER ABSORBENT MATERIAL AND SHOVELED INTO CONTAINERS.

PREVENT RUN-OFF TO SEWERS, STREAMS OR OTHER BODIES OF WATER. IF RUN-OFF OCCURS, NOTIFY PROPER AUTHORITIES AS REQUIRED, THAT A SPILL HAS OCCURED.

WASTE DISPOSAL METHOD:

SMALL SPILL: DISPOSE OF IN ACCORDANCE WITH ALL LOCAL, STATE AND FEDERAL REGULATIONS.

LARGE SPILL: DISPOSE OF IN ACCORDANCE WITH ALL LOCAL, STATE AND FEDERAL REGULATIONS.

SECTION VIII-PROTECTIVE EQUIPMENT TO BE USED

RESPIRATORY PROTECTION: IF WORKPLACE EXPOSURE LIMIT(S) OF PRODUCT OR ANY COMPONENT IS EXCEEDED (SEE SECTION II), A NIOSH/MSHA APPROVED AIR SUPPLIED RESPIRATOR IS ADVISED IN ABSENCE OF PROPER ENVIRONMENTAL CONTROL. OSHA REGULATIONS ALSO PERMIT OTHER NIOSH/MSHA RESPIRATORS (NEGATIVE PRESSURE TYPE) UNDER SPECIFIED CONDITIONS (SEE YOUR SAFETY EQUIPMENT SUPPLIER). ENGINEERING OR ADMINISTRATIVE CONTROLS SHOULD BE IMPLEMENTED TO REDUCE EXPOSURE.

VENTILATION: PROVIDE SUFFICIENT MECHANICAL (GENERAL AND/OR LOCAL EXHAUST) VENTILATION TO MAINTAIN EXPOSURE BELOW TLV(S).

PROTECTIVE GLOVES: WEAR RESISTANT GLOVES SUCH AS:, NITRILE RUBBER

EYE PROTECTION: CHEMICAL SPLASH GOGGLES IN COMPLIANCE WITH OSHA REGULATIONS ARE ADVISED; HOWEVER, OSHA REGULATIONS ALSO PERMIT OTHER TYPE SAFETY GLASSES. (CONSULT YOUR SAFETY EQUIPMENT SUPPLIER)

OTHER PROTECTIVE EQUIPMENT: TO PREVENT REPEATED OR PROLONGED SKIN CONTACT, WEAR IMPERVIOUS CLOTHING AND BOOTS.

SECTION IX-SPECIAL PRECAUTIONS OR OTHER COMMENTS

CONTAINERS OF THIS MATERIAL MAY BE HAZARDOUS WHEN EMPTIED.SINCE EMPTIED CONTAINERS RETAIN PRODUCT RESIDUES (VAPOR, LIQUID, AND/OR SOLID), ALL HAZARD PRECAUTIONS GIVEN IN THE DATA SHEET MUST BE OBSERVED.

THE INFORMATION ACCUMULATED HEREIN IS BELIEVED TO BE ACCURATE BUT IS NOT WARRANTED TO BE WHETHER ORIGINATING WITH THE COMPANY OR NOT. RECIPIENTS ARE ADVISED TO CONFIRM IN ADVANCE OF NEED THAT THE INFORMATION IS CURRENT, APPLICABLE, AND SUITABLE TO THEIR CIRCUMSTANCES.

APPENDIX B
MEDICAL EMERGENCY INFORMATION FORM

EMERGENCY INFORMATION FORM

Emergency Contacts	Name	Telephone Number
Hospital: NAVSTA Mayport Clinic		
Beaches Baptist Medical Center	Emergency Center	(904) 247-2999
Fire Department	Emergency Switchboard	911/Base (0) 5333
Ambulance and Paramedics	Emergency Switchboard	911/Base (0) 5444
Police Department	Emergency Switchboard	911/Base (0) 5111
Poison Control	Emergency Switchboard	(800) 362-0101
Battelle Health Services		(614) 424-6337
Other		
Program Contacts		
Navy (Southern Division)	Dave Driggers	(803) 820-5501
Battelle	G.B. Wickramanayake	(614) 424-4698
	Steve Rosansky	(614) 424-7289
NAVSTA Mayport	Cheryl Mitchell	(904) 270-6730
ABB Environmental Services	Terry Hansen	(904) 656-1293
	Frank Lesesne	

Emergency Routes

Hospital (map attached, Figure B-1).

