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PART I

Bioventing Pilot Test Work Plan for

AIRCRAFT GROUND EQUIPMENT (AGE) MAINTENANCE AREA (Site 11)

BEALE AIR FORCE BASE, CALIFORNIA

PART II

Draft Interim Pilot Test Results for

AIRCRAFT GROUND EQUIPMENT (AGE) MAINTENANCE AREA (Site 11)

BEALE AIR FORCE BASE, CALIFORNIA

Prepared for

Air Force Center for Environmental Excellence
Brooks Air Force Base, Texas
and Beale Air Force Base, California

October 1993

Prepared by

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PART I

Bioventing Pilot Test Work Plan for

AIRCRAFT GROUND EQUIPMENT (AGE) MAINTENANCE AREA (SITE 11)

BEALE AIR FORCE BASE, CALIFORNIA

Prepared for

Air Force Center for Environmental Excellence
Brooks Air Force Base, Texas
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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

PART I

BIOVENTING PILOT TEST WORK PLAN FOR AIRCRAFT GROUND EQUIPMENT (AGE) MAINTENANCE AREA (SITE 11)

Beale Air Force Base, California

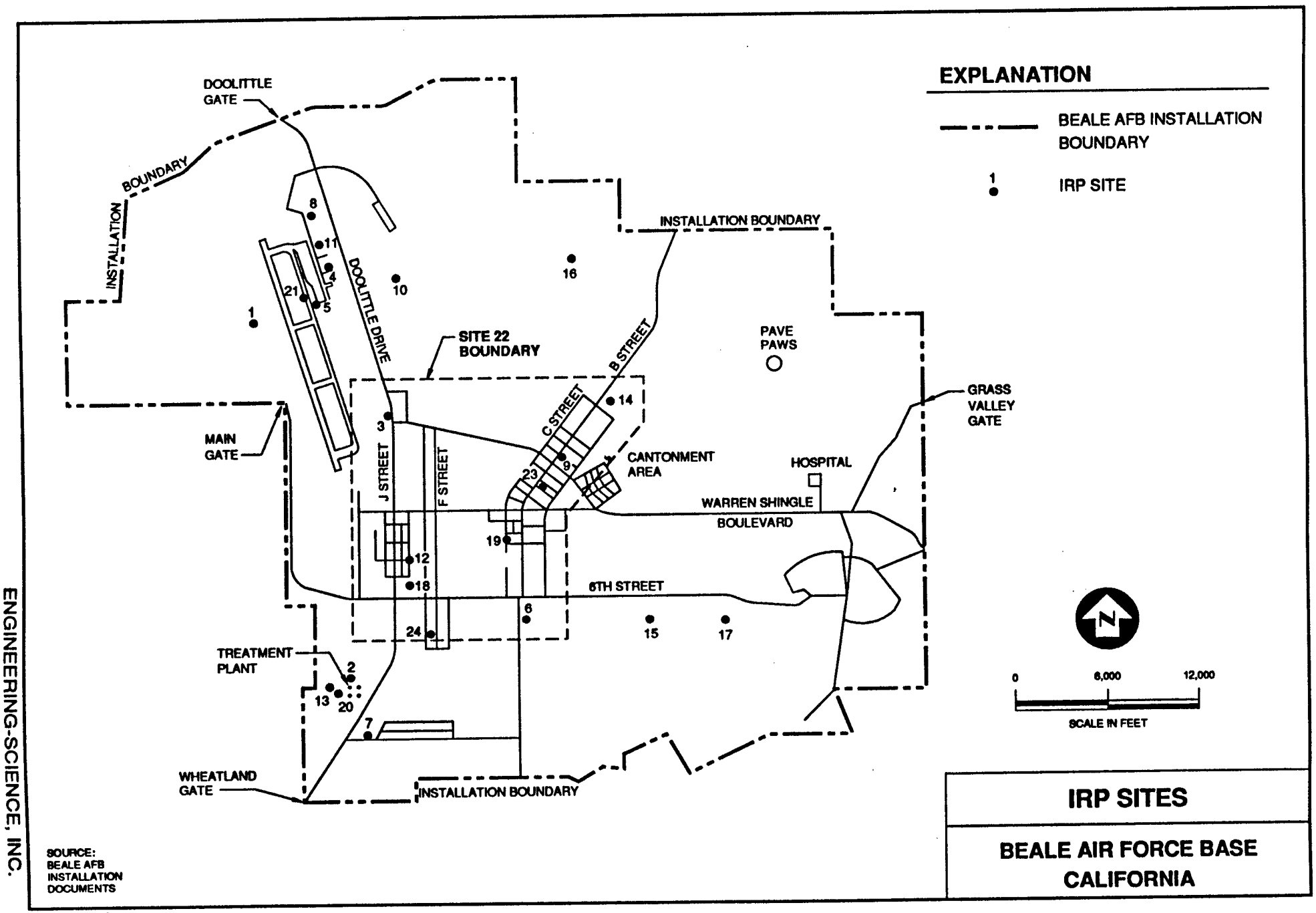
1.0 INTRODUCTION

This Pilot Test Work Plan presents the scope of an *in situ* bioventing pilot test for treatment of fuel contaminated soils at the Aircraft Ground Equipment (AGE) Maintenance Area (IRP Site 11) at Beale Air Force Base, Yuba County, California (Beale AFB) which is approximately 10 miles east of Marysville and 130 miles northeast of San Francisco. The location of Installation Restoration Program (IRP) sites at Beale AFB, including Site 11, is shown in Figure 1.1. The pilot test has three primary objectives: 1) to assess the potential for supplying oxygen throughout the fuel hydrocarbon-contaminated soil zone, 2) to determine the rate at which indigenous microorganisms will degrade the fuel in the soil when stimulated by oxygen rich soil gas, and 3) to evaluate the potential for sustaining these rates of fuel biodegradation until the contamination is remediated below regulatory standards.

The bioventing pilot test at Beale AFB will be divided into two test events. An initial pilot test will determine the technical feasibility and important design parameters such as air permeability, fuel biodegradation rates, and potential air emissions. An extended (one-year) pilot test will determine the long-term application of this remedial technology to biodegrade hydrocarbons at the site. If bioventing proves to be applicable at the site, pilot test data could be used to design and implement a bioventing remediation system. A significant amount of the fuel contamination should be biodegraded during the extended (one-year) pilot test since the bioventing will take place within the most contaminated soils at the site.

Additional background information on the development and recent success of the bioventing technology is found in the document entitled "Test Plan and Technical Protocol for a Field Treatability Test for Bioventing". This protocol document will also serve as the primary reference for pilot test well designs and detailed procedures which will be used during the test.

Successful bioventing pilot testing has been implemented at Beale AFB. An air permeability (AP) and *in situ* respiration (ISR) pilot test was performed by Engineering-Science, Inc. (ES) at IRP Site 22-A20 between 15 and 23 October 1991 with good results. This heating oil underground storage tank (UST) site was initially remediated in September 1990 with the excavation and removal of the 600-gallon UST along with approximately 600 cubic yards of Total Petroleum Hydrocarbon (TPH) contaminated soil. Approximately 1,000 cubic yards of TPH-contaminated soil, mainly associated with



SOURCE: BEALE AFB INSTALLATION DOCUMENTS

IRP SITES

BEALE AIR FORCE BASE CALIFORNIA

FIGURE 1.1

ENGINEERING-SCIENCE, INC.

C232-01.R1 09/14/92

the sidewalls adjacent to the nearby building, remained in the ground after excavation operations with a TPH concentration range of 500 to 2,000 mg/kg. The pilot test showed that a vapor extraction rate of 65 standard cubic feet per minute (scfm) influenced soil gas movement within at least a 100-foot radius of the vapor extraction well (VEW). In addition, the test indicated that indigenous soil bacteria are capable of consuming fuel residuals at a rate of approximately 750 - 900 mg of TPH per kilogram of soil per year when supplied with oxygen by moving fresh air through the soil. Based on these successful results, ES completed the installation of an extended (one-year) pilot test system on 9 July 1992 at the site consisting of a blower system connected to a VEW. The bioventing treatment system operates by moving fresh air through the subsurface soils via extraction at a flow rate averaging about 70 scfm. Weekly maintenance and periodic monitoring are being performed.

Initial bioventing pilot tests were completed in November 1992 at two other IRP sites at Beale AFB: the Fire Protection Training Area No. 1 (IRP Site 3); and the Bulk Fuel Storage Area (IRP Site 18). Subsurface soil sampling and analysis documented significantly high concentrations of Total Recoverable Petroleum Hydrocarbons (TRPH) at each site (maximum concentration of 40,000 mg/kg TRPH). The initial pilot tests showed that air injection rates of 35 to 38 scfm influenced soil gas movement within at least a 55-foot radius of the vent well (VW) at each site. In addition, the tests indicated existing soil bacteria are capable of consuming fuel residuals at rates approximating 200 mg fuel/kg of soil per year at IRP Site 3 and 600 mg fuel/kg soil per year at IRP Site 18. These are conservative estimates and actual rates may exceed these estimates. At each site, a small, 2.5-horsepower regenerative blower was connected to the VW to continue air injection at a rate of approximately 30 scfm. In July 1993, ES personnel returned to each site to sample and analyze the soil gas and conduct a second respiration test. In January 1994, final respiration tests will be conducted, and both soil and soil gas samples will be collected to determine the degree of remediation achieved during the first year of *in situ* treatment. Results of both initial pilot tests are summarized in the Draft Interim Pilot Test Results Report for Sites 3 and 18 (ES 1993).

Much of the background information on IRP Site 11 used in this Draft Pilot Test Work Plan is derived from prior IRP studies and reports (AeroVironment 1987, CH2M Hill 1991). This information includes site maps, site histories, site geology and hydrogeology, and sampling and analytical data.

2.0 SITE DESCRIPTION

The following sections provide a brief summary of the location, history, geology, and existing level of contamination at the AGE Maintenance Area (IRP Site 11).

2.1 Site Location and Description

The bioventing pilot test site is a former UST location approximately 300 feet south of Building 1225 in the AGE Maintenance Area, which is northeast of the base flightline (Figure 2.1). Previous IRP studies at IRP Site 11 (AeroVironment 1987, CH2M Hill 1991) have only focused on contamination in the area along the drainage ditch east of Building 1225. The proposed bioventing pilot test will be performed in the former UST area south of Building 1225, where contamination was recently discovered during UST removal operations in June 1992.

2.2 Site History

AGE maintenance activities have been performed at IRP Site 11 over the past 30 years. These activities have included storage of gasoline, diesel, and JP4 jet fuel in three former USTs connected to a fuel island and pumps. In addition, aircraft ground support vehicles have been stored and operated from the paved areas south of Building 1225 and these vehicles have been known to leak oil and hydraulic fluids.

In June 1992, all three USTs were removed and replaced by above ground storage tanks which were located slightly south of the original USTs. During soil excavation and UST removal operations, soil contamination was observed in the soil beneath all three USTs. Although soil around and beneath the tanks was removed, some contaminated soil was left in place. The maximum depth of soil excavation was 30 feet below ground surface (bgs), and the excavated area was backfilled to the surface with clean fill.

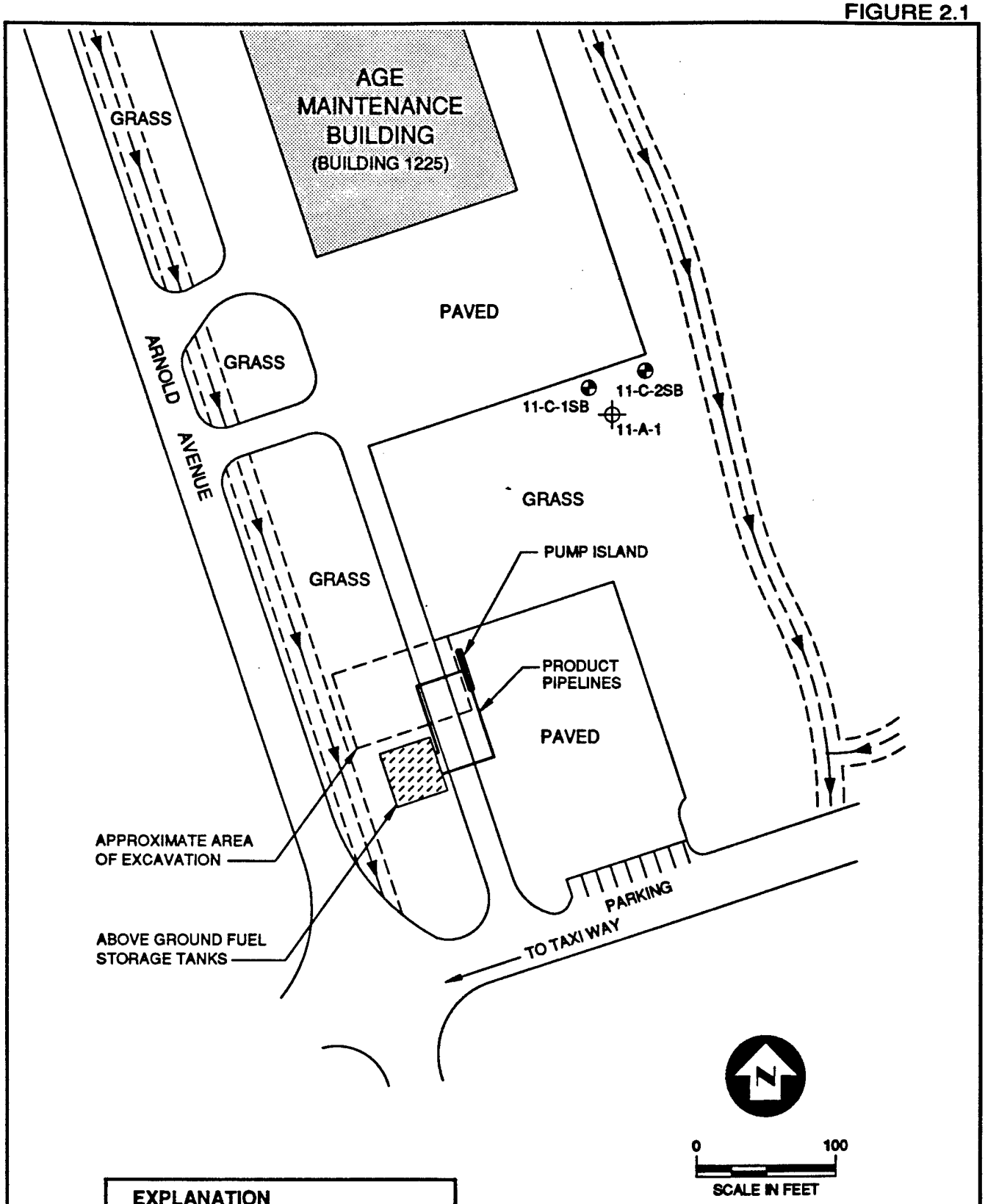
2.3 Site Geology

As part of previous IRP investigations (AeroVironment 1987, CH2M Hill 1991), six soil borings and one groundwater monitoring well (11-A-1) were installed at IRP Site 11. However, because the purpose of the monitoring well and soil borings was to investigate contamination in the vicinity of the drainage ditch east of Building 1225, the locations of the monitoring well and soil borings are 200-800 feet away from the excavated area. Therefore, evaluation of the geology and hydrogeology in this Draft Pilot Test Work Plan is from base-wide mapping studies, and well logs for the nearest groundwater monitoring well (11-A-1) and soil borings (11-C-1SB and 11-C-2SB).

The uppermost geologic unit in the western portion of Beale AFB, including IRP Site 11, has been mapped as the Laguna Formation (Page 1980). This formation consists of a Plio-Pleistocene alluvial sequence of silt, sand, clay, and unsorted gravels. These deposits overlie older volcanic rocks which outcrop in the Sierra Nevada Foothills to the east.

Figure 2.2 is the well log for monitoring well 11-A-1, located approximately 200 feet northeast of the excavated area. The soil profile encountered in 11-A-1 from ground surface to 140 feet bgs is predominantly interbedded sands and gravels with occasional

FIGURE 2.1



EXPLANATION

- 11-C-1SB — SOIL BORING
- 11-A-1 — MONITORING WELL
- UNLINED DRAINAGE CHANNEL

SOURCE: MODIFIED FROM CH2M HILL, 1989

SITE MAP
SITE 11, AGE MAINTENANCE AREA

BEALE AIR FORCE BASE
CALIFORNIA

REV. 1 C243-14.DWG 02/12/93

ENGINEERING-SCIENCE, INC.

WELL NO. 11-01

Project Name Beale AFB IRP No. 10416K Logged By J. Miller

Site #11 AGE Shop Checked By T. O'Gara

Drilling Method 8" Air/Water Rotary Date 11/21-22/85

Geologic Description	Graphic Log	Depth (ft.)	Well Design	Remarks
Silty sand to 1 foot followed by bright orange/red silt/sand/clay at 2-4 feet; probably Bc soil horizon.				
Gravel and sand with large cobbles and boulders. 10-15% sand.		10		
Thin bedded medium to coarse sand with fine sand. Thin (<1 foot) sand zones with 10-20% gravel at 29 feet, 39 feet and 45 feet.		20 30 40 50 60		
Gravel and cobbles.		70		
Thin medium sand layer. Sand and gravel with small pebbles.		80		
Medium and coarse sand with a few pebbles. Light brown/buff/tan silty fine to medium sand.		90		
Medium and coarse sand, minor silt slightly moist, becoming wet at 110 feet.		100 110	Steel Blank SS Grout to Surface	
Silt with 20% fine sand and minor coarse sand. 6" gravel layer at 120 feet.		120		
Medium to coarse sand with silt and 10-15% gravel. Grading into lower unit.		130		
Excellent gravel and pebbles with coarse sand. Makes good, clean water.		140 150		

SOURCE: AeroVironment 1987

zones of cobble- and pebble-sized grains. Soil borings 11-C-1SB and 11-C-2SB were halted at approximately 8 feet bgs due to auger refusal at the top of the cobble/gravel layer shown on Figure 2.2 at about 8 feet bgs.

Groundwater was measured as 125 feet bgs in monitoring well 11-A-1 at the time of well development in November 1985. Since the unsaturated zone consists of predominantly sand and gravel units, the aquifer is probably unconfined. Subsequent water levels were taken at various times between 1986 and 1991 and ranged from 110 to 130 feet bgs, and were found to be steadily rising over this period, which is consistent with observed water level rises at other nearby IRP sites.

Groundwater flow at IRP Site 11 is generally to the southwest based on 1989 base-wide groundwater elevation data. The average hydraulic gradient is very gentle (approximately 0.002 ft/ft) in the vicinity of the site and increases to approximately 0.02 ft/ft east of the site. No aquifer pumping tests have been performed in the vicinity.

Since the soils at IRP Site 11 appear to be composed of permeable sands and gravels down to the water table, they should have sufficient moisture and air permeability to be suitable for remediation using the bioventing technology.

2.4 Site Contaminants

The primary contaminants documented in soils at the Site 11 excavated area are fuel residuals and aromatic hydrocarbons. Table 2.1 presents the analytical data for each of the soil samples collected during UST removal operations. Soil sampling locations are shown in Figure 2.3, and are within the excavated limits. The soils which were left in place had visual evidence of contamination. Although soil samples were also taken from monitoring well 11-A-1 and soil borings 11-C-1SB and 11-C-2SB, their locations are upgradient and too distant from the excavation area to be used for characterization of the pilot test site.

Soil samples from the excavation were analyzed for total petroleum hydrocarbons as diesel (TPH-d) and gasoline (TPH-g), and purgeable aromatics including benzene, toluene, ethylbenzene, and total xylenes (BTEX). The maximum levels found were 6,000 mg/kg TPH-d (S6), 860 mg/kg TPH-g (SWBC), 48 mg/kg benzene (S3), 190 mg/kg toluene (S3), 83 mg/kg ethylbenzene (S3), and 400 mg/kg total xylenes (S3). Samples from S3 and S6 were taken at 30 feet bgs, and samples from SWBC were taken from 10 feet bgs. It is not known how deep residual fuel contamination exists at the site since the deepest samples (30 feet bgs) had significantly high concentrations of fuel components.

Analytical results of groundwater samples from monitoring well 11-A-1 collected during initial sampling events in 1986 and subsequent semi-annual sampling events in 1989 indicated very low concentrations of chemical analytes. Maximum concentrations of trichloroethylene (TCE) and toluene were 0.4 µg/L and 1.0 µg/L, respectively. Major anion and cation concentrations at this well are generally similar to other sites near the flightline. All other major analytes of purgeable halocarbons (EPA Method 8010),

Table 2.1
Soil Contaminant Concentrations at Site 11, AGE Maintenance Area Beale AFB, California

		Extractable Petroleum HC	Purgeable Petroleum HC	Purgeable Aromatics			
	Method:	3550/8015	5030/8015	8020			
	Analyte:	TPH-d	TPH-g	Benzene	Toluene	Ethylbenzene	Total Xylenes
Location	Depth (ft bgs)	concentrations in mg/kg					
S1	30	1,500	NA	9.5	66	45	250
S2	30	1,000	NA	0.15	1.4	0.98	5.3
S2*	30	130	NA	1.7	3.0	1.4	7.3
S3	30	2,800	NA	48	190	83	400
S4	30	920	NA	4.0	52	18	120
S5	30	2,600	NA	9.8	80	41	230
S6	30	6,000	NA	28	140	51	250
NWW	10	2.4					
NEW	10	1.5					
SWW	5	45	6.0				0.55
SEW	30	1.9					
NWBC	15	1,300	540	2.4	19	8.6	48
SWBC	10	1,000	860	1.7	22	11	25

LEGEND

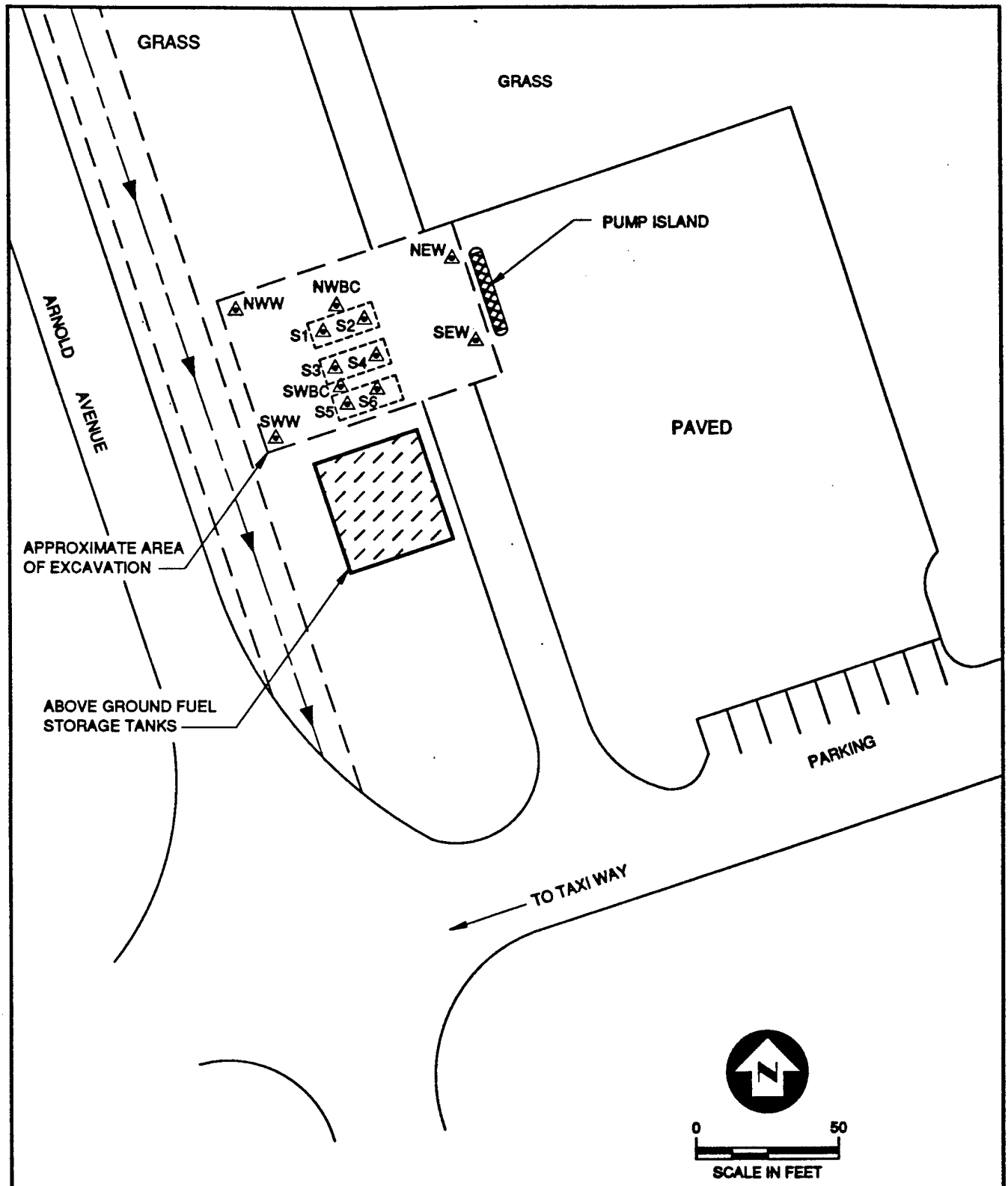
bgs : below ground surface
* : duplicate
TPH-d : Total petroleum hydrocarbons as diesel
TPH-g : Total petroleum hydrocarbons as gasoline
NA : not analyzed
: not detected

s11_t21

SOURCE : Martech USA, 1992

02/16/93

FIGURE 2.3



SOIL SAMPLING LOCATIONS
SITE 11, AGE MAINTENANCE AREA

BEALE AIR FORCE BASE
CALIFORNIA

SOURCE: MODIFIED FROM CH2M HILL, 1989

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purgeable aromatics (EPA Method 8020), semi-volatile organics (EPA Method 8270), metals (EPA Method 6010), and TPH-g/-d [California Department of Toxic Substances Control (DTSC)/Leaking Underground Fuel Tank (LUFT) Method] have not been detected. However, well 11-A-1 is located 200 feet upgradient of the excavation area and therefore may not be representative of groundwater conditions below the pilot test site.

3.0 SITE-SPECIFIC ACTIVITIES

The purpose of this section is to describe the work that will be performed by ES at the former UST excavation area within IRP Site 11. Activities that will be performed include siting and construction of a central vent well (VW) and vapor monitoring points (VMPs), an initial pilot test (including an air permeability test and an *in situ* respiration test), and an extended (one-year) pilot test. Soil and soil gas sampling procedures and the blower configuration that will be used to introduce air (oxygen) into contaminated soils by injection are also discussed in this section. No dewatering or groundwater treatment will take place during bioventing pilot testing. Pilot test activities will be confined to unsaturated soils remediation. Because monitoring well 11-A-1 is screened below the current water table elevation and is located 200 feet from the pilot test site, this well will not be suitable for use as a VMP.

3.1 Location and Construction of Vent Well and Vapor Monitoring Points

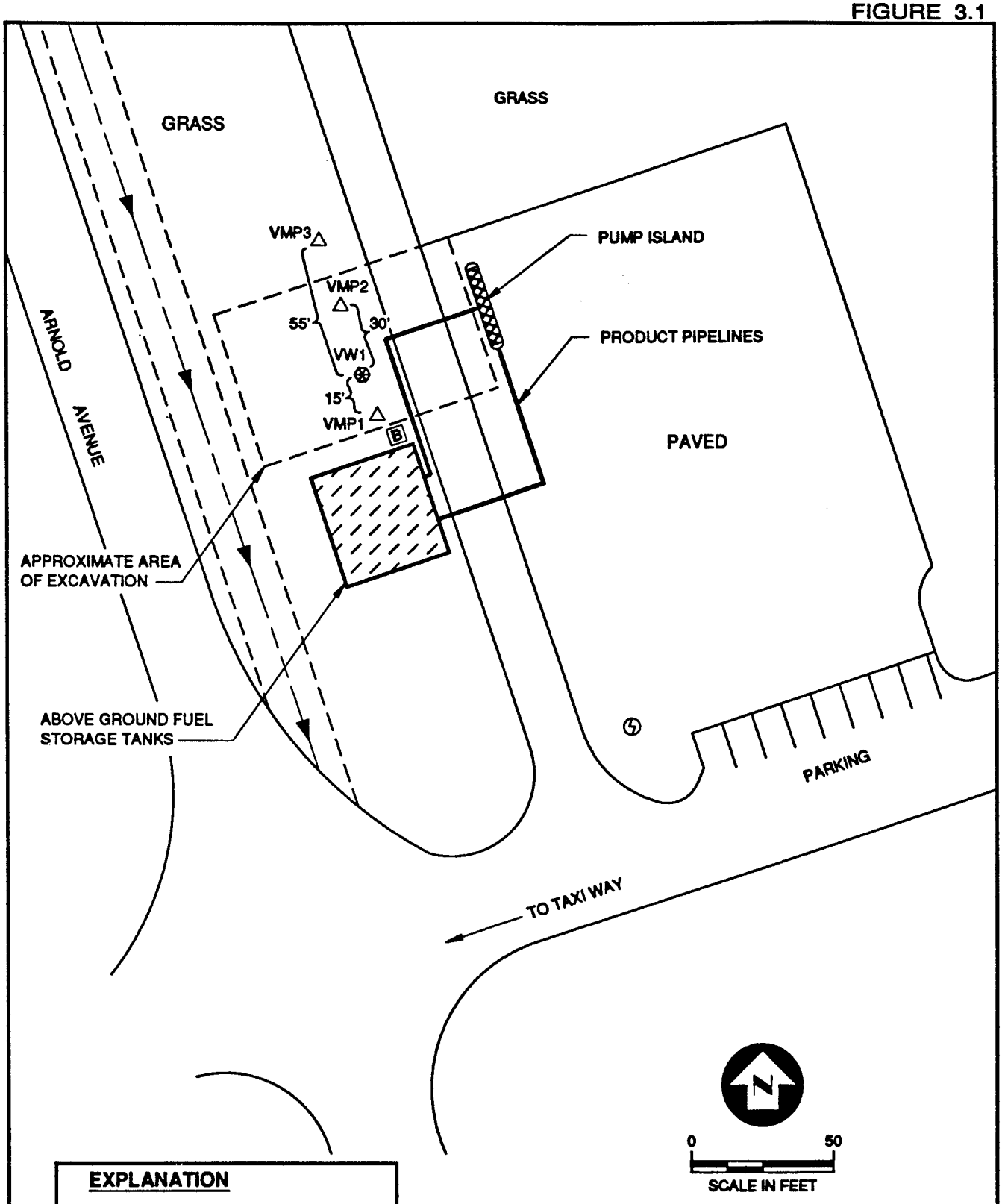
A general description of criteria for siting a central VW and VMPs is included in the protocol document. Figure 3.1 indicates the proposed locations of the central VW and VMPs.

The final location of the VW and VMPs may vary slightly from the proposed location if significant fuel contamination is not observed in the boring for the central VW. Based on site investigation data, the central VW should be located near the center of the excavated area. This area is expected to have high TPH-d and BTEX concentrations. Soils in this area are expected to be oxygen depleted (< 2 percent) and increased biological activity should be stimulated by oxygen-rich soil gas ventilation during both the initial pilot test and the extended (one-year) pilot test.

The radius of venting influence around the central VW is expected to be at least 60 feet based on the composition of the soils at IRP Site 11. Three VMPs will be located within a 55-foot radius of the central VW including one VMP outside the former excavated area. The background VMP previously installed as part of bioventing pilot testing at IRP Site 3 will also be used as a background VMP for this site, where the soils are of similar composition. The background VMP will be used to measure background levels of oxygen and carbon dioxide and to determine if natural carbon sources are contributing to oxygen uptake during the *in situ* respiration test. A more detailed description of the *in situ* respiration test is found in Section 3.6.

Figure 3.2 is a central VW construction diagram for this site. The central VW will be constructed of 4-inch inside diameter (ID) Schedule 40 polyvinyl chloride (PVC) casing, with an interval of 0.04-inch slotted screen set between 10 feet bgs down to the base of contamination as determined by field organic vapor analysis (OVA) of soils samples. The start of the screen interval may be set lower than 10 feet bgs to prevent short-circuiting of injected air within the excavation fill material. A 100 ppmv OVA reading will be the criterion used in determining the depth selected as the base of contamination. A Total Hydrocarbon Vapor Analyzer (THVA) will be used for field OVA readings. This platinum catalyst combustion detector is not specific for fuel hydrocarbons and will also detect low levels of other soil gases, such as methane, which are common at old,

FIGURE 3.1



SOURCE: MODIFIED FROM CH2M HILL, 1989

PROPOSED VENT WELL AND VAPOR MONITORING POINT LOCATIONS SITE 11, AGE MAINTENANCE AREA

BEALE AIR FORCE BASE CALIFORNIA

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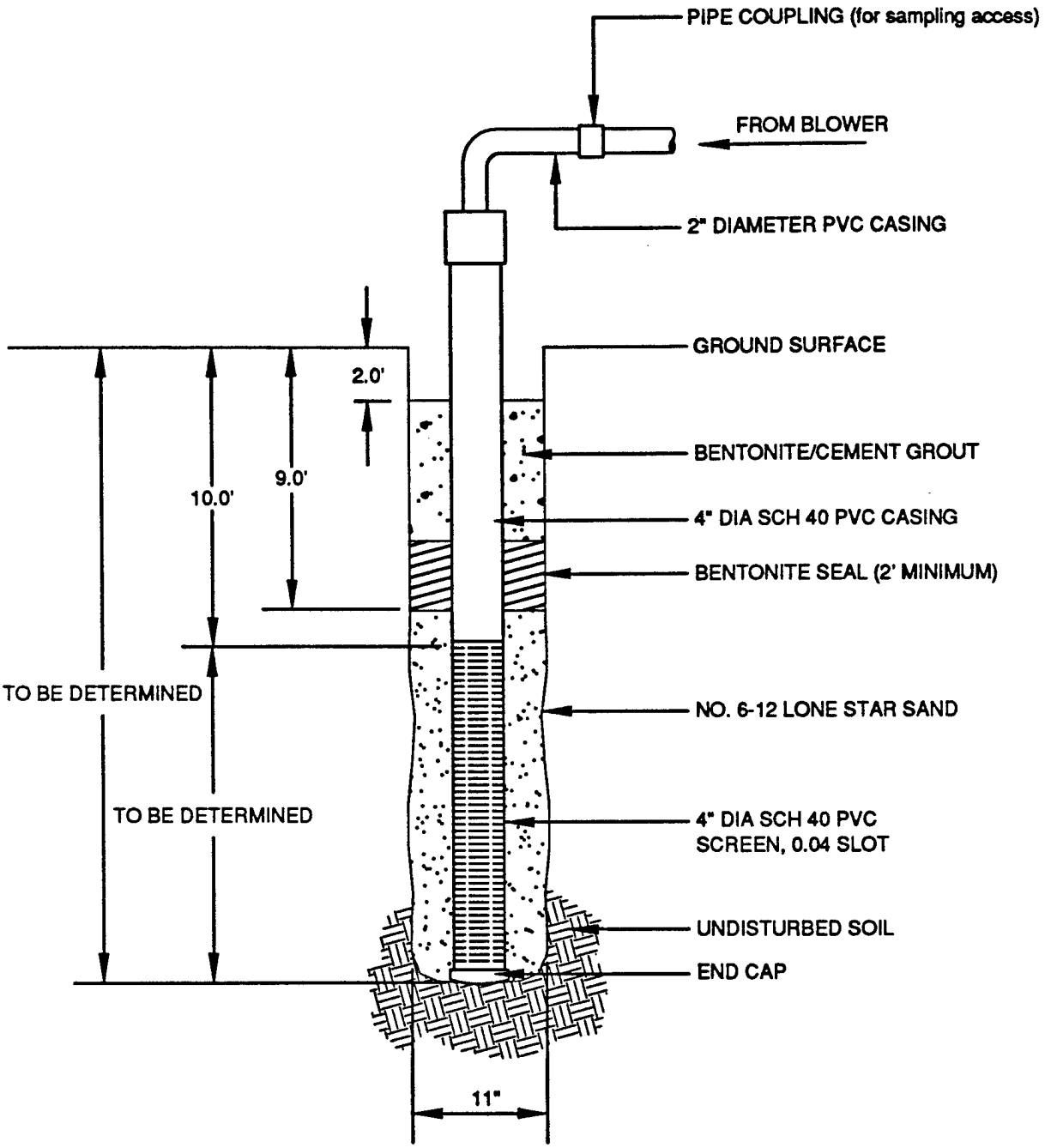
FIGURE 3.2



NOT TO SCALE

NOTE: DEPTH OF SCREENED INTERVAL WILL BE NEAR THE BASE OF CONTAMINATION AS DETERMINED IN THE FIELD.

VENTING WELL CONSTRUCTION DIAGRAM SITE 11, AGE MAINTENANCE AREA

BEALE AIR FORCE BASE CALIFORNIA

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fuel-contaminated sites. Flush-threaded PVC casing and screen will be used with no organic solvents or glues. The filter pack will be clean Lone Star sand with a 6-12 grain size and will be placed in the annular space of the screened interval. A 3-foot layer of bentonite will be placed directly over the filter pack. The remainder of the annular space, except for a 2-foot open area directly below the ground surface, will be filled with a bentonite/cement grout. A complete seal is critical to prevent the short-circuiting of air from the surface during the bioventing test.

A typical multi-depth VMP installation for this site is shown in Figure 3.3. Soil gas oxygen and carbon dioxide concentrations will be monitored via vapor monitoring screens placed at depth intervals of 30 feet and 40 feet (underneath the clean fill), and near the base of contamination (if below 40 feet) as determined by the field OVA of soil samples at each location. An additional vapor monitoring point screen at 20 feet will be installed in any VMPs located outside the excavation fill. This additional screen will be used to characterize soil gas movement and respiration rates outside the fill area, but within the radius of influence of the vent well. If the base of contamination is determined to be below 40 feet, then the vapor monitoring screen depths may be altered to provide better vertical coverage for soil gas monitoring. Multi-depth monitoring will determine the amount of oxygen across the entire soil profile and will be used to measure fuel biodegradation rates at all monitored depths. The annular space between the vapor monitoring screen filter packs will be sealed with bentonite to isolate the monitoring intervals. As with the central VW, several inches of bentonite pellets will be used to shield the filter pack intervals from rapid infiltration of bentonite slurry additions. At the inner vapor monitoring point (VMP1), thermocouples will also be installed at the same depths as the deepest and shallowest screens to measure soil temperatures. Additional details on VW and VMP construction are found in Section 4 of the protocol document.

3.2 Handling of Drill Cuttings

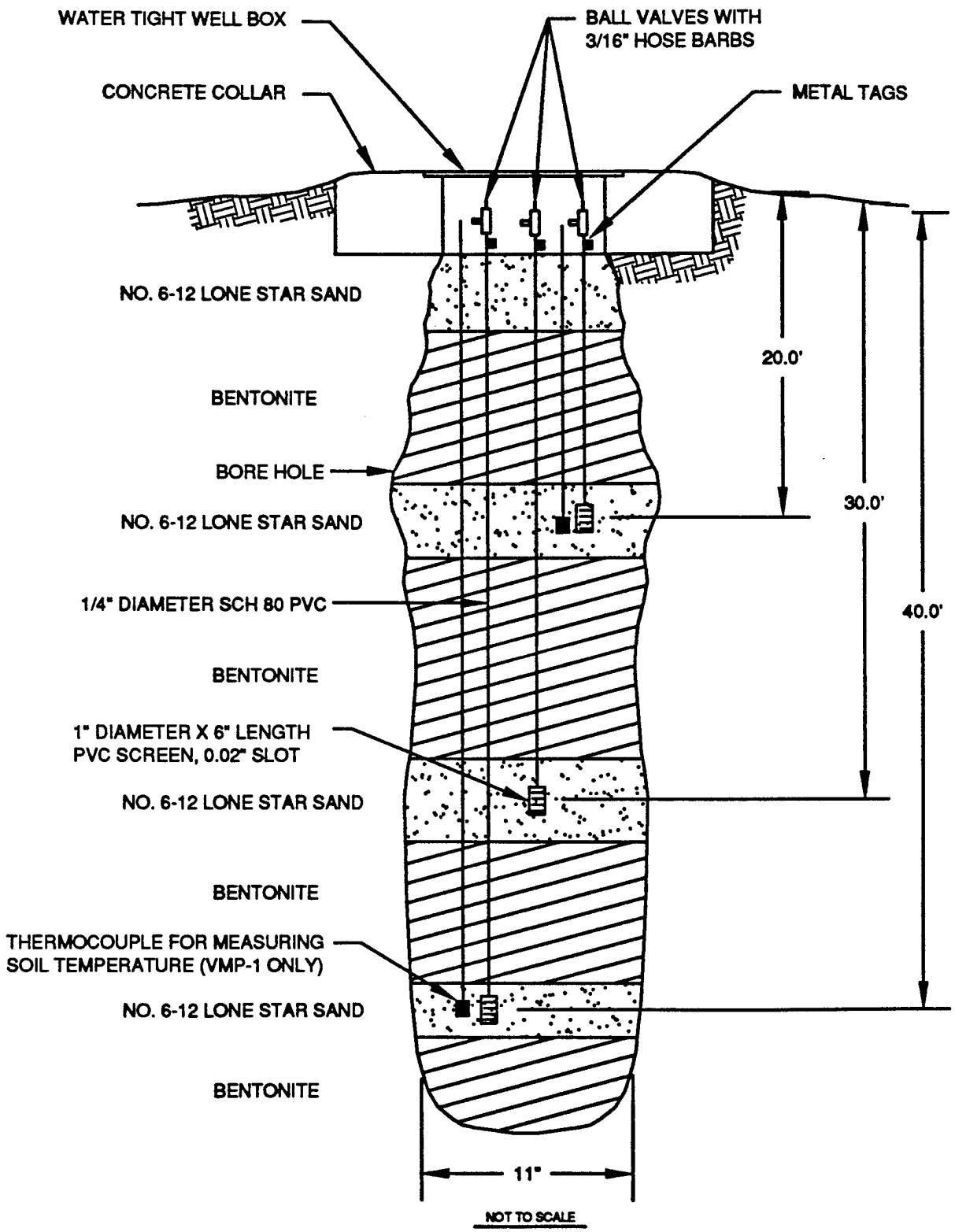
Drill cuttings from all VW and VMP borings will be handled in conformance with the base Draft Soil Management Plan (ES 1991). The cuttings will be screened with a photoionization detector (PID) and/or a THVA by the on-site geologist or engineer to identify potential contamination. Soil cuttings with PID/THVA readings < 10 ppm will be spread out on the ground at the drill site. Soil cuttings with PID/THVA readings of > 10 ppm will be temporarily stockpiled on Visqueen at the drill site. This soil will then be transported by the drilling contractor to the contaminated soil holding area located south of 9th Street between K and L Streets on the base.

3.3 Soil and Soil Gas Sampling

3.3.1 Soil Sampling

Three soil samples will be collected from the pilot test area during the installation of the VW and VMPs. One sample will be collected from the most contaminated interval of the central VW boring, and one sample will be collected from the most contaminated interval in each of the borings for the two inner VMPs (VMP1 and VMP2). These soil

FIGURE 3.3



NOTE: AN ADDITIONAL VMP SCREEN MAY BE INSTALLED NEAR THE BASE OF CONTAMINATION (AS DETERMINED IN THE FIELD).

VAPOR MONITORING POINT CONSTRUCTION DIAGRAM SITE 11, AGE MAINTENANCE AREA

BEALE AIR FORCE BASE CALIFORNIA

samples will be analyzed for TRPH, BTEX, soil moisture, pH, grain size distribution, alkalinity, total iron, and nutrients including total Kjeldahl nitrogen (TKN) and phosphates.

Samples collected for BTEX and TRPH analysis will be collected using a split-spoon sampler containing brass tube liners. Soil samples collected in the brass tubes will be immediately trimmed and the ends sealed with Teflon fabric held in place by plastic caps. Soil samples collected for physical parameter analysis will be placed into appropriate sample containers. Soil samples will be labeled following the nomenclature specified in Section 5.5 of the protocol document, wrapped in plastic, and placed in an ice chest for shipment. A chain of custody form will be filled out and the ice chest shipped to the Pace, Inc. laboratory in Berkeley, California, for analysis. This laboratory has been audited by the U.S. Air Force and meets all quality assurance/quality control and certification requirements for the State of California.

3.3.2 Soil Gas Sampling

A THVA (see protocol document Section 4.5.2) will be used to screen split-spoon samples during drilling for determination of the most contaminated intervals. During the pilot test, initial and final soil gas samples will be collected in Summa® canisters from the central VW (VW1) and the VMPs closest to and furthest from the central VW (VMP1 and VMP3). These soil gas samples will be used to predict potential air emissions and to determine the reduction in BTEX and total hydrocarbons.

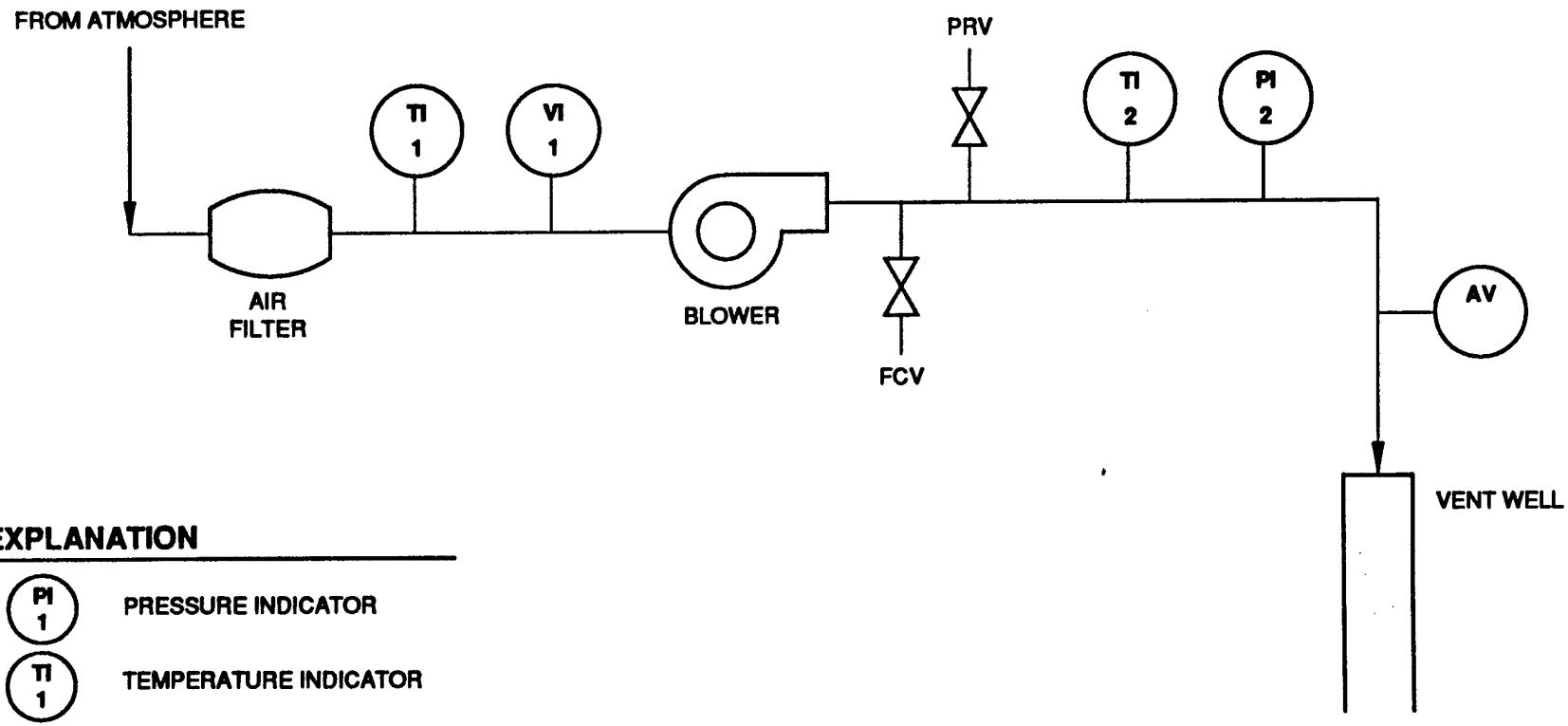
Soil gas samples will be placed in an ice chest and packed with foam pellets to prevent excessive movement during shipment. Samples will not be sent on ice in order to prevent condensation of hydrocarbons. A chain of custody form will be filled out and the ice chest shipped to the Air Toxics Laboratory in Rancho Cordova, California for analysis.