From main gate at NAVSTA Mayport turn right on Mayport Rd. Follow Mayport Rd. to Atlantic Blvd. and turn left. Follow Atlantic Blvd. to Third St. and turn right. Follow Third St. to 13th Ave. South, then turn right. Beaches Baptist Medical Center is located on the left side of the street at 1350 13th Ave. South, Jacksonville Beach, Florida.

Other

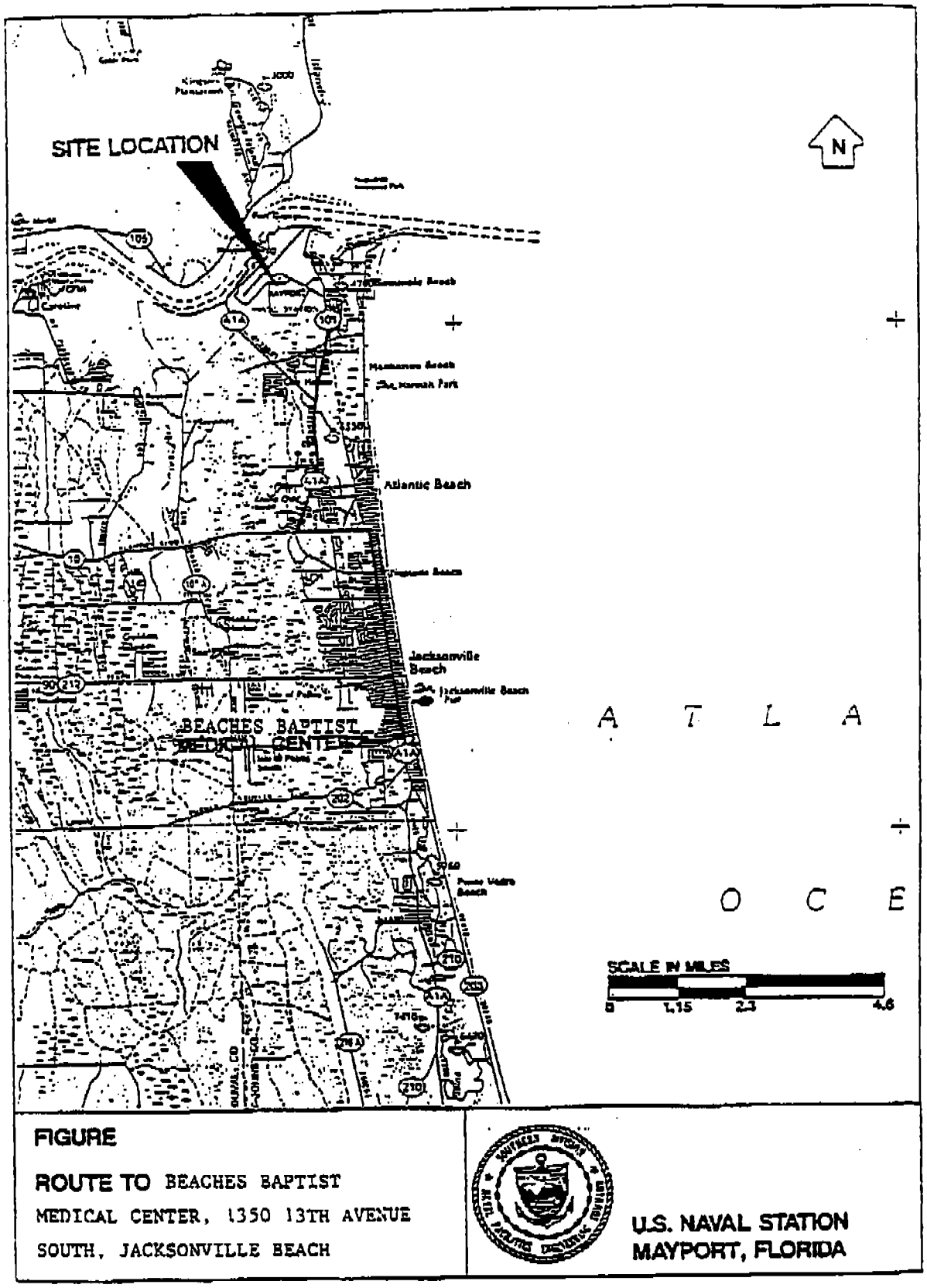

Figure B-1. Map of Route from NAVSTA Mayport to Beaches Baptist Medical Center.