3.4 Blower System

A portable 3.0 horsepower positive displacement blower capable of injecting 40 standard cubic feet per minute (scfm) at 4 pounds per square inch (psi) will be used to conduct the initial air permeability test at the site. Figure 3.4 is a schematic of a typical air injection system used for pilot testing. The maximum power requirement anticipated for these pilot tests is a 230 volt, single-phase, 30 amp service. Additional details on power supply requirements are described in Section 5.0, Base Support Requirements.

3.5 Air Permeability Test

The objective of the air permeability test is to determine the extent of the subsurface that can be oxygenated using one air injection unit. Air will be injected into the 4-inch diameter central VW (VW1) using the portable blower unit, and pressure response will be measured at each VMP with differential pressure gauges to determine the region influenced by the unit. Oxygen will also be monitored in the VMPs to ascertain that oxygen levels in the soil increase as a result of air injection. One air permeability test lasting approximately 8 hours will be performed. Additional details on the air permeability test are found in Section 5.6 of the protocol document.



EXPLANATION

PI 1	PRESSURE INDICATOR
TI 1	TEMPERATURE INDICATOR
VI 1	VACUUM INDICATOR
FCV	FLOW CONTROL VALVE
PRV	PRESSURE RELIEF VALVE
AV	AIR VELOCITY PORT

BLOWER SYSTEM INSTRUMENTATION DIAGRAM FOR AIR INJECTION SITE 11, AGE MAINTENANCE AREA

BEALE AIR FORCE BASE, CALIFORNIA

FIGURE 3.4

3.6 *In Situ* Respiration Tests

The objective of the *in situ* respiration test at Beale AFB IRP Site 11 is to determine the rate at which soil bacteria will biodegrade the TPH contamination in the soil. Respiration tests will be performed at vapor monitoring screens (points) where bacterial degradation of hydrocarbons is noted. These points of hydrocarbon degradation are characterized by low oxygen levels and elevated carbon dioxide concentrations in the soil gas. Air will be injected at points containing low levels of oxygen (below approximately 2 percent) for approximately 20 hours to oxygenate local contaminated soils. At the end of the 20-hour air injection period, the air supply will be cut off and oxygen and carbon dioxide levels will be monitored for the following 48 to 72 hours. The decline in oxygen and increase in carbon dioxide concentrations over time will be used to estimate rates of bacterial degradation of fuel residuals.

Helium, an inert gas, will be injected at a concentration of 2 to 4 percent into every vapor monitoring point that is being used for respiration testing. Helium injection is used as a system leak-testing method. Additional details of the *in situ* respiration test procedures are found in Section 5.7 of the protocol document.

3.7 Installation of Extended Bioventing Pilot Test System

An extended (one-year) bioventing pilot test system will be installed at IRP Site 11 if the initial pilot test successfully demonstrates the feasibility of providing oxygen throughout the contaminated soil profile. Continuous air injection would determine the long-term radius of oxygen influence, and the effect of time, available nutrients, and changing temperatures on fuel biodegradation rates. A fixed 1.0 hp Gast™ regenerative blower unit capable of injecting up to 60 scfm at 30 inches of water will be installed as part of this extended pilot test system. The blower will be housed in a small shed to provide protection from the weather and to minimize noise. This small "dog house" will be located in a low-traffic area.

The system will be in operation for one year, and ES personnel will monitor it biannually, scheduled for October 1993 and April 1994. This biannual monitoring will consist of *in situ* respiration tests to monitor the long-term performance of the bioventing system. Weekly system checks will be performed by Beale AFB personnel. If required, major maintenance of the blower unit will be performed by ES-Alameda personnel. Detailed blower system information and a maintenance schedule will be included in the Operation and Maintenance (O&M) manual provided to the base. In addition, sub-surface soil samples will be collected at locations as close as possible to the original VMP/VW soil sample locations in order to assess the degree of remediation achieved during the first year of *in situ* treatment.

4.0 EXCEPTIONS TO PROTOCOL PROCEDURES

The procedures that will be used to construct wells, measure the air permeability of the soil, and conduct the *in situ* respiration test are described in Sections 4 and 5 of the protocol document. The only anticipated exceptions to the protocol document are the slight changes in helium-injection protocol discussed in this Pilot Test Work Plan.

5.0 BASE SUPPORT REQUIREMENTS

The following base support is needed prior to the arrival of a driller and the ES test team:

- Obtaining all necessary regulatory permits for the vent well and vapor monitoring points, and any needed air permits necessary for pilot test approval.
- Obtaining a base digging permit.
- Installation of a 230V/single phase/30 amp breaker box with one 230V receptacle, and two 110V receptacles. This breaker box must be within 20 feet of the proposed blower location (see Figure 3.1).
- Provide any paperwork required to obtain gate passes and security badges for approximately three ES employees and two drillers. Vehicle passes will be needed for two trucks and a drill rig.
- Provide keys to the on-site groundwater monitoring well.

During the initial three week pilot test, the following base support is needed:

- Twelve square feet of desk space and a telephone in a building located as near to the site as practical.
- The use of a fax machine for transmitting 15 to 20 pages of test results.
- A decontamination area where the driller can clean augers between borings.

During the extended (one-year) pilot test:

- Check the blower system once a week to ensure that it is operating and to record the air injection pressure and temperature. ES will provide a brief training session on this procedure.
- If the blower stops working, notify: Mr. Frederick Stanin or Mr. Michael Phelps, ES-Alameda, (510) 769-0100; or Mr. Doug Downey, ES-Denver, (303) 831-8100; or Mr. Sam Taffinder of AFCEE, (210) 536-4366.
- Arrange site access for ES technicians to conduct *in situ* respiration tests at approximately six months and one year after the initial pilot tests.

6.0 PROJECT SCHEDULE

The following schedule is contingent upon timely approval of this pilot test work plan.

Event	Date
Draft Pilot Test Work Plan to AFCEE/Beale AFB	12 March 1993
Approval to Proceed	26 March 1993
Begin VW and VMP Construction	12 April 1993
Begin Initial Pilot Test	19 April 1993
Complete Initial Pilot Test	26 April 1993
Interim Results Report	June 1993
Respiration Test	October 1993
Final Respiration Test and Soil Sampling	April 1994

7.0 POINTS OF CONTACT

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8.0 REFERENCES

AeroVironment 1987, Installation Restoration Program Phase II, Stage 1 Confirmation/Quantification Study Final Report. May

CH2M Hill 1991, Installation Restoration Program Stage 2-1 Remedial Investigation, Final Report for Beale AFB, California. March

Engineering-Science 1991, Installation Restoration Program Stage 2, Soil Management Plan, Beale AFB, California, Second Draft. August

Engineering-Science 1993, Part II, Draft Interim Pilot Test Results for IRP Sites 3 and 18, Beale AFB, California. February

Hinchee et al. 1992, Test Plan and Technical Protocol for a Field Treatability Test for Bioventing, U.S. Air Force Center for Environmental Excellence (AFCEE). January

Page 1980, Groundwater Conditions at Beale AFB and Vicinity, California, USGS Open File Report 80-204.

PART II

DRAFT

Interim Bioventing Pilot Test Results Report for

AIRCRAFT GROUND EQUIPMENT (AGE) MAINTENANCE AREA
Site 11
BEALE AIR FORCE BASE, CALIFORNIA

Prepared for

Air Force Center for Environmental Excellence
Brooks Air Force Base, Texas
and
Beale Air Force Base, California

October 1993

Prepared by

ENGINEERING-SCIENCE, INC.
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41-40

TABLE OF CONTENTS

PART II
DRAFT INTERIM BIOVENTING PILOT TEST RESULTS REPORT FOR SITE 11
AIRCRAFT GROUND EQUIPMENT (AGE)
MAINTENANCE AREA

Beale Air Force Base, California

LIST OF FIGURES

LIST OF TABLES

PART II

DRAFT INTERIM PILOT TEST RESULTS REPORT
for
AIRCRAFT GROUND EQUIPMENT (AGE) MAINTENANCE AREA
(SITE 11)
Beale Air Force Base, California

1.0 PILOT TEST DESIGN AND CONSTRUCTION

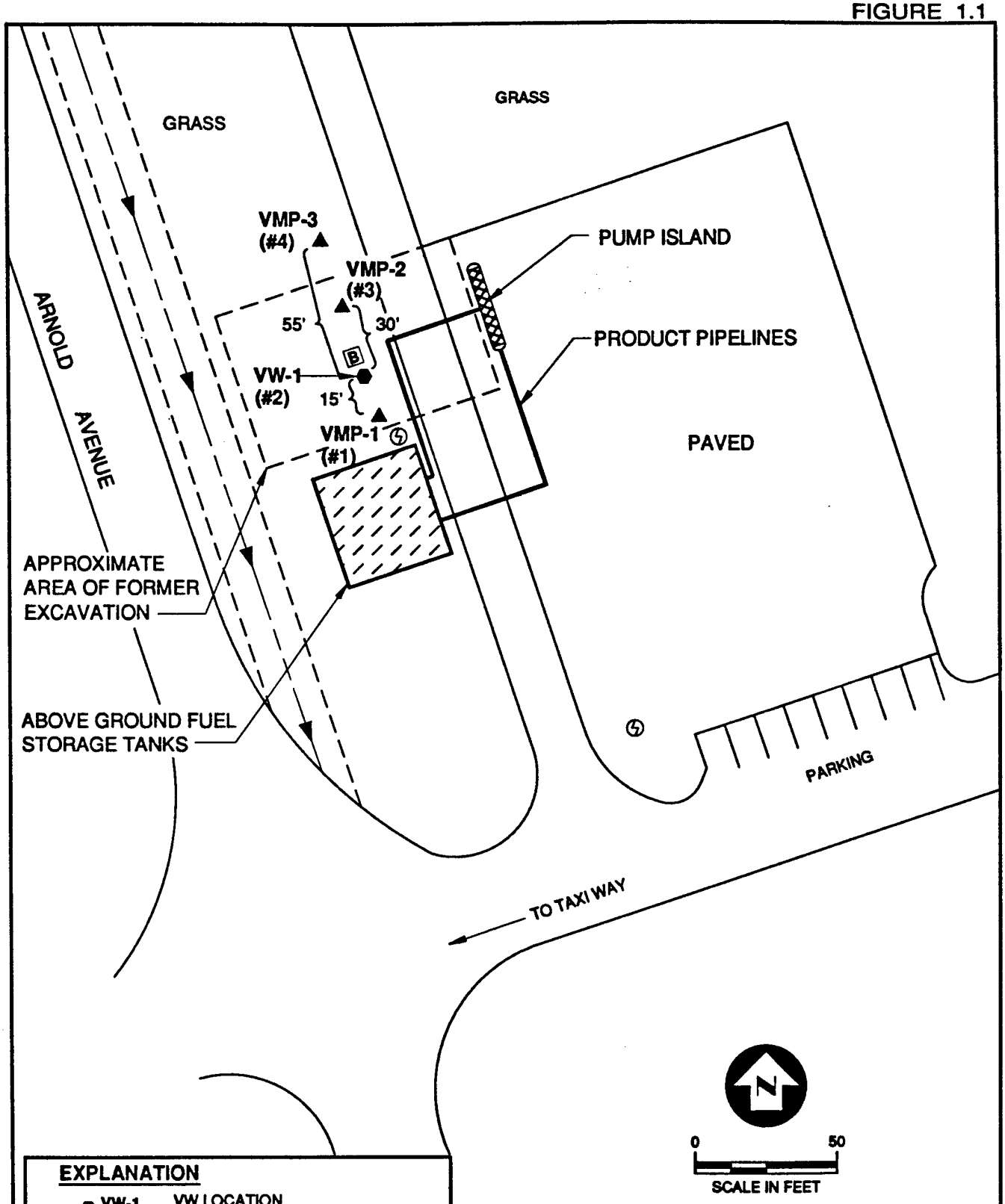
An initial bioventing pilot test was completed at Installation Restoration Program (IRP) Site 11: Aircraft Ground Equipment (AGE) Maintenance Area, Beale Air Force Base, California (Beale AFB). The purpose of this Part II Interim Report is to describe the results of the initial pilot test and make specific recommendations for the extended (one-year) pilot test which will determine the long-term impact of bioventing on site contaminants. Site history, known contamination distributions and concentrations, and geologic/hydrogeologic profiles are documented in Part I, Bioventing Pilot Test Work Plan.

1.1 Introduction

Installation of one Vent Well (VW) and three Vapor Monitoring Points (VMPs) was conducted at the AGE Maintenance Area Site between 19 and 22 April 1993. Locations of the VW and VMPs are shown on Figure 1.1. No background VMP was installed at the site. The background VMP installed at IRP Site 3 during a previous bioventing pilot test will be utilized for baseline soil measurements. Borehole drilling services were provided by Tonto Environmental Drilling, Inc. of Sacramento, California. Soil sampling and well installation was directed on site by Mr. Henry Pietropaoli of the ES-Alameda office.

Four boreholes were drilled at the site, and all were converted to either a VW or a VMP. No boreholes were abandoned since contamination observed during drilling was at sufficient levels for VW and VMP siting. Soil samples from split-spoon and/or continuous sampling were collected for field organic vapor analysis (OVA) to determine appropriate VW and VMP screened intervals and total depths. Both a total hydrocarbon vapor analyzer (THVA) and photoionization detector (PID) were used to screen field samples. Soil samples were also collected for laboratory analysis. Table 1.1 summarizes pertinent borehole data.

FIGURE 1.1



SOURCE: MODIFIED FROM CH2M HILL, 1989

AS -BUILT VW, VMP AND BLOWER
SITE 11, AGE MAINTENANCE AREA

BEALE AIR FORCE BASE
CALIFORNIA

REV. 3 C252-11.DWG 10/04/93

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TABLE 1.1
BOREHOLE, SOIL SAMPLE, VMP/VW SUMMARY DATA
IRP Site 11: AGE Maintenance Area
Beale AFB, California

BOREHOLE ID #	BOREHOLE TOTAL DEPTH (ft. bgs)	SPLIT-SPOON INTERVAL (ft. bgs)	THVA/PID HEADSPACE READINGS (PPM)	SOIL SAMPLE ID #	START DATE	COMPLETION DATE	COMPLETION DESIGNATION
1	55.0	6.5 – 8.0	0/16	–	19Apr93	22Apr93	VMP-1
		8.0 – 9.5	0/27	–			
		16.0 – 17.5	1900/2352	–			
		23.0 – 24.5	2050/2212	BE11-VMP1-24.5			
		28.0 – 29.5	410/106	–			
		33.5 – 35.0	6/8	–			
		38.5 – 40.0	190/88	–			
		43.5 – 45.0	35/42	–			
		48.5 – 50.0	45/37	–			
2	52.0	3.0 – 4.5	16/22	–	20Apr93	22Apr93	VW-1
		8.5 – 10.0	160/24	–			
		13.5 – 15.0	1200/1407	–			
		26.0 – 27.5	3860/2800	–			
		28.5 – 30.0	8800/3256	BE11-VW1-30			
		33.5 – 35.0	68/27	–			
		38.5 – 40.0	1400/1045	–			
		42.0 [a]	5200/3027	–			
		43.5 – 45.0	180/115	–			
		48.5 – 50.0	26/12	–			
3	54.5	5.0 [a]	110/32	–	20Apr93	22Apr93	VMP-2
		10.0 [a]	820/462	–			
		25.5 [a]	10000+/2389	BE11-VMP2-25.5			
		–	–	BE11-VMP4-22 [b]			
		30.0 [a]	5550/2572	–			
		35.0 [a]	1700/2200	–			
		40.0 [a]	1100/1517	–			
		47.5 [a]	850/437	–			
		50.0 [a]	390/1378	–			
4	54.0	3.5 – 5.0	0/0	–	21Apr93	22Apr93	VMP-3
		8.5 – 10.0	0/32	–			
		13.5 – 15.0	620/702	–			
		19.0 – 20.5	NR	–			
		23.5 – 25.0	3200/2381	–			
		28.5 – 30.0	0/1	–			
		33.5 – 35.0	0/0	–			
		38.5 – 40.0	3/9	–			
		43.5 – 45.0	0/15	–			
		48.5 – 50.0	0/5	–			

NOTES:

[a] – Depth represents the location of THVA/PID readings in a cintinuously sampled borehole.

[b] – Sample BE11-VMP4-22 is a duplicate of BE11-VMP2-25.5

NR – THVA/PID readings were not recorded.

b:\site11\bealAGE1.wk1

1.2 Soil Profile

Figure 1.2 is a geologic cross-section of the pilot test site using data from the VW and VMPs. The interpreted soil profile is shown along with OVA readings, VW and VMP screened intervals, and Total Recoverable Petroleum Hydrocarbon (TRPH) concentrations from laboratory analysis of soil samples. The soil boring logs are included as Appendix A. Groundwater was not encountered in any of the borings. Part I of this report indicates a depth to groundwater of approximately 100+ feet bgs at this site.

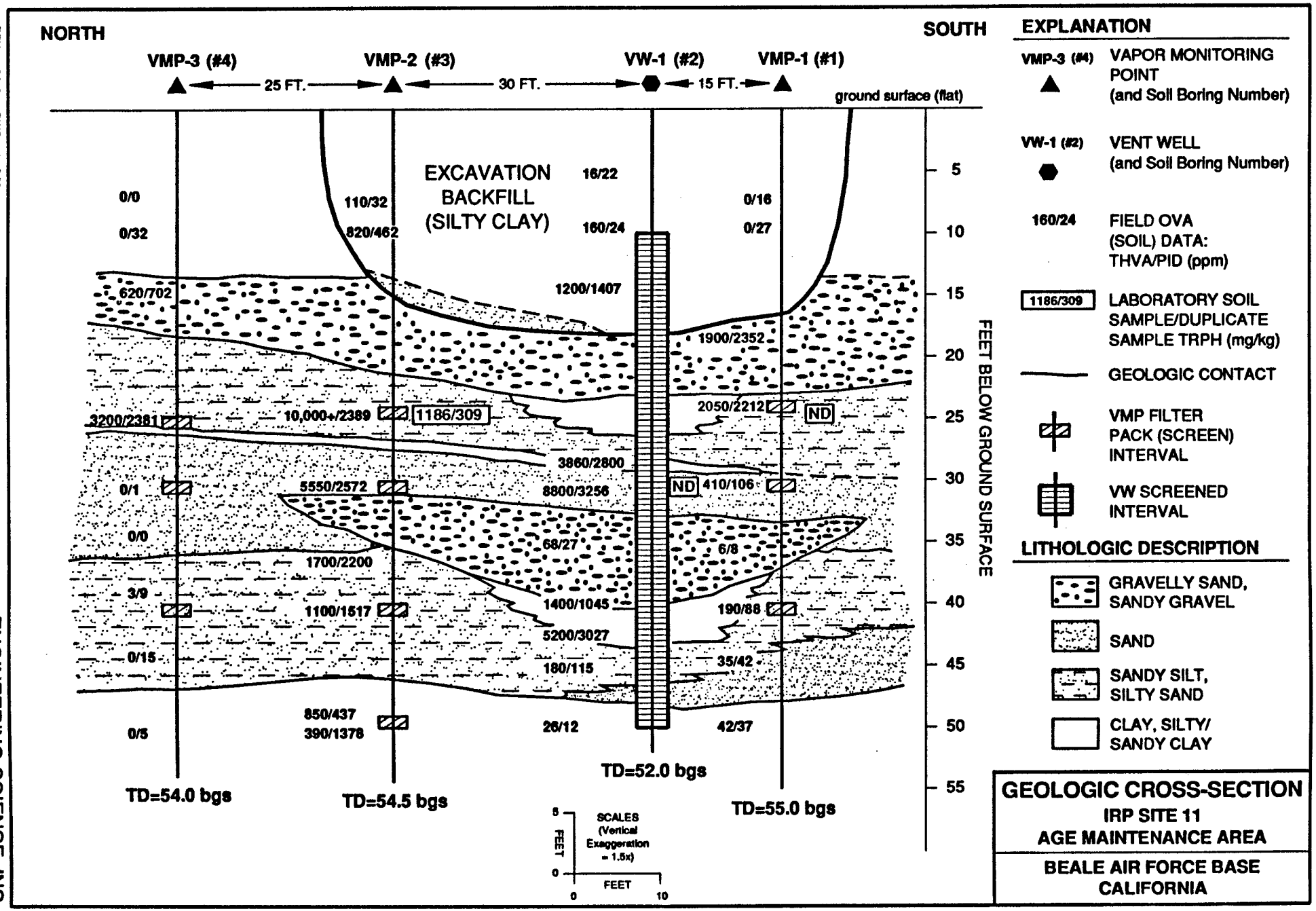
Backfill material for the former excavation is composed predominantly of silty clay with common gravel-sized fragments up to 2 inches in diameter. Much of the fill material had a putrid sewage-like odor. A mild fuel odor was noticeable at the bottom portion of the fill in 2 of the 3 borings (VMP-1 was the exception) that were drilled through the fill. The bottom foot of the fill in VMP-2 is clayey, fine-grained, sand-sized material. The base of the fill material was observed to be between 14 and 17 feet bgs in the three borings. Information from the excavation operations conducted in June 1992 reported the maximum depth of soil excavation was 30 feet bgs (see Part I). The borings recently installed indicate a much shallower excavation.

Fuel odor was noticed in the native soils of all 4 borings over a variable range of depths. Conspicuous fuel odors were noted in VMP-1 from 16 to 37 feet bgs, in VW-1 from 23 to 26 and 38 to 43 feet bgs, in VMP-2 from 15 to 46 feet bgs, and in VMP-3 from 12 to 26 feet bgs.

The native soil profile from surface to about 55 feet bgs at the site as observed in the borings is predominately coarse-grained soil (sands and gravels) and is characterized by layered intervals of various grain sizes. A prominant sandy gravel zone at the base of the excavation was encountered to as deep as 23 feet bgs and was found in all borings. Observed gravel clasts were as large as 3 inches in diameter. A predominantly clayey, silty sand interval of 5- to 7-foot thickness underlies the gravel zone, except in VW-1 where this sand interval is replaced by a silty clay of 3-foot thickness. A fuel odor was noted in the gravel and underlying sand in all borings except VW-1. In VW-1, a fuel odor was noticed in the clay interval.

A 6-inch clay layer was encountered in 3 borings between 25 and 28 feet bgs, below which is a massive sand zone ranging in thickness from 8 to 12 feet. In 3 borings, the basal portion of this sand zone is a coarse, gravelly sand from 4 to 7 feet thick. Below this zone is an 8- to 12-foot thick interval composed primarily of sandy silts and silty, clayey sands. This interval in VW-1 also had a silty clay zone and a sand zone, and in VMP-1 this interval was also partly a sand. Fuel odors were noticeable in both VW-1 and VMP-2 in the basal portion of the coarse sand and in the underlying sediment to a depth of 43 feet bgs.

The base of the observed soil profile, in the lower 4 to 8 feet of each boring, is a sandy, silty clay interval grading to a clayey silt to the south (VMP-1). The thickness of this interval is unknown.



GEOLOGIC CROSS-SECTION
IRP SITE 11
AGE MAINTENANCE AREA
BEALE AIR FORCE BASE
CALIFORNIA

FIGURE 1.2

REV. 4 C252-15.DWG 10/1/93

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1.3 Air Injection Vent Well

One air injection VW (VW-1) was installed in a location of highly contaminated soil following procedures described in the protocol document (Hinchee et al., 1992). VW-1 was installed within the area of the former excavation, 26 feet north of the above ground fuel storage tank pad, and 17 feet west of the pavement area that includes an above ground pump island (see Figure 1.1). Table 1.2 shows construction data and Figure 1.3 shows construction details for VW-1.

VW-1 was constructed using 4-inch inside diameter (ID), Schedule 40 polyvinyl chloride (PVC) casing and slotted screen (0.040-inch slot size). The annular space adjacent to the screen was filled with size 6-12 Lone Star sand (filter pack material) from the base of the borehole to 1 foot above the top of the screen. A small amount of size 1-C Lone Star sand was added to the top of this interval to inhibit penetration of the overlying bentonite seal material into the filter pack interval.

To prevent preferential air movement near the surface during pilot testing, a 2-foot thick annular bentonite seal was emplaced on the top of the filter pack. A 5-foot thick layer of bentonite/cement grout was emplaced on top of the bentonite seal to provide a complete seal to the surface. The upper 2 feet of annular space was left vacant for ease of connecting subsurface piping for pilot testing and possible future full-scale remediation system implementation. The well casing was left extending 2 feet above the ground surface until the initial pilot test was performed. The well casing was connected directly to the portable blower unit above ground for the initial pilot test and then to the fixed blower unit located adjacent to the well for the extended pilot test.

1.4 Vapor Monitoring Points

The three VMPs were installed in a line parallel to and 17 feet west of the pavement area that includes the pump island. This line of wells is north of the above ground fuel storage tank pad. VMP-1 and VMP-2 were installed within the area of the former excavation. VMP-1 was located 15 feet south of VW-1, and VMP-2 was located 30 feet north of VW-1 (see Figure 1.1). Both these VMPs are in an area of highly-contaminated native soil. VMP-3 was installed in an area of generally less-contaminated soil and was located 55 feet north of VW-1, approximately 17 feet north of the former excavation surface boundary.

All VMPs were installed following procedures described in the protocol document (Hinchee et al., 1992). Table 1.2 shows construction data and Figure 1.4 shows construction details of the VMPs. All VMPs have nearly identical construction details, with the exception of VMP-2, which has an additional VMP screen within the lower clay zone. Each VMP was constructed using 0.25-inch ID, Schedule 80 PVC casing and 1-inch ID slotted screen intervals (0.020-inch slot size). Three casing strings/screens were installed in each VMP borehole at depths of approximately 24.0, 30.5, and 40.5 feet bgs to provide monitoring points at variable depths, soil types, and contamination levels. The additional casing string/screen in VMP-2 was installed at 49.5 feet bgs due to the high soil OVA readings and to provide monitoring within the lower clay zone.

TABLE 1.2

VMP/VW CONSTRUCTION DATA
IRP Site 11: AGE Maintenance Area
Beale AFB, California

WELL ID #	BOREHOLE TOTAL DEPTH (ft.bgs)	VW SCREEN INTERVAL (ft.bgs)	CENTER of VMP SCREEN (ft.bgs)	FILTER PACK INTERVAL(s) (ft.bgs)	BENTONITE INTERVAL(s) (ft.bgs)	GROUT INTERVAL(s) (ft.bgs)
VW-1	52.0	10 – 50	–	9.0 – 52.0	7.0 – 9.0	2.0 – 7.0
VMP-1	55.0	–	24.0	23.5 – 24.5	3.0 – 23.5	None
			30.5	30.0 – 31.0	24.5 – 30.0	
			40.5	40.0 – 41.0	31.0 – 40.0	
					41.0 – 55.0	
VMP-2	54.5	–	24.0	23.5 – 24.5	3.0 – 23.5	None
			30.5	30.0 – 31.0	24.5 – 30.0	
			40.5	40.0 – 41.0	31.0 – 40.0	
			49.5	49.0 – 50.0	41.0 – 49.0	
					50.0 – 54.5	
VMP-3	54.0	–	24.0	23.5 – 24.5	3.0 – 23.5	None
			30.5	30.0 – 31.0	24.5 – 30.0	
			40.5	40.0 – 41.0	31.0 – 40.0	
					41.0 – 54.0	

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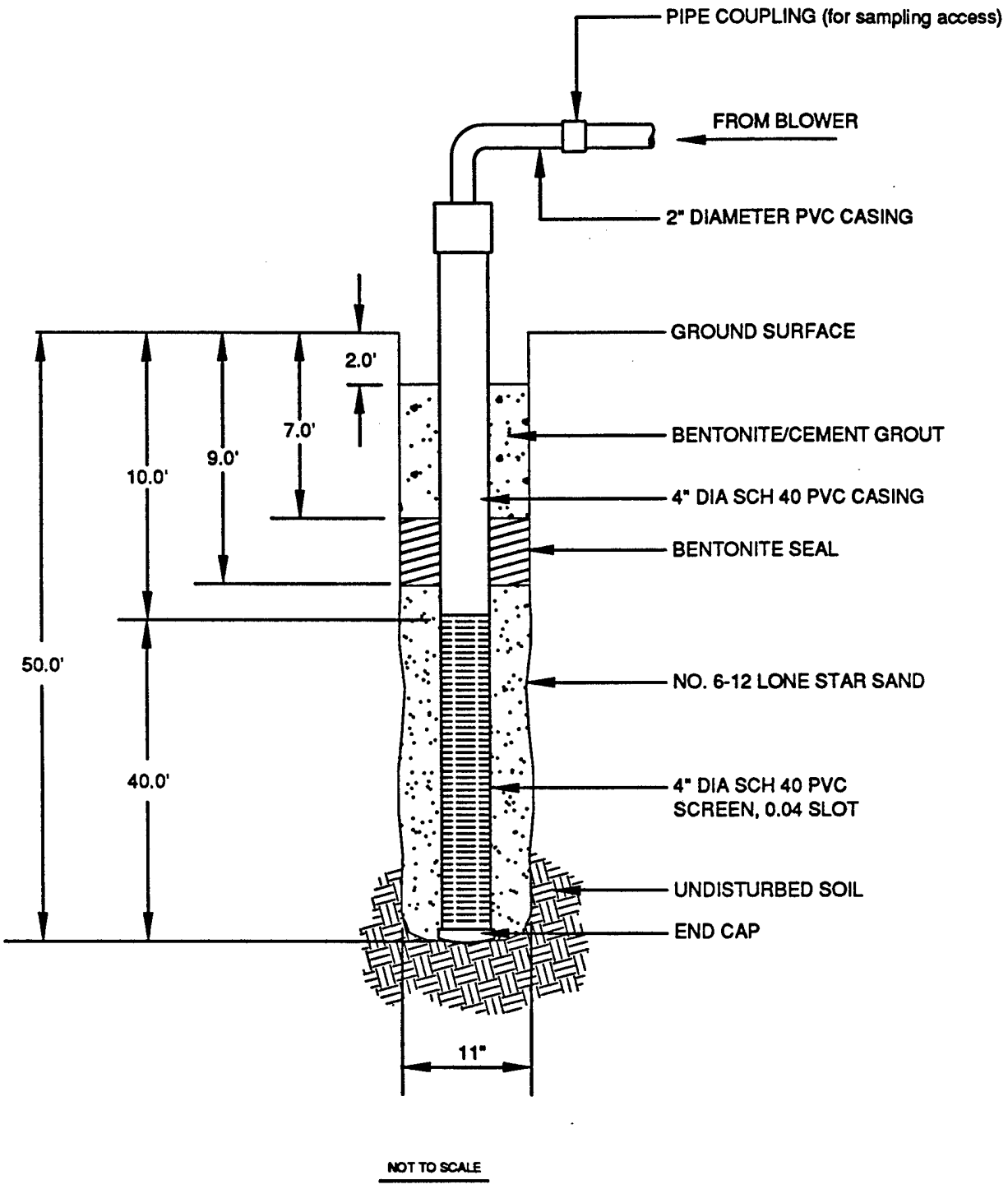
FIGURE 1.3



NOTE: SEE TABLE 1.2 FOR DETAILS

AS-BUILT INJECTION VENT WELL CONSTRUCTION DETAIL
IRP SITE 11
AGE MAINTENANCE AREA

BEALE AIR FORCE BASE
CALIFORNIA

REV. 2 C252-12.DWG 06/28/93

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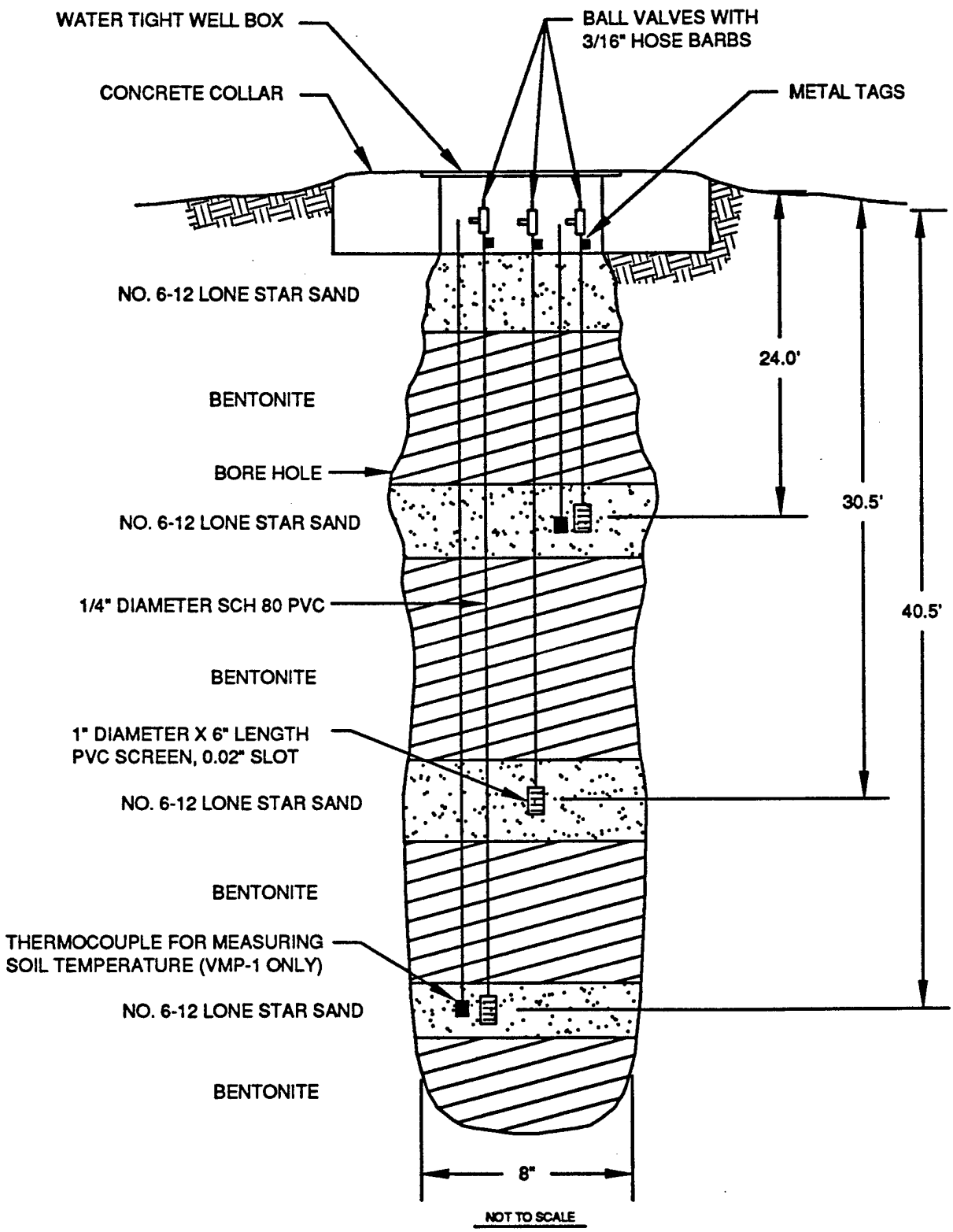
FIGURE 1.4



NOTE: A FOURTH VAPOR MONITORING POINT WAS INSTALLED IN VMP-2 AT 49.5 FT. BGS.

AS-BUILT VAPOR MONITORING POINT CONSTRUCTION DETAIL
IRP SITE 11
AGE MAINTENANCE AREA

BEALE AIR FORCE BASE
CALIFORNIA

REV. 1 C252-14.DWG 05/17/93

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Each of the screened intervals were 6 inches in length at the bottom of each individual PVC casing string, and were centered in a 1-foot thick layer of size 6-12 Lone Star sand (filter pack) topped with a thin layer of size 1-C Lone Star sand. These filter pack intervals were sealed above and below with bentonite. A sampling valve was coupled at the top of each casing string. In VMP-1, thermocouples were installed adjacent to the shallow and deep screens to allow measurement of soil temperature. The surface of each VMP was completed with a flush-mount well box set in a concrete base sloped away from the box for drainage.

1.5 Blower Unit

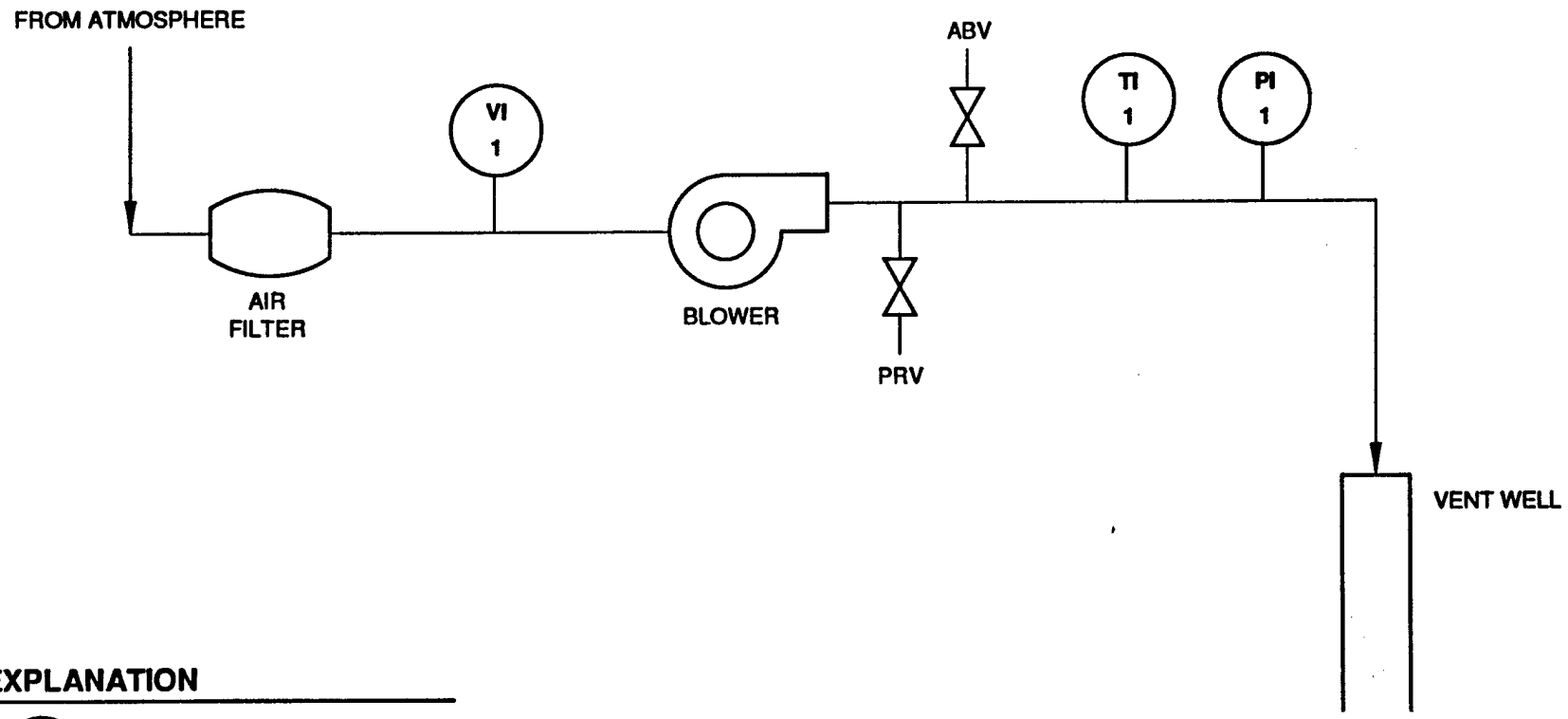
A portable 3.0-horsepower (HP) Roots™ positive displacement blower unit was used for the initial pilot test and was powered by an on site 230V, single-phase, 30A line from an above-ground power line and breaker provided by the base. A fixed 1.0-HP Gast™ regenerative blower unit (model R4) was installed on 15 May 1993 for the extended pilot test. This unit is powered by the same line used for the portable unit. Locations of the power pole and blower are shown on Figure 1.1.

The fixed blower unit is currently injecting approximately 80 standard cubic feet per minute (scfm) for the extended pilot test. Figure 1.5 shows the configuration, instrumentation, and specifications for this system. ES personnel provided an operations and maintenance (O&M) data collection sheet and blower maintenance manual to base personnel before departing the site. A copy of the data collection sheet and manual is provided as Appendix B.

1.6 Exceptions to Test Protocol Document Procedures

Procedures described in the protocol document (Hinchee et al., 1992) related to pilot test design and construction were used with the following exceptions:

- Borehole diameters for the VMPs were 8 inches instead of 11 inches.
- Lone Star 6-12 sand was used for filter pack material in all VMPs and the VW instead of 6-9 silica sand.



EXPLANATION

PI 1	PRESSURE INDICATOR
TI 1	TEMPERATURE INDICATOR
ABV	AIR BLEED VALVE
PRV	PRESSURE RELIEF VALVE
VI 1	VACUUM INDICATOR

AS-BUILT BLOWER SYSTEM INSTRUMENTATION DIAGRAM FOR AIR INJECTION

IRP SITE 11
AGE MAINTENANCE AREA

BEALE AIR FORCE BASE
CALIFORNIA

FIGURE 1.5

2.0 PILOT TEST SOIL AND SOIL-GAS SAMPLING RESULTS

2.1 Soil Sample Field Analysis

Contaminated soils were identified based on field observations such as visual appearance, odor, and OVA readings. OVA readings were monitored using both a PID and a THVA on all soil samples in order to estimate the relative amount and extent of soil contamination detectable by such devices. Neither OVA device showed consistently higher or lower readings (see Table 1.1).

2.2 Soil Sample Laboratory Analysis

Soil samples for laboratory analysis were collected by using a hammer-driven split-spoon sampler lined with brass sleeves. The samples were preserved in the brass sleeves and capped with Teflon™ tape and plastic end-caps. Selection of soil samples for laboratory analysis was based in part on field OVA readings. Samples from VMP-1 and VMP-2 boreholes with the highest OVA readings were selected for laboratory analysis and were collected from a depth of approximately 24 feet bgs. The sample from the VW-1 borehole with the highest OVA reading was also selected for laboratory analysis and was collected from a depth of approximately 30 feet bgs (see Table 1.1).

The selected soil samples were shipped via Federal Express™ to Pace Laboratories (formerly known as ES Laboratory) in Berkeley, California for chemical and physical analysis. Analytes were: total recoverable petroleum hydrocarbons (TRPH); benzene, toluene, ethylbenzene, and total xylenes (BTEX); iron; alkalinity; hydrogen ion index (pH); total Kjeldahl nitrogen (TKN); phosphates; moisture; and grain size distribution. Samples to be analyzed for TKN, phosphates, and grain size distribution were transferred to Sequoia Analytical in Redwood City, California. The results of all analyses are summarized in Table 2.1. Chain-of-custody forms are included in Appendix C. The TRPH concentrations are also included on the geological cross section (Figure 1.2).

2.3 Soil-Gas Sample Laboratory Analysis

Subsurface soil-gas samples were collected for laboratory analysis in Summa® cannisters. These samples were collected from the vent well (VW-1), the screen at 24.0 feet bgs in VMP-1, and the screen at 24 feet bgs in VMP-3 after purging the individual casings of at least one volume of air. The soil-gas samples were shipped via Federal Express™ to Air Toxics, Ltd. in Rancho Cordova, California for analysis of total volatile hydrocarbons as jet fuel (TVH-jf) and BTEX. The results of these analyses are summarized in Table 2.1. The chain-of-custody form is included in Appendix C.

Additional soil-gas samples were collected during the air permeability test for laboratory analysis to determine potential emissions of TVH-jf and BTEX to the atmosphere resulting from air injection during the pilot test (described in detail in Section 3.5 of this report). Two samples were collected at a surface location 17 feet to the south of VW-1. One sample was collected prior to the start of air injection (sample BKT-1) and one sample 4 hours after the start of air injection (sample BKT-2) during the air

TABLE 2.1

SOIL and SOIL GAS ANALYTICAL RESULTS
IRP Site 11: AGE Maintenance Area
Beale AFB, California

ANALYTE	UNITS	SAMPLE LOCATION - DEPTH (well number and feet below ground surface)			
Soil Hydrocarbons:		**VW1-30**	**VMP1-24.5**	**VMP2-25.5**	**VMP2-25.5(dup)**
TRPH	(mg/kg)	ND	ND	1,186	309
Benzene	(mg/kg)	0.0035	1.8	ND	ND
Toluene	(mg/kg)	0.02	1.8	150	48
Ethylbenzene	(mg/kg)	0.0043	0.11	68	27
Total Xylenes	(mg/kg)	0.039	0.65	510	190
Soil Inorganics:		**VW1-30**	**VMP1-24.5**	**VMP2-25.5**	**VMP2-25.5(dup)**
Iron	(mg/kg dry wt.)	16,400	20,800	16,500	16,100
Alkalinity	(mg/kg as $CaCO_3$)	590	200	89	85
pH	(units)	8.2	8.0	8.3	8.3
TKN	(mg/kg dry wt.)	ND	29	ND	ND
Phosphates	(mg/kg dry wt.)	720	1,100	730	730
Soil Physical Parameters:		**VW1-30**	**VMP1-24.5**	**VMP2-25.5**	**VMP2-25.5(dup)**
Moisture	(% by wt.)	12.6	23.6	15.3	15.8
Gravel	(% by wt.)	0.0	0.0	0.0	0.7
Sand	(% by wt.)	88.0	90.7	84.0	83.7
Silt	(% by wt.)	2.1	6.2	12.9	10.8
Clay	(% by wt.)	9.9	3.1	3.1	4.7
Soil Gas Hydrocarbons:		**VW1**	**VMP1-24.0**	**VMP3-24.0**	
TVH-jf	(ppmv)	51,000	72,000	55,000	
Benzene	(ppmv)	30	430	580	
Toluene	(ppmv)	74	550	970	
Ethylbenzene	(ppmv)	13	40	59	
Total Xylenes	(ppmv)	310	240	350	

Soil Gas Hydrocarbons (at surface):		**BKT-1**	**BKT-2**
TVH-jf	(ppmv)	600	780
Benzene	(ppmv)	1.0	4.0
Toluene	(ppmv)	7.8	16
Ethylbenzene	(ppmv)	1.2	1.7
Total Xylenes	(ppmv)	16	16

NOTES:

(dup) - Duplicate sample; sample ID: BE11-VMP4-22
TRPH - Total recoverable petroleum hydrocarbons
TVH-jf - Total volatile hydrocarbons as jet fuel
TKN - Total Kjeldahl nitrogen
ppmv - Parts per million by volume
$CaCO_3$ - Calcium carbonate
mg/kg - milligrams per kilogram
ND - Not Detected
NA - Not Analyzed

permeability test. These "bucket" or flux-chamber samples were collected in Summa® cannisters. The results of these analyses are shown in Table 2.1.

2.4 Field QA/QC Results

A duplicate soil sample (field duplicate) was collected from the VMP-2 borehole at approximately 25 feet bgs. The regular sample was designated as "BE11-VMP2-25.5", and the duplicate sample was designated as "BE11-VMP4-22" so the laboratory would not be able to identify the sample as a duplicate. Analytes for the duplicate sample were the same as for the regular sample (Table 2.1). The two analyses resulted in nearly identical measurements of their soil inorganics and soil physical parameters. A higher level of fuel hydrocarbon contamination was detected in the regular sample than detected in the duplicate. This may be a result of a heterogeneous distribution of fuel-hydrocarbon contamination in the soil sample.

2.5 Subsurface Contamination

The extent of the hydrocarbon contamination remains unknown. All boreholes encountered evidence of hydrocarbon contamination. Field evidence suggests that the contamination is greatest in the central and southern areas of the site and may extent to depths greater than 50 feet below ground surface. The highest OVA readings in each boring were recorded in the sandy layers between 23 and 46 feet below ground surface (Figure 1.2). A noticeable fuel odor was encountered in all boreholes and was noted at depths as great as 46 feet below ground surface in VMP-2.

Laboratory analysis of soil and soil-gas samples showed hydrocarbon contamination in all wells. TVH-jf greater than 50,000 ppmv and significant BTEX was detected in all soil-gas samples, indicating that the vadose zone has significant fuel hydrocarbon contamination. Although TRPH was detected only in soil samples from VMP-2, the TRPH laboratory test analyzes for only a fraction of the range of jet fuel, and this could indicate gasoline contamination and/or a very fresh jet fuel spill. More importantly, the sandy soils which underlay the site have likely produced a heterogeneous contaminant distribution. Supporting evidence for this interpretation is provided by the widely varying laboratory results for soils, but consistently high results for soil gas.

2.6 Exceptions to Test Protocol Document Procedures

Procedures described in the protocol document (Hinchee et al., 1992) related to soil and soil-gas sampling were used with the following exceptions:

- Soil samples were screened in the field (OVA readings) using both a THVA and a PID in order to compare data from both devices.
- Surface soil-gas samples were collected during the air permeability test and were analyzed for TVH-jf and BTEX. This sampling was performed at the request of Beale AFB since the Feather River Air Quality Management District had requested similar sampling at a previous bioventing pilot test site at Beale AFB (IRP Site 3).

3.0 PILOT TEST RESULTS

3.1 Initial Soil-Gas Chemistry

Prior to initiating any air injection, all VMPs were purged until oxygen levels had stabilized, and then initial oxygen and carbon dioxide concentrations were sampled using portable gas analyzers, as described in the protocol document (Hinchee et al., 1992). Depleted oxygen levels and increased carbon dioxide levels were found in soil gas at all VMP screened intervals, indicating significant soil contamination and natural biological activity. The initial soil-gas chemistry measured at IRP Site 11 shows significant contamination at 24.0 to 49.5 feet bgs as summarized in Table 3.1. TRPH and BTEX data for soil samples are also provided to demonstrate the relationship between oxygen levels and the contaminated soils.

3.2 Air Permeability

An air permeability (AP) test was conducted on 11 and 12 May 1993 according to protocol document procedures. Air was injected at VW-1 for approximately 18 hours at a rate of 33 scfm with an average pressure at the well head of 55 inches H_2O. The pressure responses at the VMPs are shown in Figures 3.1 through 3.4.

Due to the slow response and relatively long time to achieve steady-state, the dynamic response method was used to calculate air permeability values, as detailed in the protocol document. Calculated air permeabilities for each VMP and depth are shown in Figures 3.1 through 3.4. Permeability values ranged from 22 to 43 darcys, values typical for the sandy soils which were found at Site 11. Significant pressure response was noted at all VMPs and at all depths. The permeability values from the VMPs indicate that the site soils are very permeable to air.

3.3 Oxygen Influence

The depth and radius of oxygen influence in the subsurface resulting from air injection into the VW during pilot testing is the primary design parameter for extended bioventing systems. The pilot test data determine the volume of soil that can be oxygenated at a given flow rate and vent well screen configuration.

Table 3.2 presents the change in soil-gas chemistry during the AP test. Changes in soil-gas oxygen levels were monitored at VMP1-24, VMP2-49.5, and VMP3-30.5 indicating successful oxygen transport in all VMPs and to a distance of at least 55 feet.

Based on measured pressure response, which is an indicator of long-term oxygen transport, and the change in oxygen levels during the AP test, it is anticipated that the radius of oxygen influence for a long-term bioventing system at this site will be at least 55 feet from VW-1. The effective treatment radius for the extended pilot test will be better defined by monitoring the oxygen and contaminated soil-gas levels during the extended pilot test at the site.

Table 3.1
INITIAL CONDITIONS
IRP Site 11: AGE Maintenance Area
Beale AFB, California

	SOIL GAS				SOIL				
Well No.– depth	O_2 (%)	CO_2 (%)	TVH–jf (ppmv)	TVH (ppmv)	TRPH (mg/kg)	Benzene (mg/kg)	Toluene (mg/kg)	Ethylbenzene (mg/kg)	Total Xylenes (mg/kg)
VW1–(10 – 50)	2.0	8.0	51,000	9,600	ND	0.0035	0.02	0.0043	0.039
VMP1–24	3.0	11.0	72,000	>10,000	ND	1.8	1.8	0.11	0.65
VMP1–30.5	2.8	7.5		>10,000					
VMP1–40.5	3.0	7.0		>10,000					
VMP2–24	2.0	6.8		>10,000	1,186	ND	150	68	510
VMP2–30.5	3.5	7.2		>10,000					
VMP2–40.5	3.0	6.6		>10,000					
VMP2–49.5	2.2	6.2		7,800					
VMP3–24	1.0	6.6	55,000	2,000					
VMP3–30.5	1.5	7.8		9,200					
VMP3–40.5	1.6	5.8		5,600					

LEGEND

: Sample was not taken/analyzed.

TRPH : Total Recoverable Petroleum Hydrocarbons (EPA 418.1)

TVH–jf : Total Volatile Hydrocarbons as jet fuel (EPA TO–3)

TVH : Total Volatile Hydrocarbons (THVA field instrument)

ND : not detected

mg/kg : milligrams per kilogram

ppmv : parts per million by volume

NOTES

1. O_2/CO_2 measurements by field instrumentation.
2. Depths for soil samples are shown in Table 2.1
3. Benzene, Toluene, Ethylbenzene, and Total xylenes by EPA Method 8020.

s11tab31

09/25/93

FIGURE 3.1

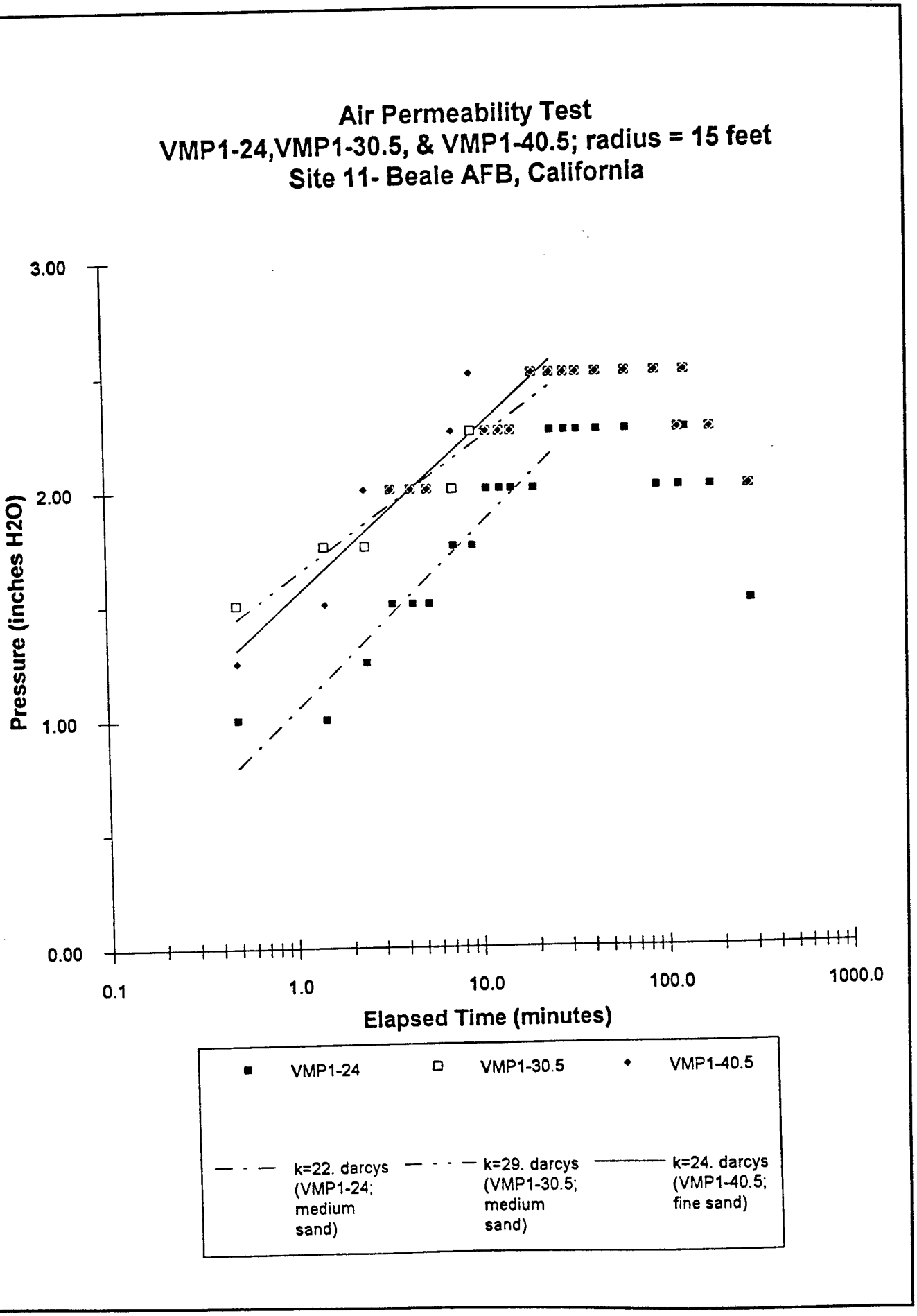


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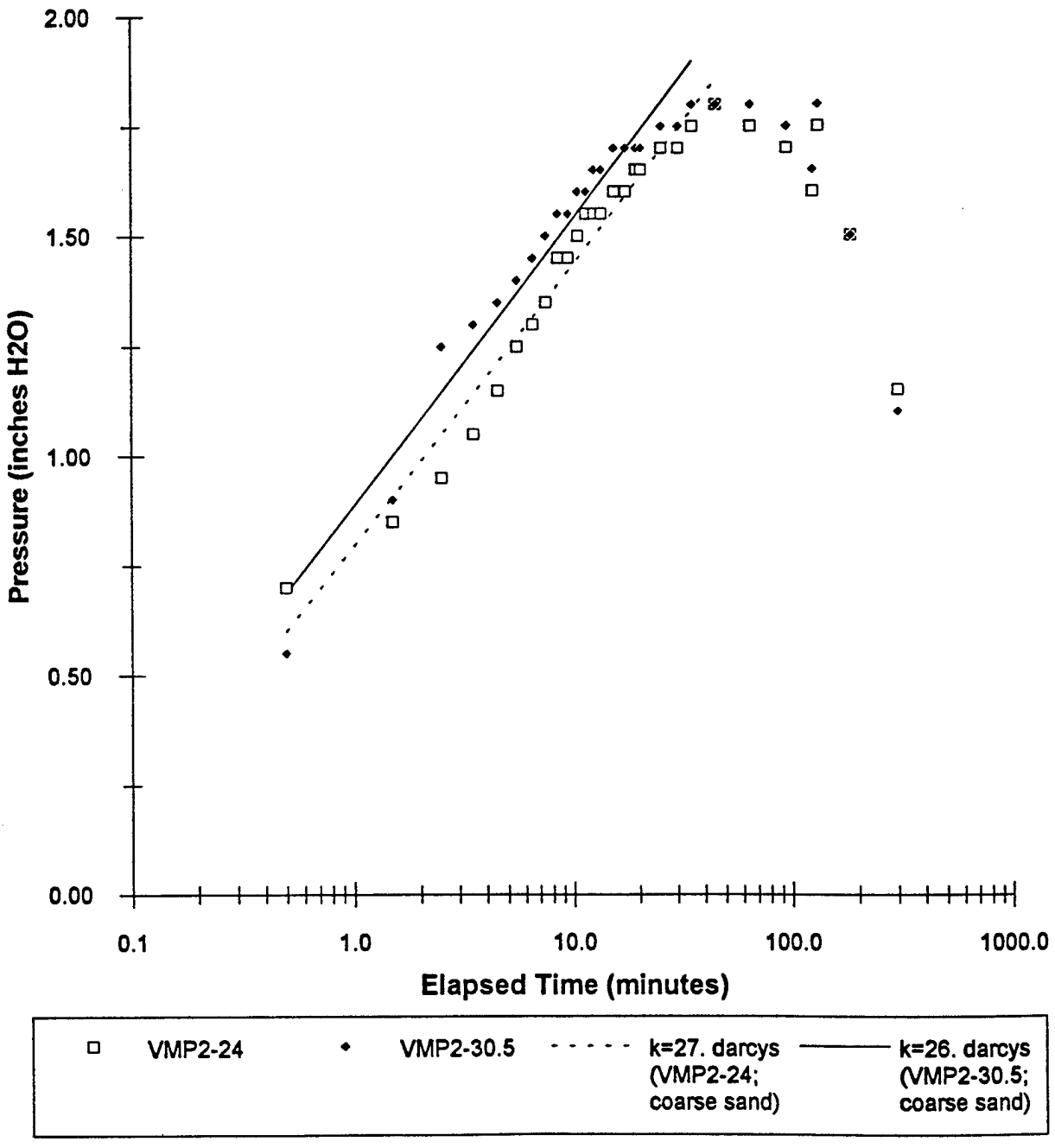
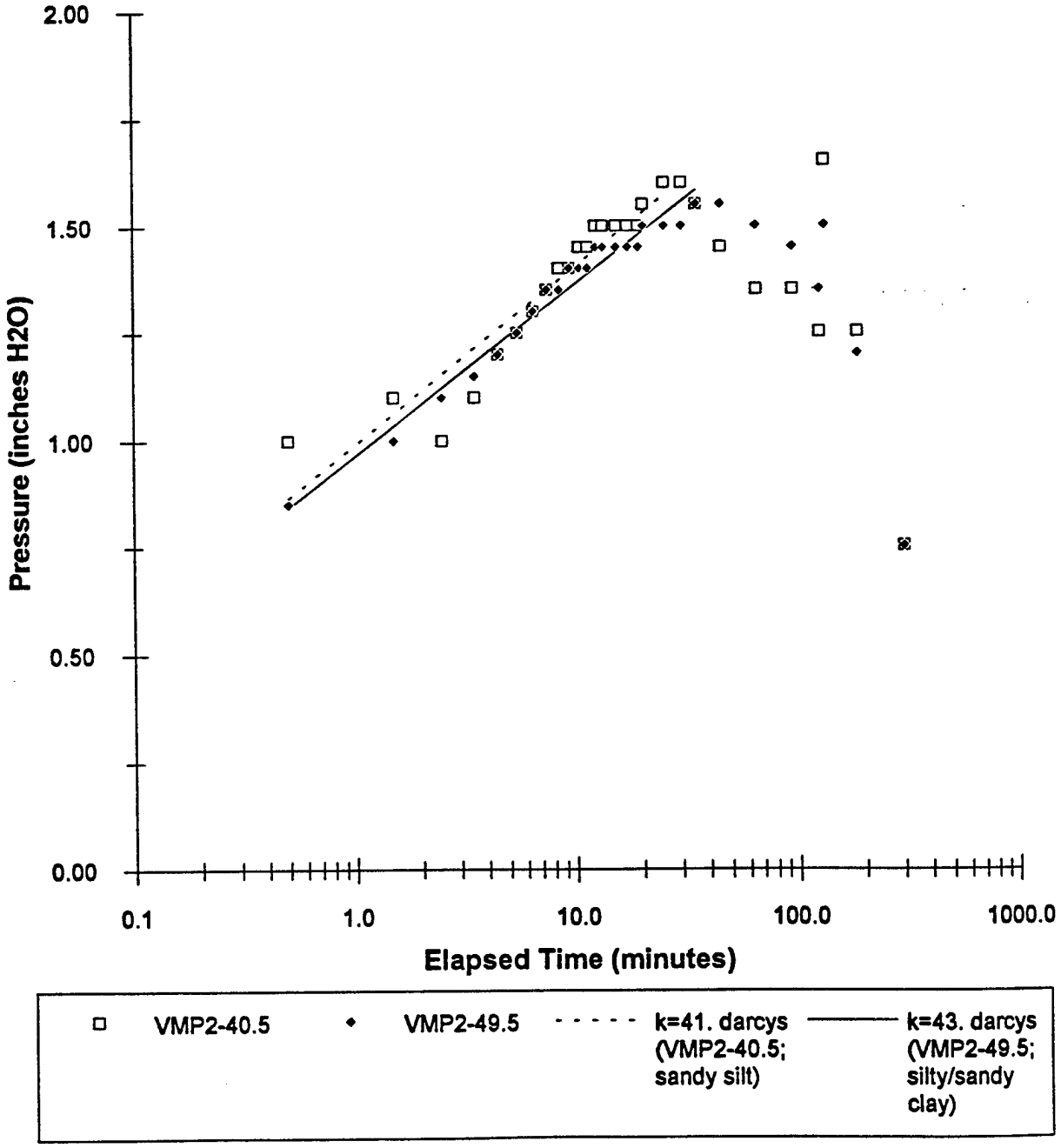
FIGURE 3.2


Air Permeability Test
VMP2-24 & VMP2-30.5, radius = 30 feet
Site 11- Beale AFB, California
2.00
1.50
1.00
0.50
0.00
Pressure (inches H2O)
0.1
1.0
10.0
100.0
1000.0
Elapsed Time (minutes)
VMP2-24
VMP2-30.5
k=27. darcys (VMP2-24; coarse sand)
k=26. darcys (VMP2-30.5; coarse sand)

Air Permeability Test
VMP2-40.5 & VMP2-49.5, radius = 30 feet
Site 11- Beale AFB, California



Air Permeability Test
VMP3-24, VMP3-30.5, & VMP3-40.5, radius = 55 feet
Site 11- Beale AFB, California

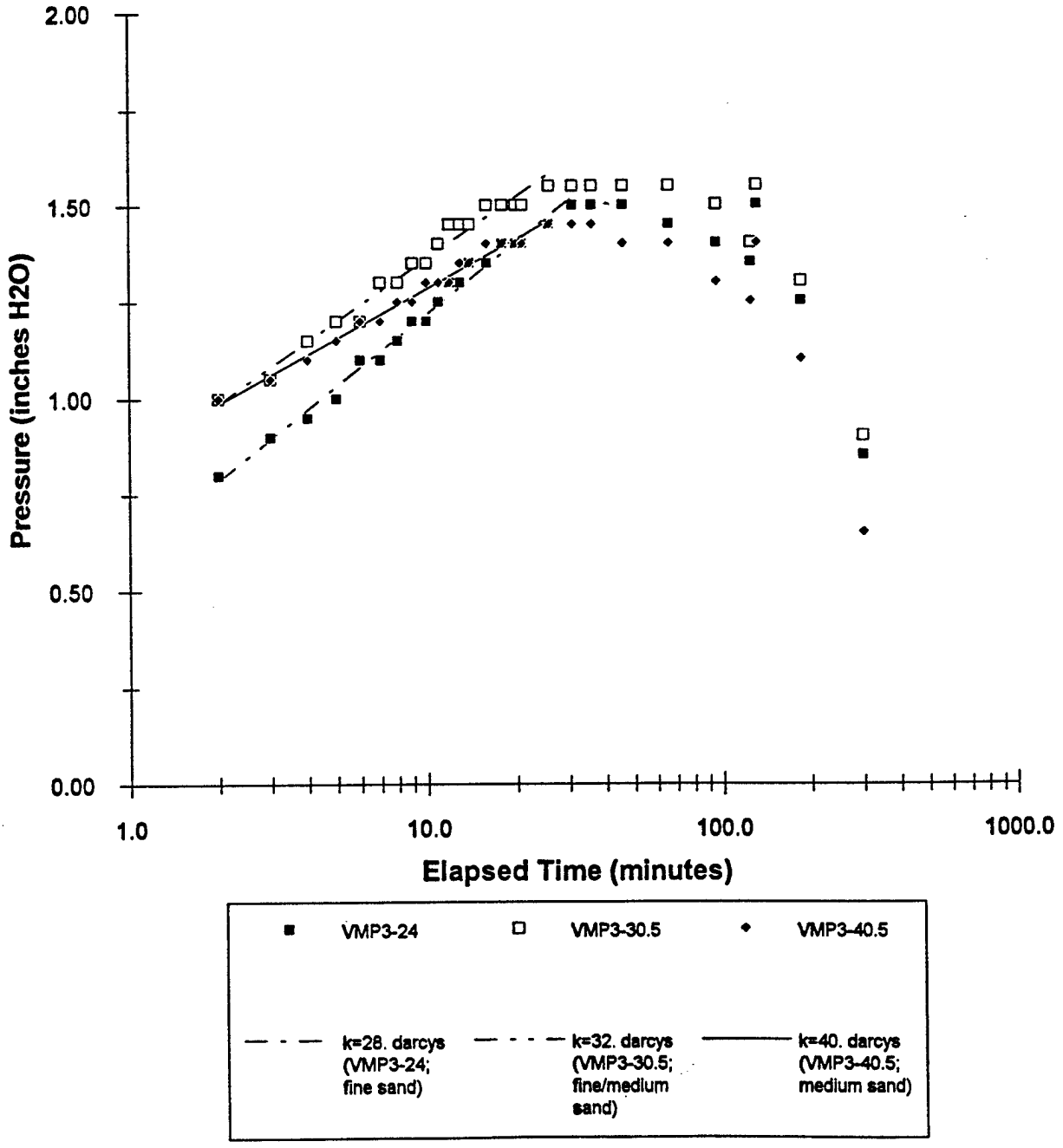


Table 3.2
INFLUENCE OF AIR INJECTION ON OXYGEN LEVELS
AGE Maintenance Area (Site 11)
Beale AFB, California

Well No.– depth	Distance from VEW–1 (ft)	Inital O_2 (%)	Final O_2[1] (%)
VMP1–24	15	3.0	9.5
VMP1–30.5	15	2.8	
VMP1–40.5	15	3.0	
VMP2–24	30	2.0	
VMP2–30.5	30	3.5	
VMP2–40.5	30	3.0	
VMP2–49.5	30	2.2	10.5
VMP3–24	55	1.0	
VMP3–30.5	55	1.5	12.0
VMP3–40.5	55	1.6	

LEGEND

: Sample was not taken/analyzed.

[1] : Final O_2 results taken after 18 hrs of air injection.

s11tab32

10/11/93

3.4 *In Situ* Respiration Rates

An *in situ* respiration (ISR) test was conducted between 12 and 15 May 1993 according to protocol procedures. Air (20.8 percent oxygen) was injected at a rate of 1 scfm into three VMP screened intervals (VMP1-24, VMP2-24, and VMP3-30.5) for 23.5 hours in order to oxygenate surrounding soils. After air injection was ceased, oxygen, carbon dioxide, and TVH levels were measured in soil gas for the following 50 hours. Oxygen utilization rates were then calculated and used to estimate biodegradation rates. The results of the ISR test at this site are presented in Figures 3.5 to 3.7.

Results from the ISR test were mixed. The oxygen utilization rate at VMP2-24 was slow, 0.047% per hour, yet the highest levels of fuel-hydrocarbon contamination in soil were found there (see Table 2.1). The lower than expected oxygen utilization rate may be the result of a fuel spill which occurred in the area a few weeks prior to the pilot test, which could have temporarily lowered native microbial populations, or because of the lower than normal levels of nutrients in the site soils. TKN was not detected in three of the four soil samples taken at the site (see Table 2.1). The biannual ISR test to be conducted after six months of bioventing will provide additional data to evaluate how the oxygen utilization rate changes over time and evaluate the long-term effect of the recent fuel spill.

The oxygen utilization rates at VMP1-24 and VMP3-30.5 were moderate, 0.12% per hour and 0.18% per hour, respectively, yet lower contaminant levels were found in soil at VMP1-24 compared to VMP2-24. The source of hydrocarbon contamination and subsequent biological activity at these points may be from volatile hydrocarbons in the soil gas rather than contamination residuals sorbed onto the soil, which are measured by the laboratory analysis for TRPH.

The air injected into the four VMPs during the ISR test was a 3.5-percent helium mixture in air. The helium is used as a tracer gas to evaluate the effectiveness of the bentonite seals in the VW and VMPs. At VMP1-24 and VMP2-24, no appreciable loss of helium occurred between the end of air injection and the final ISR readings taken after 50 hours. Therefore, most of the oxygen loss observed at these points during the ISR test was a result of bacterial respiration and not faulty well construction.

However, significant helium loss was noted at VMP3-30.5 (see Figure 3.7), indicating possible short-circuiting or a poorly sealed VMP screen. Therefore, the oxygen utilization rate at this point may be biased high.

Based on oxygen-utilization rates calculated for the VMPs, an estimated 50 to 530 milligrams (mg) of fuel per kilogram (kg) of soil can be biodegraded each year at this site. The lower estimate reflects the high moisture content found in the soil sample taken at VMP1-24. A high moisture content means that less air-filled porosity is available for supplying oxygen to sustain biodegradation. The higher estimate reflects the higher respiration rate and larger air-filled porosities found at VMP3-30.5. However, the higher estimate is also based on the oxygen utilization rate measured at VMP3-30.5, where significant helium loss occurred and, therefore, this value may be biased high. These biodegradation rate estimates are based on calculated air-filled porosities and a ratio of

FIGURE 3.5

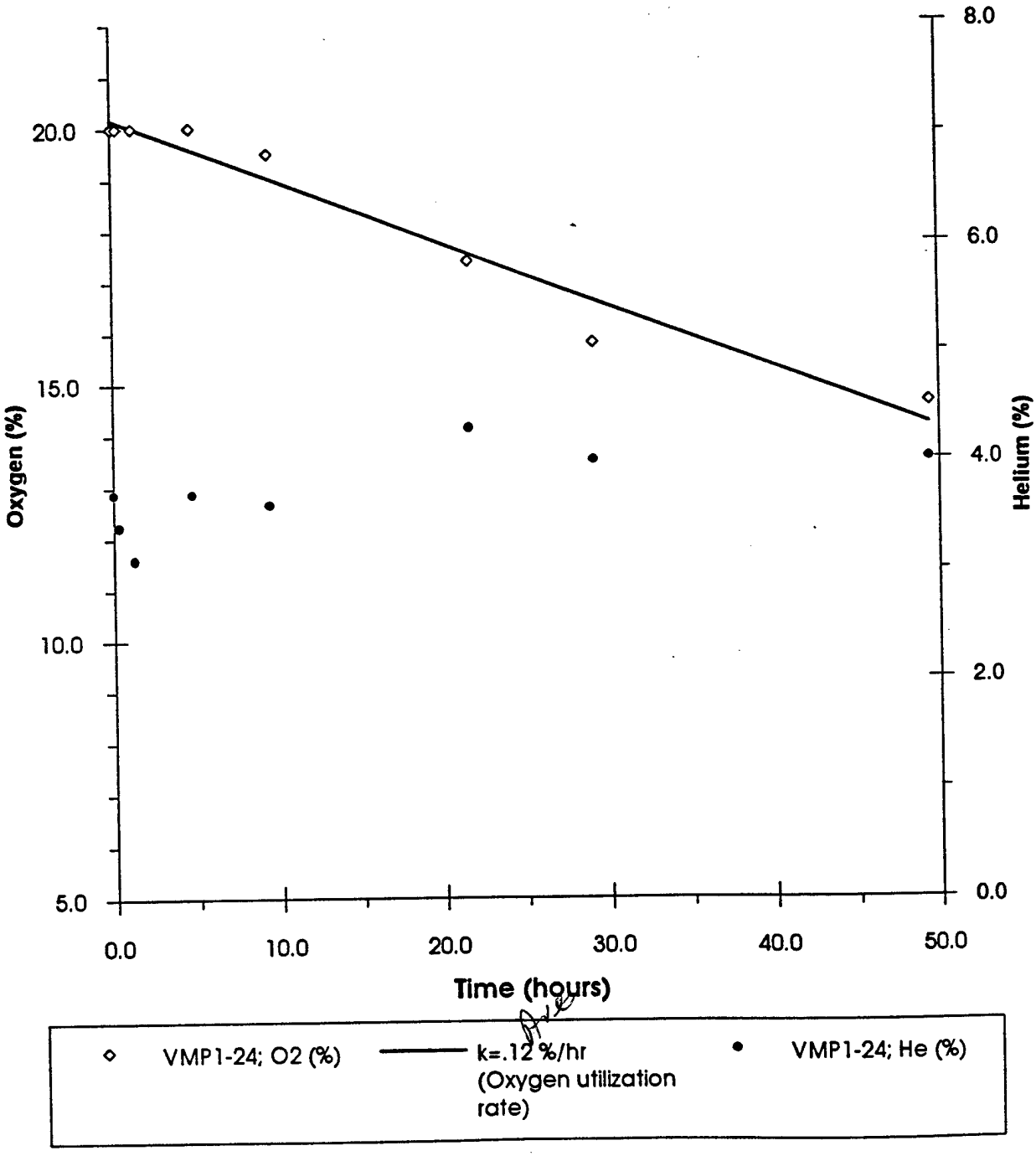


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FIGURE 3.6

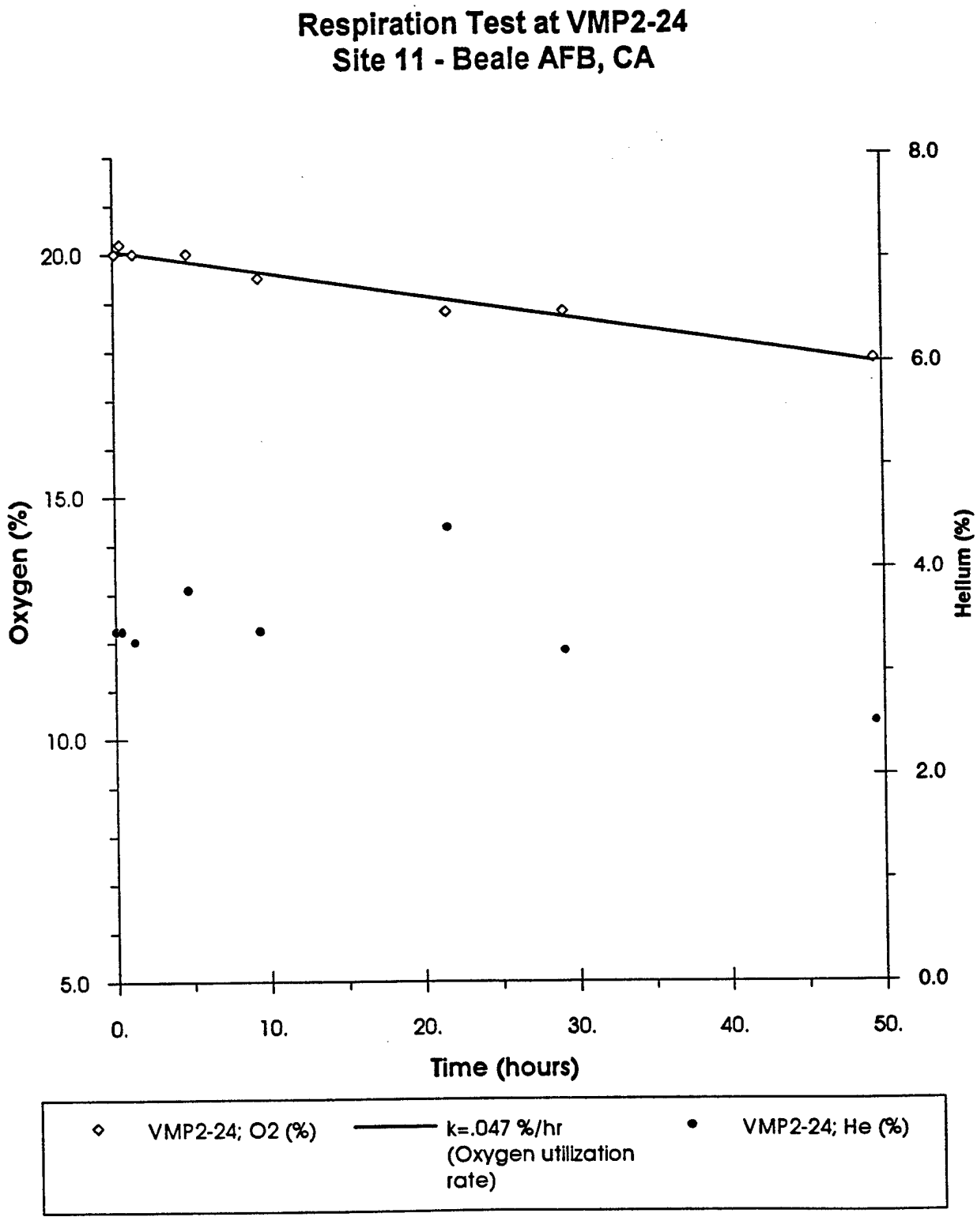

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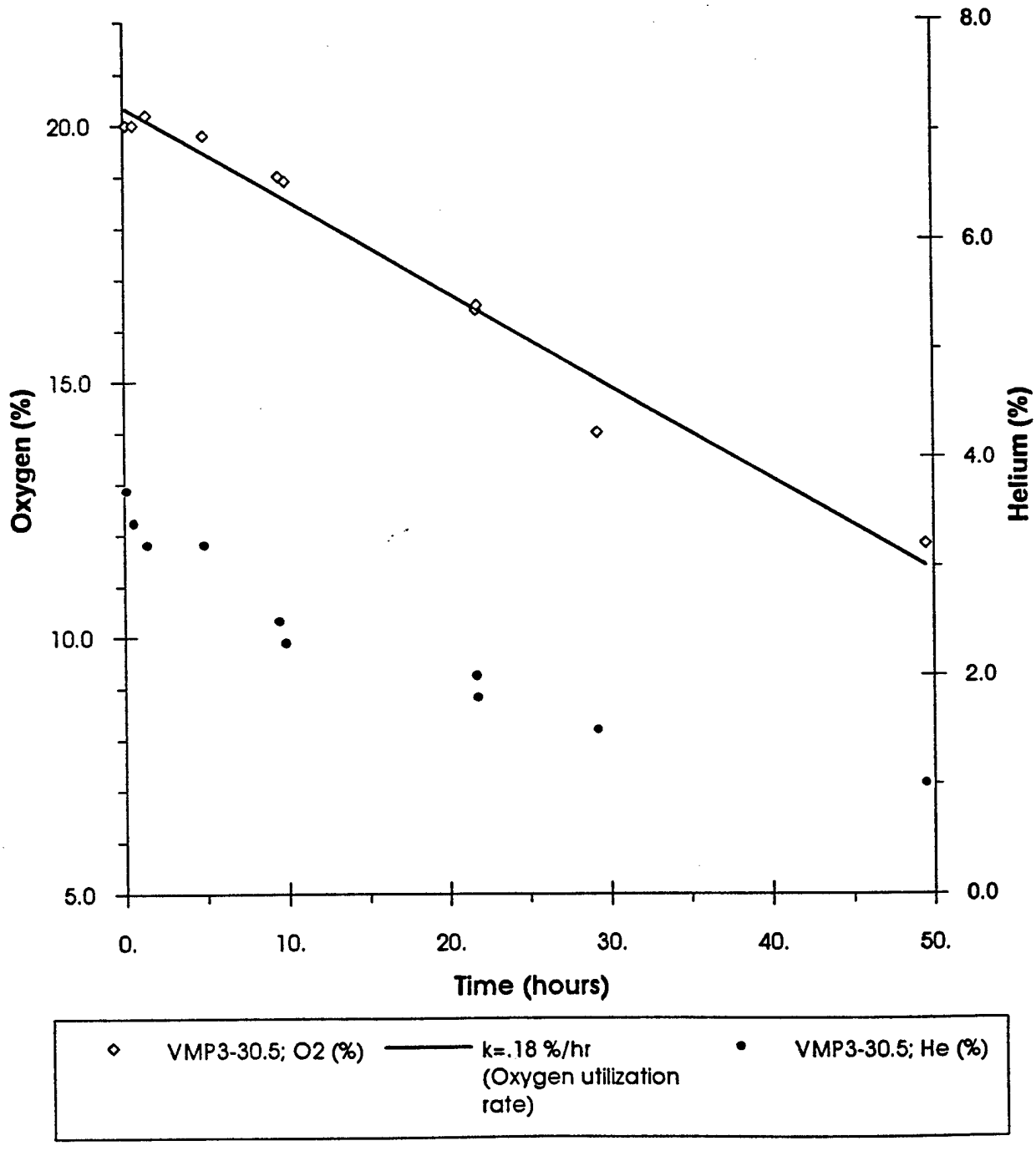
FIGURE 3.7



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3.5 mg of oxygen consumed for every 1 mg of fuel biodegraded. Methods of calculation followed the procedures in the protocol document and are detailed in Appendix D.

Additional respiration testing at 6 months and one year following the installation of the extended pilot test system, and soil sampling one year following installation, will better define the long-term biodegradation rates. Table 3.3 summarizes the data from the initial pilot test at Site 11.

3.5 Potential Air Emissions

Air emission measurements were taken at Site 11 before and during air injection in order to evaluate the potential for discharge of hydrocarbons to the atmosphere resulting from subsurface air injection. The results indicate that no appreciable increase in TVH or BTEX levels above those found currently at the site occurred due to air injection.

In order to determine the TVH-jf and BTEX content of the soil-gas emissions, two soil-gas samples were collected for laboratory analysis from a surface monitoring location 17 feet south of the injection well. Samples were collected by placing a simple flux chamber on the ground surface and then withdrawing the gas sample. The first sample (BKT-1) was collected before air injection was begun and the second sample (BKT-2) was collected after approximately 4 hours of air injection. The samples were collected in evacuated, 1-liter Summa® cannisters. The samples were sent for laboratory analysis using EPA Method TO-3 to Air Toxics, Ltd. in Rancho Cordova, California. Results from these samples were shown in Table 2.2.

Based on the laboratory analysis, it appears that no significant levels of TVH or BTEX emissions will result from air injection. Total hydrocarbon emissions are conservatively estimated at only 8 pounds per day, assuming all air flow escapes to the surface, an injected flow rate of 80 scfm, and an emission level of 180 ppmv TVH-jf (the increase measured at the surface monitoring point after air injection). Benzene emissions are conservatively estimated at only 0.06 lbs per day with the same conservative assumptions. In order to better control potential emissions, the flow rate will be reduced when long-term testing is conducted.

It is anticipated that long-term emissions at this pilot test site will also be insignificant as accumulated hydrocarbon vapors in the soil will move slowly outward from the air injection point and will be biodegraded as they move horizontally through the soil.

3.6 Recommendations

Initial bioventing tests at the Site 11 indicate that oxygen has been depleted in the contaminated soils, and that air injection is an effective method of increasing aerobic biodegradation of fuel. The Air Force Center for Environmental Excellence (AFCEE) has recommended that air injection be implemented at this site to determine the long-term radius of oxygen influence and the effect of time, available nutrients, and changing soil temperatures on fuel biodegradation rates.

A small, 1.0-horsepower Gast™ regenerative blower has been installed at Site 11 to continue a rate of air injection of approximately 80 scfm. In December 1993, ES personnel will return to the site to sample and analyze the soil gas and conduct a second

Table 3.3
PILOT TEST DATA SUMMARY
AGE Maintenance Area (Site 11)
Beale AFB, California

	Soil and Soil Gas Data				Air Permeability Test				*In Situ* Respiration Test					Calculated Biodegradation Rate
	Soil Type	Laboratory Analytical Results			Initial Soil Gas		Final Soil Gas	Air Perm.	Initial Soil Gas		Final Soil Gas		O_2 Util. Rate	
WELL No.–DEPTH		TRPH (mg/kg)	TVH–jf (ppmv)		O_2 (%)	CO_2 (%)	O_2 (%)	k (darcy)	O_2 (%)	He (%)	O_2 (%)	He (%)	k_o (%/hr)	K_b (mg fuel/kg soil per year)
VW1–(10 – 50)	silty CLAY/SAND	ND	51,000		2.0	8.0								
VMP1–24	clayey/silty SAND	ND	72,000		3.0	11.0	9.5	22	20.0	3.7	14.6	4.0	0.12	50
VMP1–30.5	SAND				2.8	7.5		29						
VMP1–40.5	clayey/silty SAND				3.0	7.0		24						
VMP2–24	SAND	1,186/309 [1]			2.0	6.8		27	20.0	3.4	17.8	2.5	0.047	130
VMP2–30.5	SAND				3.5	7.2		26						
VMP2–40.5	sandy SILT				3.0	6.6		41						
VMP2–49.5	sandy/silty CLAY				2.2	6.2	10.5	43						
VMP3–24	clayey SAND		55,000		1.0	6.6		28						
VMP3–30.5	SAND				1.5	7.8	12.0	32	20.0	3.7	11.8	1.0	0.18	530
VMP3–40.5	clayey SAND				1.6	5.8		40						

LEGEND

: Sample was not taken/analyzed.

TRPH : Total Recoverable Petroleum Hydrocarbons (EPA 418.1)

TVH–jf : Total Volatile Hydrocarbons as jet fuel (EPA TO–3)

[1] : duplicate sample

ND : not detected

mg/kg : milligrams per kilogram

ppmv : parts per million by volume

NOTES

a. VW1 soil sample collected from 30 ft bgs.

b. Air Permeability Test conducted for 18 hrs at air injection rate of 33 scfm.

c. *In Situ* Respiration Test: air injection at selected VMPs for 23.5 hrs at 1.1 scfm; O_2/CO_2/TVH/He measurements taken for 50 hrs following injection.

s11tab33

10/11/98

respiration test. In June 1994, a final respiration test will be conducted, and soil and soil gas samples will be collected from the site to determine the degree of remediation achieved during the first year of *in situ* treatment.

Based on results presented by ES for the first year of pilot-scale bioventing, AFCEE will recommend one of two options:

1. Upgrade, if necessary, and continue operation of the bioventing system for full-scale remediation of the site. AFCEE can assist the base in obtaining regulatory approval for upgrading and continued operations.
2. If significant difficulties or poor results are encountered during bioventing at this site, AFCEE may recommend removal of the blower system and proper abandonment of the VW and VMPs.

4.0 REFERENCES

Hinchee, R.E., S.K. Ong., R.N. Miller, and D.C. Downey 1992, Test Plan and Technical Protocol for a Field Treatability Test for Bioventing, prepared for USAF Center for Environmental Excellence. May

APPENDIX A

GEOLOGIC BORING LOGS

ES ENGINEERING-SCIENCE

BOREHOLE NUMBER: 1 (VMP-1)

PROJECT NUMBER: DE 268.20.04	PROJECT NAME: BIOVENTING INITIATIVE
CLIENT: AFCEE	DRILLER: TONTO DRILLING
LOCATION: BEALE AFB, CA	DRILLING METHOD: HOLLOW-STEM
IRP Site 11	AUGER W/ CONTINUOUS SAMPLING
GEOLOGIST: HENRY PIETROPAOLI	HOLE DIAMETER: 8 INCHES
COMPLETION DATE:	TOTAL DEPTH: 55.0 FT bgs

DEPTH feet	SAMPLE LOCATION	SAMPLE NUMBER	BLOW COUNT	PID (ppm) [THA (ppm)]	GRAPHIC LOG	SOIL CLASS	GEOLOGIC DESCRIPTION
							Gravel
5				16 [0]			FILL: SILTY CLAY, reddish-brown, moist to wet, very stiff, plastic, common organics, rock fragments ½" to 1" diam. common, putrid smell.
10				27 [0]			
15			50 (3")	2352 [1900]			GRAVEL: Sandy (coarse), light green-brown, rounded clasts up to 3½ in. diam, fuel odor, loose, damp. Note: Very little recovery during continuous sampling.
20							
25		BE11-VMP1-24.5	26 25 25	2212 [2050]			SAND: Clayey to silty, med to coarse grained, damp, dense, hard, sl. plastic, green-blue to gray, fuel odor.
30			26 27 28	106 [410]			gradational contact — SAND: Med to coarse grained, loose to med dense, damp, fuel odor.

▼ - Equilibrated waterlevel.

▽ - First encountered groundwater.

▮ - Brass tube sample submitted for laboratory analysis

jm2

ES ENGINEERING-SCIENCE

BOREHOLE NUMBER: 1 (VMP-1)

PROJECT NUMBER:	PROJECT NAME:
CLIENT:	DRILLER:
LOCATION:	DRILLING METHOD:
GEOLOGIST:	HOLE DIAMETER:
COMPLETION DATE:	TOTAL DEPTH:

DEPTH feet	SAMPLE LOCATION	SAMPLE NUMBER	BLOW COUNT	PID (ppm) [THVA] (ppm)	GRAPHIC LOG	SOIL CLASS	GEOLOGIC DESCRIPTION
35			32 36 25	8 [6]			as above, with common rounded gravels up to 1½" diam.
							Gradational Contact
40			34 50 (4")	88 [190]			SAND: Clayey/Silty, fine grained, reddish-brown, loose to mod. dense, damp, sli. plastic.
45			26 26 40	42 [35]			SAND: Coarse grained, loose to mod. dense, damp, light gray to red-brn.
50			44 50 (3")	37 [45]			SILT: Clayey, reddish-brown, moist to wet (perched water???), plastic, soft, black streaks (organics?).
55							

▼ - Equilibrated waterlevel.

▽ - First encountered groundwater.

▮ - Brass tube sample submitted for laboratory analysis

jm2

ES ENGINEERING-SCIENCE

BOREHOLE NUMBER: 2 (VW-1)

PROJECT NUMBER: DE 268.20.04	PROJECT NAME: BIOVENTING INITIATIVE
CLIENT: AFCEE	DRILLER: TONTO DRILLING
LOCATION: Beale AFB, CA	DRILLING METHOD: HOLLOW-STEM
IRP Site 11	AUGER w/ CONTINUOUS SAMPLING
GEOLOGIST: HENRY PIETROPAOLI	HOLE DIAMETER: 8 IN → Reamed to 11 IN
COMPLETION DATE:	TOTAL DEPTH: 52.0 FT. bgs

DEPTH feet	SAMPLE LOCATION	SAMPLE NUMBER	BLOW COUNT	PID (ppm) [TVA] (4pm)	GRAPHIC LOG	SOIL CLASS	GEOLOGIC DESCRIPTION
							GRAVEL
5				22 [16]			FILL: Silty CLAY, reddish-brown, common gravels 1/8" to 1/4" diam., damp, stiff, sli. plastic. @ 5', grades to green-brown with putrid sewage-like smell, common gravels up to 2" diam.
10				24 [160]			
15				1407 [1200]			as above, with same putrid odor and mild fuel odor. extremely hard zone (16'-17' bgs).
20							GRAVEL: Coarse Sandy, clasts ≤ 3" diam, lgt green-grey, damp, loose. Note: Very little recovery
25							CLAY: Silty, med brown-green, damp, plastic, mod stiff, fuel odor.
				2800 [3860]			SAND: Silty, Fine to med grained, lgt grn-brn, mod stiff to hard. At 28 ft: 6" lens of light tan clay overlying coarser sand (loose to med dense).
30		BE11-VW1-30		3256 [8800]			

▼ - Equilibrated waterlevel.

▽ - First encountered groundwater.

▮ - Brass tube sample submitted for laboratory analysis

jm2

ES ENGINEERING-SCIENCE

BOREHOLE NUMBER: 2 (VW-1)

PROJECT NUMBER:	PROJECT NAME:
CLIENT:	DRILLER:
LOCATION:	DRILLING METHOD:
GEOLOGIST:	HOLE DIAMETER:
COMPLETION DATE:	TOTAL DEPTH:

DEPTH feet	SAMPLE LOCATION	SAMPLE NUMBER	BLOW COUNT	PID (ppm) [TNVA] (ppm)	GRAPHIC LOG	SOIL CLASS	GEOLOGIC DESCRIPTION
35				27 [68]			SAND: as above with gravels up to 2" diam. common.
				1045 [1400]			as above, with Fuel odor.
40				3027 [5200]			CLAY: Silty, red-brown, sli plastic, damp, stiff, Fuel odor.
45				115 [180]			SAND: Clayey, fine grained, red-brown, sli plastic, damp.
							SANDSTONE: coarse, dense to very dense, light green-grey, damp.
50				12 [26]			CLAY: silty, tan, plastic, damp, soft to mod. stiff, rare sand. grades downward to red-brown silty fine to med sdy clay, abund. black streaks, damp, friable black inclusions.
55							

▼ - Equilibrated waterlevel.

▽ - First encountered groundwater.

▮ - Brass tube sample submitted for laboratory analysis

jm2

ES ENGINEERING-SCIENCE

BOREHOLE NUMBER: 3 (VMP-2)

PROJECT NUMBER: DE 268.20.04	PROJECT NAME: BIOVENTING INITIATIVE
CLIENT: AFCEE	DRILLER: TONTO DRILLING
LOCATION: Beale AFB, CA	DRILLING METHOD: HOLLOW-STEM
IRP SITE 11	AUGER W/ CONTINUOUS SAMPLING
GEOLOGIST: HENRY PIETROFAOLI	HOLE DIAMETER: 8 INCHES
COMPLETION DATE:	TOTAL DEPTH: 54.5 FT. bgs

DEPTH feet	SAMPLE LOCATION	SAMPLE NUMBER	BLOW COUNT	PID (ppm) [THVA (ppm)]	GRAPHIC LOG	SOIL CLASS	GEOLOGIC DESCRIPTION
							Gravel
5				32 [110]			FILL: Silty Clay, red brown, damp, plastic, mod stiff, common organics 5': grades to yellow-brown silty-clay with abundant organics, black inclusions (< 1/4" dia) & gravels up to 1" dia (OLDER FILL), dry to damp, sli plastic, putrid sewer-like smell with dark green zones.
10				462 [820]			
							13': Clayey Fine SAND, lgt grn, mottled, common coarse clasts & gvls (2"), fuel odor, sli plastic, damp, loose.
15							GRAVEL: Sandy, coarse, clasts ≤ 3", green-gray, damp, fuel odor, loose, very hard drilling. Note: very little recovery.
20							
							SAND: Coarse, gray, mod dense to dense, damp, fuel odor.
25		BE 11-VMP2-25.5 [AND] VMP4-22 (duplicate)		2389 [10,000+]			@ 25.5': 6" lgt brn. clay, very stiff, fuel odor. SAND: as above
30				2572 [5550]			

▼ - Equilibrated waterlevel.

▽ - First encountered groundwater.

▮ - Brass tube sample submitted for laboratory analysis

jm2

ES ENGINEERING-SCIENCE

BOREHOLE NUMBER: 3 (VMP-2)

PROJECT NUMBER:	PROJECT NAME:
CLIENT:	DRILLER:
LOCATION:	DRILLING METHOD:
GEOLOGIST:	HOLE DIAMETER:
COMPLETION DATE:	TOTAL DEPTH:

DEPTH feet	SAMPLE LOCATION	SAMPLE NUMBER	BLOW COUNT	PID (ppm) [FINAL] (uncorr.)	GRAPHIC LOG	SOIL CLASS	GEOLOGIC DESCRIPTION
35				2200 [1700]			SAND: as above with common rounded gravels up to 3", fuel odor.
							SAND: gravelly, coarse.
40				1517 [1100]			SILT: sandy, lgt reddish brown, med, damp, sli plastic, mod. stiff, sli fuel odor.
							gradational boundary
45							SAND: clayey, fine, sli plastic, damp, mod. stiff, slight fuel odor.
				437 [850]			CLAY: silty, coarse sandy, red-brn, black streaks, stiff, damp, round black inclusions.
50				1378 [390]			
55							

▼ - Equilibrated waterlevel.

▽ - First encountered groundwater.

▮ - Brass tube sample submitted for laboratory analysis

jm2

ES ENGINEERING-SCIENCE

BOREHOLE NUMBER: 4 (VMP-3)

PROJECT NUMBER: DE 268.20.04	PROJECT NAME: BIOVENTING INITIATIVE
CLIENT: AFCEE	DRILLER: TONTO DRILLING
LOCATION: Beale AFB, CA	DRILLING METHOD: HOLLOW-STEM
IRP Site 11	AUGER
GEOLOGIST: HENRY PIETROPAOLI	HOLE DIAMETER: 8 INCHES
COMPLETION DATE:	TOTAL DEPTH: 54.0 FT bgs

DEPTH feet	SAMPLE LOCATION	SAMPLE NUMBER	BLOW COUNT	PID (ppm) [FINAL] (ppm)	GRAPHIC LOG	SOIL CLASS	GEOLOGIC DESCRIPTION
							GRAVEL
5			32 50 (4")	0 [0]			CLAY: sandy, gravelly, silty, yellow-brown, micaceous, damp, sli plastic, grls avg ≤ 1" diam.
10			20 65 (6")	32 [0]			med-brn, soft, plastic, damp, with fuel odor
15			50 (3")	702 [620]			GRAVEL: coarse, sandy, fuel odor.
20			28 50 (4")	NR			SAND: clayey, fine, sli plastic, stiff, dense, damp, fuel odor.
25			28 30 38	2381 [3200]			@ 24.5': 6" lgt. tan gray silty clay, dense.
							SAND: fine to medium, mod. dense.
30			24 30 36	1 [0]			

▼ - Equilibrated waterlevel.

▽ - First encountered groundwater.

▮ - Brass tube sample submitted for laboratory analysis

jm2

ES ENGINEERING-SCIENCE

BOREHOLE NUMBER: 4 (VMP-3)

PROJECT NUMBER:	PROJECT NAME:
CLIENT:	DRILLER:
LOCATION:	DRILLING METHOD:
GEOLOGIST:	HOLE DIAMETER:
COMPLETION DATE:	TOTAL DEPTH:

DEPTH feet	SAMPLE LOCATION	SAMPLE NUMBER	BLOW COUNT	PID (ppm) (TMVA) (4pm)	GRAPHIC LOG	SOIL CLASS	GEOLOGIC DESCRIPTION
35			22 32 46	0 [0]			SAND: as above.
40			50 50 (3")	9 [3]			SAND: Clayey, medium, red-brown, damp, sli plastic, stiff
45			70 (6")	15 [0]			SILT: Clayey, sandy, med, yellow-brown, damp to moist, sli plastic, stiff to very stiff.
50			70 (6")	5 [0]			CLAY: Sandy, Silty, med, red-brn, damp, common gravels ≤ 1½", black streaks.
55							

▼ - Equilibrated waterlevel.

▽ - First encountered groundwater.

▮ - Brass tube sample submitted for laboratory analysis

jm2

APPENDIX B

O & M MANUAL AND DATA COLLECTION SHEET

GENERIC BLOWER SYSTEM OPERATIONS AND MAINTENANCE MANUAL FOR EXTENDED PILOT TESTING SYSTEM

Prepared for:

AIR FORCE CENTER FOR ENVIRONMENTAL EXCELLENCE

BROOKS AFB, TEXAS

USAF CONTRACT F33615-90-D-4010, DELIVERY ORDER 14

April 1993

Prepared by:

Engineering-Science, Inc.
1700 Broadway, Suite 900
Denver, Colorado

A7-15-43

CONTENTS

FIGURES

SECTION 1

INTRODUCTION

This document has been prepared by Engineering-Science, Inc. to support the bioventing initiative contract awarded by the Air Force Center for Environmental Excellence. The contract involves the conducting of bioventing pilot tests at 35 sites on 23 Air Force bases across the United States.

At most sites, bioventing systems will be installed upon completion of the initial bioventing pilot tests for the purpose of extended pilot testing. These systems will operate for a 1-year period to provide further information as to the feasibility of the technology at each site, and to provide interim remedial action.

This Operations and Maintenance Manual has been created for sites at which regenerative or rotary-vane blowers have been installed for extended pilot testing. Basic maintenance of these systems is the responsibility of the Air Force facility. This manual is to be used by facility personnel to guide and assist them in operating and maintaining the blower system. Section 2 provides a summary of the bioventing system components installed. Section 3 of this document describes the blower system. Section 4 details the maintenance requirements and provides maintenance schedules. Section 5 describes the system monitoring that is required to forecast system maintenance needs and to provide data for the extended pilot test. Blower performance curves and relevant service information for regenerative and rotary-vane blowers are provided in Appendices A and B, respectively, and data collection sheets are provided in Appendix C.

SECTION 2

BLOWER SYSTEM CONFIGURATION SUMMARY

System Type (injection, extraction) Injection
Blower (regenerative, rotary vane) Regenerative
Blower Model R4110N-50
Motor (Hp) 1.0
Knock-Out Chamber (yes, no) No
Sampling Port (yes, no) No
Inlet Temperature Gauge (range) not installed
Inlet Pressure/Vacuum Gauge (range) 0 - 60 "H_2O
Inlet Filter (part no.) F-30P-150
Outlet Temperature Gauge (range) 0 - 250 °F
Outlet Pressure/Vacuum Gauge (range) 0 - 100 "H_2O
Pressure/Vacuum Relief Valve Set @ (give unit of measure) 50 "H_2O

SECTION 3

BIOVENTING SYSTEM OPERATION

3.1 PRINCIPLE OF OPERATION

Bioventing is the forced injection of fresh air, or withdrawal of soil gas, to enhance the supply of oxygen for *in situ* bioremediation. Either a pressure (air injection) or vacuum (vapor extraction) blower unit is used to inject or withdraw air into or from the soil, thereby supplying fresh air with 20.8 percent oxygen to the contaminated soils. Once oxygen is provided to the subsurface, existing bacteria will proceed with the breakdown of fuel residuals.

At IRP Site 11 : AGE Maintenance Area a air injection blower system has been installed.

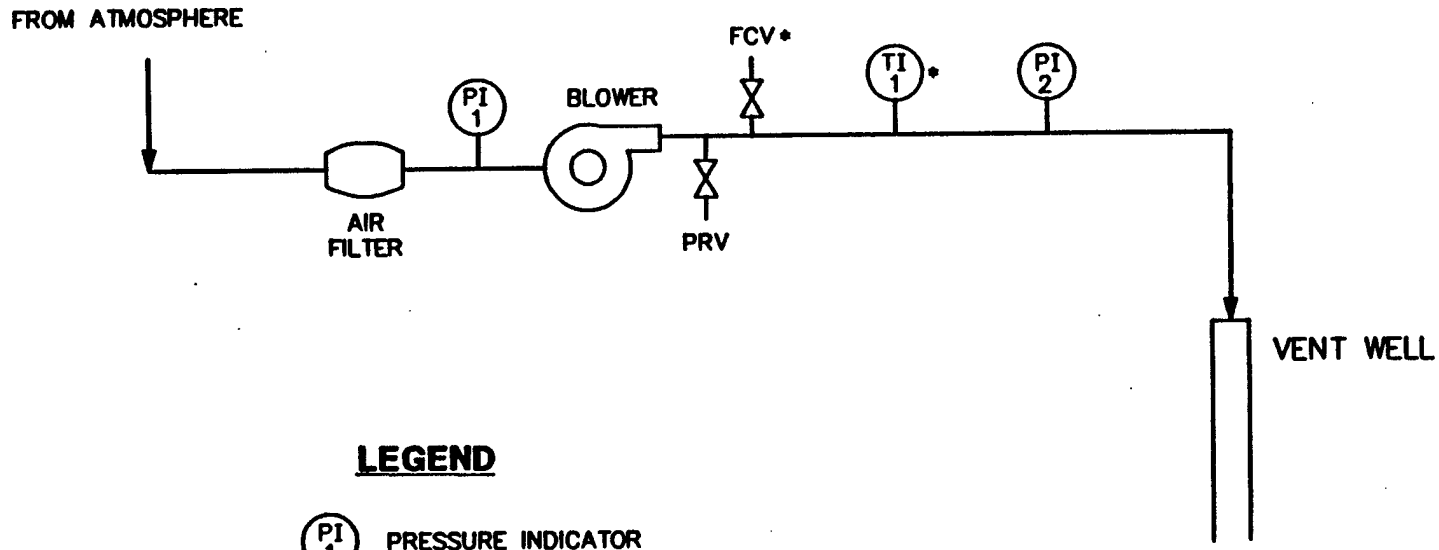
3.2 SYSTEM DESCRIPTION

3.2.1 Blower System

A regenerative blower powered by a 1.0 horsepower direct-drive motor is the workhorse of the bioventing system. This blower is rated at a flow rate of 60 standard cubic feet per minute (scfm) at a pressure of 30 " H_2O ; however, the actual performance of the blower will vary with changing site conditions. As installed, the blower was producing an estimated flow rate of 80 scfm at a pressure of 10 " H_2O. Vapor extraction systems may include an inlet knockout chamber for water condensation. All systems include an air filter to remove any particulates which are entrained in the air stream, and several valves and monitoring gauges which are described in the next section. A schematic of the blower system installed at IRP Site 11 : AGE Maintenance is shown on Figure 3.1. Corresponding blower performance curves, and relevant service information are provided in Appendices A and B.

3.2.2 Monitoring Gauges

The bioventing system is equipped with vacuum and pressure gauges, temperature gauges, and a sampling port (vapor extraction only). Generally, gauges have been installed on the air injection system at the following locations: a vacuum gauge in the inlet piping and a pressure gauge in the outlet piping. For vapor extraction systems gauges are generally installed as follows: vacuum gauges in the



LEGEND

PI 1	PRESSURE INDICATOR
TI 1	TEMPERATURE INDICATOR
FCV	FLOW CONTROL VALVE
PRV	PRESSURE RELIEF VALVE
*	OPTIONAL

FIGURE 3.1

TYPICAL BLOWER SYSTEM INSTRUMENTATION DIAGRAM FOR AIR INJECTION

ENGINEERING-SCIENCE, INC.
Denver, Colorado

93DN0413, 04/05/93 at 12:54

inlet piping and at the knock-out chamber (as applicable), and a pressure gauge in the discharge piping. See Figure 3.1 for the locations of the gauges installed on the blower system at this site.

Temperature gauges may be located at the inlet and outlet of the blower system. These gauges are used to monitor the inlet and outlet temperature to determine the change in temperature across the blower. For air injection systems, ambient air temperature should be used when an inlet temperature gauge is not present. For vapor extraction systems, the inlet temperature is also used as an estimate of soil gas temperatures in the contaminated soil zone. See Figure 3.1 for the location(s) of the temperature gauges installed on the blower system at this site.

A sample port is located in the discharge piping on the outlet side of vapor extraction systems only. This sample port is used to collect offgas that is analyzed for carbon dioxide/oxygen and volatile organic compound concentrations. See Figure 3.1 for the location of the sampling port installed on the blower system at this site.

SECTION 4

SYSTEM MAINTENANCE

Although the motor and blower are relatively maintenance free, periodic system maintenance is required for proper operation and long life. Recommended maintenance procedures and schedules are described in detail in the instruction manuals included in Appendices A and B and briefly summarized in this section.

Filter inspection and knock-out chamber draining (as applicable) must be performed with the system turned off. ~~To re-start the motor, open the manual air dilution valve (red handle) to protect the motor from excessive strain, start motor, and slowly close dilution valve. If the handle has been removed from the manual air dilution valve,~~ do not open the valve or otherwise change the setting (it has been pre-set for a specific flow rate) before re-starting the blower.

4.1 Blower/Motor

The blower and motor are relatively maintenance free and should not require any periodic maintenance during the 1-year extended testing period. Both blower and motor have sealed bearings and do not require lubrication.

4.2 KNOCK-OUT CHAMBER

This section applies only to vapor extraction systems equipped with moisture knock-out chamber. To avoid damage caused by passing liquids solids through the blower a knock-out chamber has been installed in-line before the blower.

Free liquid should not be pumped through the blower. The knock-out chamber installed in-line before the blower intercepts entrained liquid, preventing damage to the blower. The knock-out chamber should be drained into an appropriate container once a month for the first few months and at less frequent intervals thereafter, if it appears that this will be sufficient to keep liquid from building up in the knock-out chamber. Condensation generally increases during the cold winter months. A facility employee should determine the best schedule for draining the knock-out chamber. The knock-out chamber can be drained by turning the system off and removing the cap or opening the valve at the base of the knock-out chamber. When all of the liquid has drained out, the system can be turned back on. It is recommended when re-starting the system that the air dilution valve (red-handled valve) be opened to protect the motor from excessive strain. If oily, drained liquids should be disposed of in an oil/water separator.

4.3 AIR FILTER

To avoid damage caused by passing solids through the blower, an air filter has been installed in-line before the blower. The filter element is paper and is accompanied by a polyurethane foam prefilter. The filter should be checked weekly for the first 2 months of operation. Again, a facility employee should determine the best schedule for filter replacement. The polyurethane prefilters can be washed with lukewarm water and a mild detergent. Paper filter elements should never be washed, but should be disposed of and replaced as necessary. When the pressure or vacuum drop across the filter is above 15 inches of water, a dirty filter element should be suspected, and cleaning or replacement should be performed.

To remove the filter, loosen the three clamps or the wing nut, lift the metal top off the air filter, and lift the air filter from the metal housing. Remove the polyurethane prefilter (if applicable) and wash before replacing. When replacing the filter, be careful that the rubber seals remain in place.

The filter element is manufactured by Solberg Manufacturing, Inc. in Itasca, Illinois. Their telephone number is (708) 773-1363. Additional filters can also be obtained through Engineering-Science, Inc. in Denver, Colorado. The ES contacts are Mr. Brian Blicker and Mr. Robert Williams and they can be reached at (303) 831-8100. The filter model number is F-30P-150, and the number for the replacement element is 30P. It is recommended that CES/DEV office keep at least one spare air filter at the site, four spare filters were supplied with the blower system.

4.4 MAINTENANCE SCHEDULE

The following maintenance schedule is recommended for this system. During the initial months of operation more frequent monitoring is recommended to ensure that any startup problems are quickly corrected. A daily drive-by inspection is recommended during the initial 2 weeks of operation to ensure that the blower system is still operating with no unusual sounds. Data collection sheets that can be used to record maintenance activities are included in Appendix C.

Maintenance Item	Maintenance Frequency
Filter	Check once per month, wash or replace as necessary (see Section 4.3).
Knock-out chamber	Drain once per month initially, then periodically (see Section 4.2).

4.5 MAJOR REPAIRS

Blowers systems are very reliable when properly maintained. Occasionally, a motor or blower will develop a serious problem. If a blower system fails to start, and a qualified electrician verifies that power is available at the blower or starter,

the Engineering-Science, Inc. site manager Michael Phelps should be called at (510) 769-0100. ES is responsible for major repairs during the first year of operation.

SECTION 5

SYSTEM MONITORING

5.1 BLOWER PERFORMANCE MONITORING

To monitor the blower performance, vacuum, pressure, and temperature will be measured. These data should be recorded weekly on a data collection sheet (provided in Appendix C). All measurements should be taken at the same time while the system is running. Because the system is loud, hearing protection should be worn at all times.

5.1.1 Vacuum/Pressure

With hearing protection in place, open the blower enclosure and record all vacuum and pressure readings directly from the gauges (in inches of water or psi). Record the measurements on a data collection sheet (Appendix C).

5.1.2 Flow Rate

The flow rate through the vent well and soils can be calculated when the inlet vacuum and outlet pressure of the blower are known. This pressure change across the blower (vacuum + pressure) can be compared to the performance curves for the blower in Appendix A or Appendix B to determine the approximate flow rate.

5.1.3 Temperature

With hearing protection in place, open the blower enclosure and record the temperature readings directly from the gauges in degrees Fahrenheit (°F). Record the measurements on a data collection sheet (provided in Appendix C). The temperature change can be converted to degrees Celsius (°C) using the formula °C= (°F - 32) X 5/9.

5.3 MONITORING SCHEDULE

The following monitoring schedule is recommended for this system. During the initial months of operation, more frequent monitoring is recommended to ensure that any start up problems are quickly corrected. Data collection sheets have been provided to assist your data collection and are included in Appendix C.

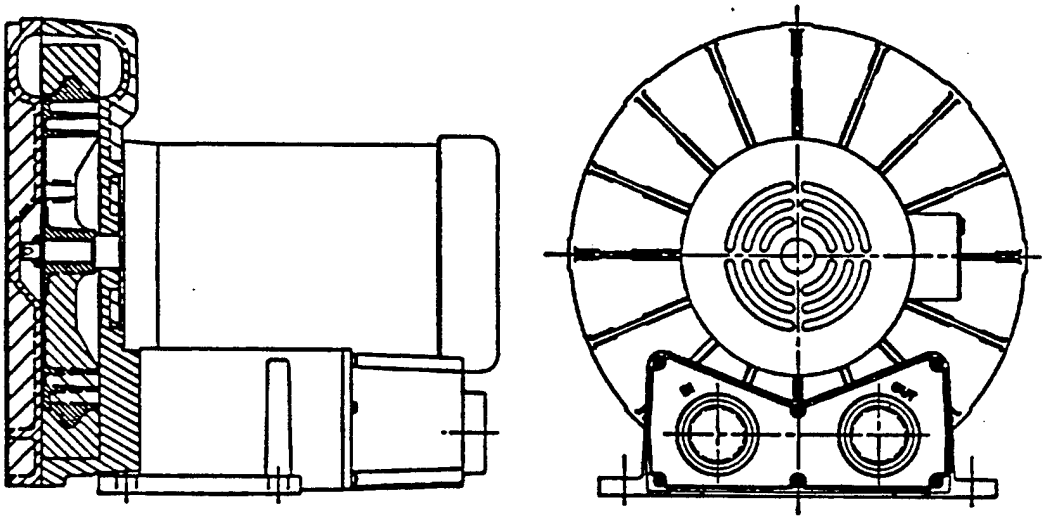
Monitoring Item	Monitoring Frequency
Vacuum/Pressure	Daily during first week, then once per week.
Temperature	Daily during first week, then once per week.

APPENDIX A
REGENERATIVE BLOWER INFORMATION

GAST.

Post Office Box 97
Benton Harbor, Michigan 49023-0097
Ph: 616/926-6171
Fax: 616/925-8288

Maintenance Instructions for Gast Standard Regenerative Blowers



For original equipment manufacturers special models, consult your local distributor

Gast Rebuilding Centers

Gast Mfg. Corp.
2550 Meadowbrook Rd.
Benton Harbor MI. 49022
Ph: 616/926-6171
Fax: 616/925-8288

Gast Mfg Corp.
505 Washington Avenue
Carlstadt, N. J. 07072
Ph: 201/933-8484
Fax: 201/933-5545

Brenner Fiedler. & Assoc.
13824 Bentley Place
Cerritos, CA. 90701
Ph: 213/404-2721
Fax: 213/404-7975

Wainbee, Limited
121 City View Drive
Toronto, Ont. Canada M9W 5A9
Ph: 416/243-1900
Fax: 416/243-2336

Wainbee, Limited
215 Brunswick Drive
Pointe Claire, P.Q. Canada H9R 4R7
Ph: 514/697-8810
Fax: 514/697-3070

Gast Mfg. Co. Limited.
Halifax Rd, Cressex Estate
High Wycombe, Bucks HP12 3SN
Ph. 44 494 523571
Fax: 44 494 436588

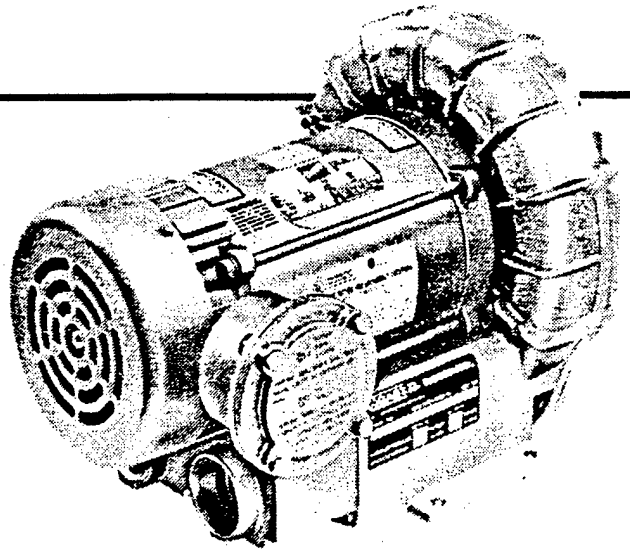
Japan Machinery Co. Ltd.
Central PO Box 1451
Tokyo 100-91 Japan
Ph: 813/3573-5421
Fax: 813/3571-7865

Regenerative Blowers For Soil Remediation to 260 cfm

(5-91)

GAST

R4, R5, R6P Series



MODEL R4 SERIES
48" H_2O MAX. VAC., 88 CFM OPEN FLOW

MODEL R5 SERIES
60" H_2O MAX. VAC., 145 CFM OPEN FLOW

MODEL R6P SERIES
90" H_2O MAX. VAC., 260 CFM OPEN FLOW

PRODUCT FEATURES

- Explosion-proof motors UL (class 1, group D; class 2, groups F & G)
- Sealed air stream
- Rugged construction
- Low maintenance

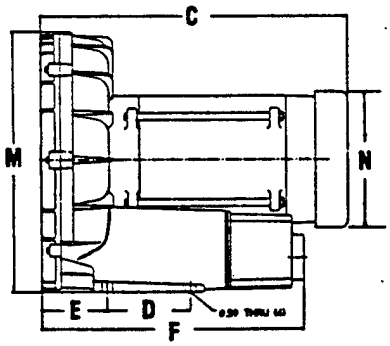
RECOMMENDED ACCESSORIES

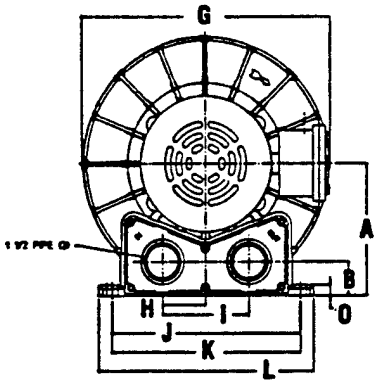
- Inlet filter AJ151G
  (Reducing filter plumbing from 2½" to 1½" is needed to accommodate filter on R4 and R5 models.)
- Relief valve AG258
- Vacuum gauge AE134

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

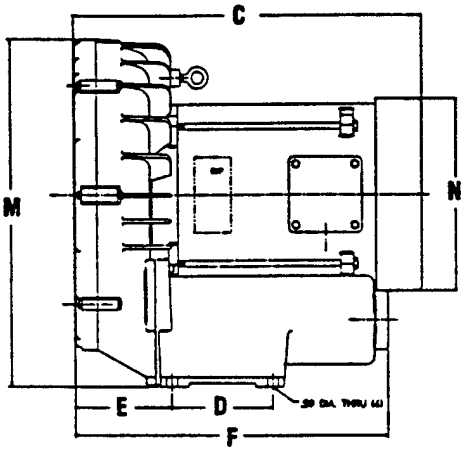
Model	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
R4110N-50	157	43	360	95	72	316	313	50	101	225	227	254	293	175	11
	6.18	1.68	14.16	3.75	2.85	12.44	12.31	1.98	3.96	8.86	8.93	10.00	11.73	6.88	.44
R4310P-50	157	43	360	95	72	316	313	50	101	225	227	254	293	175	11
	6.18	1.68	14.17	3.75	2.84	12.44	12.31	1.98	3.96	8.86	8.93	10.00	11.73	6.88	.44
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
R6P355R-50	248	80	482	140	137	438	428	64	127	–	290	325	463	257	13
	9.77	3.15	18.98	5.51	5.39	17.25	16.87	2.50	5.00	–	11.42	12.80	18.21	10.12	.50

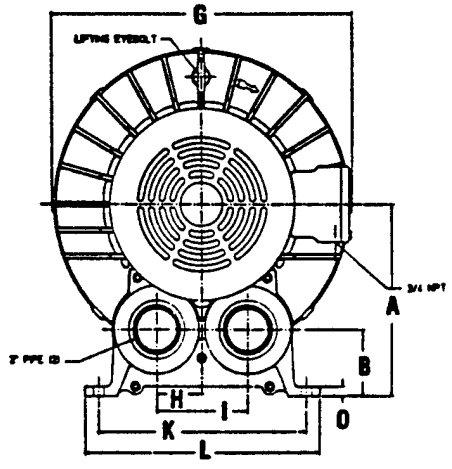
Model R4 Series
Model R5 Series



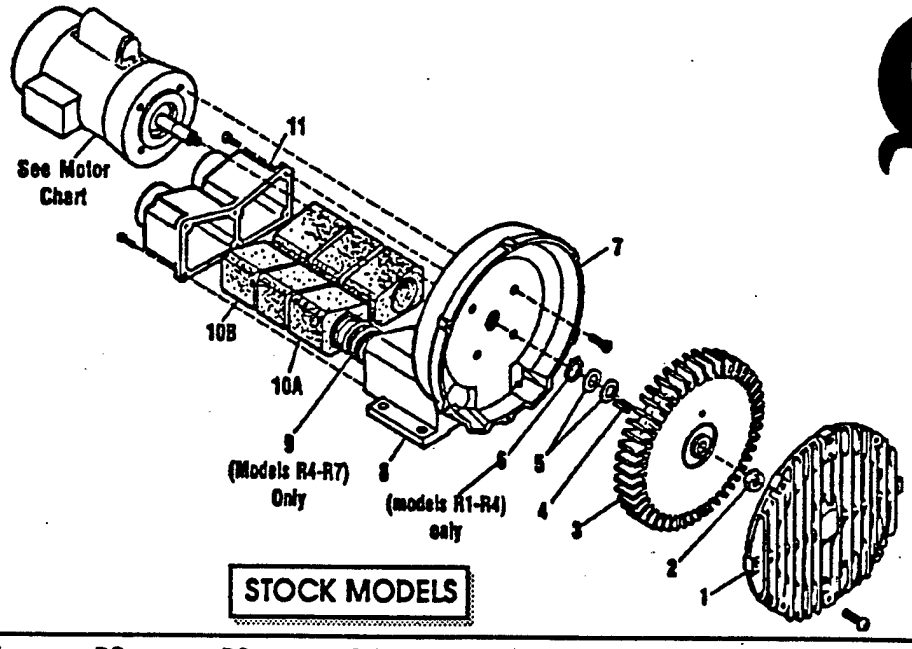


Model R6P Series





NOTE: These units with explosion-proof motors are designed specifically for qualified OEMs in the soil remediation industry. They are not intended to be applied for other uses without written acknowledgement from an authorized employee of Gast Manufacturing Corporation.



STOCK MODELS

Part Name	R1	R2	R3	R4	R5	R6	R6P	R6PP/R6PS	R7
#1 Cover	AJ101A	AJ101B	AJ101C	AJ101D	AJ101EQ	AJ101F	AJ101K	(2)AJ101KA	AJ101G
#2 Stopnut	BC187	BC187	BC181	BC181	BC181	BC181	BC181	(2)BC182	BC183
#3 Impeller	AJ102A	AJ102BQ	AJ102C	AJ102D	AJ102E	AJ102FR	AJ102K	(2)AJ102KA	AJ102GA
#4 Square Key	AH212C	AH212	AB136A	AB136D	AB136	AB136	AB136	(2)AB136	AC628
#5 Shim Spacer (s)	AJ132	AE686-3	AJ109	AJ109	AJ109	AJ116A	AJ116A	AJ116A	AJ110
#6 Retaining Ring	AJ145	AJ145	AJ149	AJ149					
#7 Housing	AJ103A	AJ103BQ	AJ103C	AJ103DR	AJ103E	AJ103F	AJ103K	AJ103KD	AJ103GA
#8 Muffler Box					AJ104E	AJ104F			
#9 Spring				AJ113DR	AJ113DQ	AJ113FQ	AJ113FQ		AJ113G
#10A Foam	(4)AJ112A	(4)AJ112B	(4)AJ112C	(4)AJ112DS	(4)AJ112ER	(6)AJ112F	(8)AJ112K		(8)AJ112GA
#10B Foam		(2)AJ112BQ	(2)AJ112CQ	(2)AJ112DR	(2)AJ112EQ				
#11 Muffler Extension/ Adapter Plate	AJ106H	AJ106BQ	AJ106CQ	AJ106DQ	AJ106EQ	AJ106FQ	AJ104K		AJ104GA
Shim Kit	K396	K396							K395

MOTOR CHART

REGENAIR MODEL NUMBER	MOTOR NUMBER	MOTOR SPECIFICATIONS 60 HZ VOLTS	50 HZ VOLTS	PHASE
R1102	J111X	115/208-230	110/220-240	1
R1102C	J112X	115		1
R2103	J311X	115/208-230	110/220	1
R2105	J411X	115/208-230	110/220	1
R2303A	J310	208-230/460	220/380-415	3
R2303F	J313	208-230	220	3
R3105-1/R3105-12	J411X	115/208-230	110/220-240	1
R3305A-1/R3305A-13	J410	208-230/460	220/380-415	3
R4110-2	J611AX	115/208-230	110/220-240	1
R4310A-2	J610	208-230/460	220/380-415	3
R5125-2	J811X	115/208-230		1
R5325A-2	J810X	208-230/460	220/380-415	3
R6125-2	J811X	115/208-230		1
R6325A-2	J810X	208-230/460	220/380-415	3
R6335A-2	J910X	208-230/460	220/380-415	3
R6150J-2	J1013	230		1
R6350A-2	J1010	208-230/460	220/380-415	3
R6P335A	J910X	208-230/460	220/380-415	3
R6P350A	J1010	208-230/460	220/380-415	3
R6P355A	J1110A	208-230/460	220/380-415	3
R7100A-2*	J1210B	208-230/460	220/380-415	3
R6PP/R6PS3110M	JD1100	208-230/460	220/380-415	3

* No lubrication needed at start up. Bearings lubricated at factory.

* Motor is equipped with alemite fitting. Clean tip of fitting and apply grease gun. Use 1 to 2 strokes of high quality ball bearing grease.

Consistency	*Type*	*Typical Grease*
Medium	Lithium	Shell Dolium R

Hours of service per year	*Suggested Relube Interval*
5,000	3 years
Continual Normal Application	1 year
Seasonal service motor idle for 6 months or more	1 year beginning of season 6 months
Continuous-high ambients, dirty or moist applications.	

60 HZ FLOW DATA (CFM)

All performance figures relate to stock models. A few high pressure units may be available. Consult your local distributor.

Regenair Model Number	PRESSURE 0"H_2O	20"H_2O	40"H_2O	60"H_2O	80"H_2O	100"H_2O	Maximum Pressure "H_2O*
R1	26	14					28
R2	42	26					38
R3105-1	52	38	14				42
R3105-12	52	36	23				55
R3305A-13	52	36	23				55
R4	90	70	50				52
R5	145	130	100				65
R6125-2	200	180					35
R6325A-2	200	180	152				40
R6335A-2	205	175	155	135			70
R6350A-2	200	180	150	130	110	80	105
R6P335A	290	250					30
R6P350A	300	260	230	200			60
R6P355A	300	260	230	200	160		90
R7100A-2	420	380	340	310	280	230	115
R6PP311OM	485	452	420	380	330		95
R6PS311OM	265	258	252	244	236	226	170

Regenair Model Number	VACUUM 0"H_2O	20"H_2O	40"H_2O	60"H_2O	80"H_2O	Maximum Vacuum "H_2O*
R1	25	14				26
R2	40	22				34
R3105-1	50	34	9			40
R3105-12	51	34	20			50
R3305A-13	51	34	20			50
R4	82	62	39			48
R5	140	115	90	50		60
R6125-2	190	155	125			45
R6325A-2	190	155	125			45
R6335A-2	190	150	125	100		75
R6350A-2	190	180	150	100	70	90
R6P335A	270	230				37
R6P350A	280	240	210	170		70
R6P355A	280	240	210	170	100	86
R7100A-2	410	350	300	250	170	90
R6PP311OM	470	425	375	320	220	80
R6PS311OM	240	225	210	195	175	130

***This number indicates the maximum static pressure differential recommended (with cooling air still flowing through unit). In general, units 1hp or less can be dead headed. Check with local representative or distributor to verify which models apply.**

Operation of the blower above the recommended maximum duty will cause premature failure due to the build up of heat damaging the components.

Performance data was determined under the following conditions:

1) Unit in a temperature stable condition.
2) Test conditions: Inlet air density at 0.075lbs. per cubic foot. (20°C(68°F), 29.92 in. Hg(14.7PSIA)).
3) Normal performance variations on the resistance curve within +/- 10% of supplied data can be expected.
4) Specifications subject to change without notice.
5) All performance at 60Hz operation.

70-6100
F2-205/8/92
AK811 Rev. E

Post Office Box 97
Benton Harbor, MI. 49023-0097
Ph: 616/926-6171
Fax: 616/925-8288

INSTALLATION AND OPERATING INSTRUCTIONS FOR GAST HAZARDOUS DUTY REGENAIR BLOWERS

This instruction applies to the following models ONLY: R3105N-50, R4110N-50, R4310P-50, R4P115N-50, R5125Q-50, R5325R-50, R6130Q-50, R6P155Q-50, R6350R-50, R6P355R-50 and R7100R-50.

Gast Authorized Service Facilities are Located in the locations listed below

Gast Manufacturing Corporation
505 Washington Avenue
Carlstadt, N. J. 07072
Ph: 201/933-8484
Fax: 201/933-5545

Gast Manufacturing Corporation
2550 Meadowbrook Road
Benton Harbor, MI. 49022
Ph: 616/926-6171
Fax: 616/925-8288

Brenner Fiedler & Associates
13824 Bentley Place
Cerritos, CA. 90701
Ph: 213/404-2721
Ph: 800/843-5558
Fax: 213/404-7975

Wainbee Limited
215 Brunswick Blvd.
Pointe Claire, Quebec
Canada H9R 4R7
Ph: 514/697-8810
Fax: 514/-697-3070

Wainbee Limited
5789 Coopers Ave.
Mississauga, Ontario
Canada L4Z 3S6
Ph: 416/243-1900
Fax: 416/243-2336

Japan Machinery
Central PO Box 1451
Toyko 100-91, Japan
Ph: 813 3573-5421
Fax: 813 3571-7896

Gast Manufacturing Co. Ltd.
Halifax Road, Cressex Estate
High Wycombe, Bucks HP12 3SN
England
Ph: 44 494 523571
Fax: 44 494 436588

Safety

⚠ This is the safety alert symbol. When you see this symbol, personal injury is possible. The degree of injury is shown by the following signal words:

⚠ DANGER: Severe injury or death will occur if hazard is ignored.

⚠ WARNING: Severe injury or death can occur if hazard is ignored.

⚠ CAUTION: Minor injury or property damage can occur of hazard is ignored.

Review the following information carefully before operating.

General Information

⚠ DANGER: Do not pump flammable or explosive gases or operate in an atmosphere containing them. Ambient temperature for normal operation should not exceed 40 degrees C (105 degrees F). For higher ambient operation, consult the factory. Blower performance is reduced by the lower atmospheric pressure of high altitudes. If it applies to this unit, consult a Gast distributor or the factory for details.

Installation

⚠ WARNING: Electric Shock can result from bad wiring. Wiring must conform to all required safety codes and be installed by a qualified person.

Grounding is required.

The Gast Regenair blower can be installed in any position. The flow of cooling air over the blower and motor must not be blocked.

PLUMBING - The threaded pipe ports are designed as connection ports only and will not support the plumbing. Be sure to use the same or larger size pipe and fittings to prevent air flow restriction and over-heating of the blower. When installing plumbing, be sure to use a small amount of pipe thread lubricant. This protects the threads in the aluminum blower housing. Dirt and chips, often found in new plumbing, should not be allowed to enter the blower.

NOISE - To reduce noise and vibration, the unit should be mounted on a solid surface that will not increase sound. The use of shock mounts or vibration isolation material is recommended. If needed, inlet or discharge noise can be reduced by attaching muffler assemblies (see accessories).

ROTATION - The Gast Regenair blower should only rotate clockwise as viewed from the electric motor side. This is marked with an arrow in the casting. Proper rotation can be confirmed by checking air flow at the IN and OUT ports. On blowers powered by a three phase motor, rotation is reversed by changing any two of the three power wires.

Operation

⚠ WARNING: Solid or liquid material exiting the blower or piping can cause eye damage or skin cuts. Keep away from air stream.

⚠ CAUTION: Attach blower to solid surface before starting. Prevent injury or damage from unit movement.

Air containing solid particles or liquid must pass through a filter before entering the blower (see accessories list for filter suggestions). Blowers must have mufflers, filters, other accessories and all piping attached before starting. Any foreign material passing through the blower may cause internal damage.

⚠ CAUTION: Outlet piping can burn skin. Guard or limit access.

Mark "CAUTION Hot surface. Can cause burns."

Air temperature increases when passing through the blower. When run at duties above 50 in. H_2O, metal pipe may be required for hot exhaust air.

The blower must not be operated above the limits for continuous duty. "Standard" R1, R2, R3 and R4 can operate continuously with not air flowing through the blower. Other units can only be run at the rating shown on the model number label. Do *not* close off inlet (for vacuum) or exhaust (for pressure) to reduce extra air flow. This could cause added heat and motor load. ACCESSORIES - Gast pressure gauges AJ496 or AE133 and vacuum gauges AJ497 or AE134 show blower duty. The Gast pressure/vacuum relief valve, AG258, will limit the operating duty by admitting or relieving air. It also allows full flow through the blower when the relief valve closes.

Servicing

⚠ **WARNING: Disconnect electric power before servicing. Be sure rotating parts have stopped. Electric shock or severe cuts can result. Inlet and exhaust filters need occasional cleaning or replacement of the elements. Failure to do so will result in more pressure drop, reduced air flow and hotter operation. The outside of the unit requires cleaning of dust and dirt. The inside of the blower also may need cleaning to remove material coating the impeller and housing. If not done, the buildup can cause vibration, hotter operation and reduced flow. Noise absorbing foam in the mufflers may need replacement.**

KEEP THIS INFORMATION WITH THE BLOWER. REFER TO IT FOR SAFE INSTALLATION, OPERATION OR SERVICE.

TROUBLESHOOTING

Symptom	*Possible Diagnosis*	*Possible Remedy*
Excess Vibration	Impeller damaged by foreign material Impeller contaminated by foreign material	Replace impeller Clean impeller, install adequate filtration.
Abnormal sound	Motor bearing failed Impeller rubbing against cover or housing	Replace bearings Repair Blower, check clearances.
Increase in sound	Foreign material can coat or destroy muffler foam.	Replace foam muffler elements, trap or filter foreign material.
Blown fuse	Electrical wiring problem	Have qualified person check fuse capacity and wiring.
Unit very hot	Running at too high a pressure or vacuum	Install a relief valve

OPERATING AND MAINTENANCE INSTRUCTIONS

SAFETY

This is the safety alert symbol. When you see this symbol personal injury is possible. The degree of injury is shown by the following signal words:

DANGER Severe injury or death will occur if hazard is ignored.

WARNING Severe injury or death can occur if hazard is ignored.

⚠ CAUTION Minor injury or property damage can occur if hazard is ignored.

Review the following information carefully before operating.

GENERAL INFORMATION

This instruction applies to the following models ONLY: R3105N-50, R4110N-50, R4310P-50, R4P115N-50, R5125Q-50, R5325R-50, R6130Q-50, R6P155Q-50, R6350R-50, R6P355R-50 and R7100R-50. These blowers are intended for use in Soil Vapor Extraction Systems. The blowers are sealed at the factory for very low leakage. They are powered with a U.L. listed electric motor Class 1 Div. 1 Group D motors for Hazardous Duty locations. Ambient temperature for normal full load operation should not exceed 40° C (105° F). For higher ambient operation, contact the factory.

Gast Manufacturing Corporation may offer general application guidance: however, suitability of the particular blower and/or accessories is ultimately the responsibility of the user, not the manufacturer of the blower.

INSTALLATION

DANGER Models R5325R-50, R6130Q-50, R6350R-50, R5125Q-50, R6P155Q-50, R6P355R-50 AND R7100R-50 use Pilot Duty Thermal Overload Protection. Connecting this protection to the proper control circuitry is mandated by UL674 and NEC501. Failure to do so could/ may result in a EXPLOSION. See pages 3 and 4 for recommended wiring schematic for these models.

⚠ *WARNING Electric shock can result from bad wiring. A qualified person must install all wiring, conforming to all required safety codes. Grounding is necessary.*

⚠ *WARNING This blower is intended for use on soil vapor extraction equipment. Any other use must be approved in writing by Gast Manufacturing. Corp.* Install this blower in any mounting position. Do not block the flow of cooling air over the blower and motor.

PLUMBING - Use the threaded pipe ports for connection only. They will not support the plumbing. Be sure to use the same or larger size pipe to prevent air flow restriction and overheating of the blower. When installing fittings, be sure to use pipe thread sealant. This protects the threads in the blower housing and prevents leakage. Dirt and chips are often found in new plumbing. Do not allow them to enter the blower.

NOISE - Mount the unit on a solid surface that will not increase the sound. This will reduce noise and vibration. We suggest the use of shock mounts or vibration isolation material for mounting.

ROTATION - The Gast Regenair Blower should only rotate clockwise as viewed from the electric motor side. The casting has an arrow showing the correct direction. Confirm the proper rotation by checking air flow at the IN and OUT ports. If needed reverse rotation of three phase motors by changing the position of any two of the power line wires.

OPERATION

⚠ *WARNING Solid or liquid material exiting the blower or piping can cause eye damage or skin cuts. Keep away from air stream.*

⚠ *WARNING - Gast Manufacturing Corporation will not knowingly specify, design or build any blower for installation in a hazardous, combustible or explosive location without a motor conforming to the proper NEMA or U. L. standards.* Blowers with standard TEFC motors should never be utilized for soil vapor extraction applications or where local state and/or Federal codes specify the use of explosion-proof motors (as defined by the National Electric Code, Articles 100,500 c1990).

⚠ *CAUTION Attach blower to solid surface before starting to prevent injury or damage from unit movement.* Air containing solid particles or liquid must pass through a filter before entering the blower. Blowers must have filters, other accessories and all piping attached before starting. Any foreign material passing through the blower may cause internal damage to the blower.

⚠ *CAUTION Outlet piping can burn skin. Guard or limit access.* Mark *"CAUTION Hot Surface. Can Cause Burns".* Air temperature increases when passing through the blower. When run at duties above 50 in. H_2O, metal pipe may be required for hot exhaust air. The blower must not be operated above the limits for continuous duty. Only models R3105N-50, R4110N-50 and R4310P-50 can be operated continuously with no air flowing through the blower. Other units can only be run at the rating shown on the model number label. Do not Close off inlet (for vacuum) to reduce extra air flow. This will cause added heat and motor load. Blower exhaust air in excess of 230°F indicates operation in excess of rating which can cause the blower to fail.

ACCESSORIES ...Gast pressure gauge AJ496 and vacuum gauges AJ497 or AE134 show blower duty. The Gast pressure/vacuum relief valve, AG258, will limit the operating duty by admitting or relieving air. It also allows full flow through the blower when the relief valve closes.

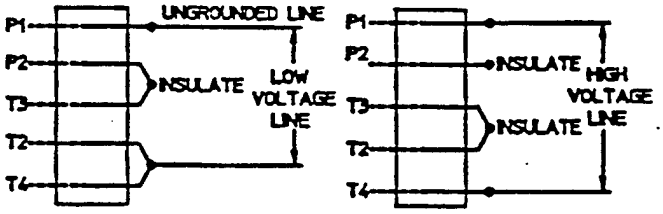
SERVICING

⚠ *WARNING* *To retain their sealed construction they should be serviced by Gast authorized service centers ONLY.* These models are sealed at the factory for very low leakage.

⚠ *WARNING* *Turn off electric power before removing blower from service. Be sure rotating parts have stopped. Electric shock or severe cuts can result.* Inlet and exhaust filters attached to the blower may need cleaning or replacement of the elements. Failure to do so will result in more pressure drop, reduced air flow and hotter operation of the blower. The outside of the unit requires cleaning of dust and dirt. The inside of the blower also may need cleaning to remove foreign material coating the impeller and housing. This should be done at a Gast Authorized Service Center. This buildup can cause vibration, failure of the motor to operate or reduced flow.

KEEP THIS INFORMATION WITH THIS BLOWER. REFER TO IT FOR SAFE INSTALLATION, OPERATION OR SERVICE.

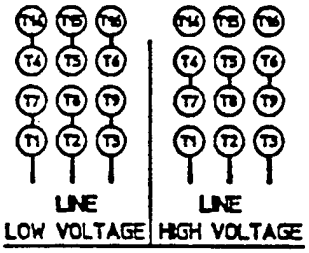
MOTOR WIRING DIAGRAM FOR R4110N-50 & R3105N-50



>>* WARNING
THIS MOTOR IS THERMALLY PROTECTED AND WILL AUTOMATICALLY RESTART WHEN PROTECTOR RESETS. ALWAYS DISCONNECT POWER SUPPLY BEFORE SERVICING.

MOTORS WIRING DIAGRAM FOR R4310P-50

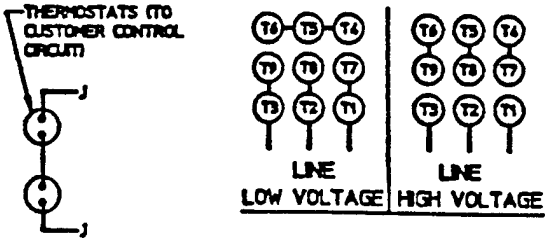
TO REVERSE ROTATION, INTERCHANGE THE EXTERNAL CONNECTIONS TO ANY TWO LEADS.



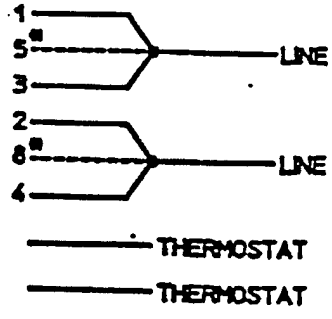
>>* WARNING
THIS MOTOR IS THERMALLY PROTECTED AND WILL AUTOMATICALLY RESTART WHEN PROTECTOR RESETS. ALWAYS DISCONNECT POWER SUPPLY BEFORE SERVICING.

MOTORS WIRING DIAGRAM FOR R5325R-50, R6350R-50, R6P355R-50, & R7100R-50

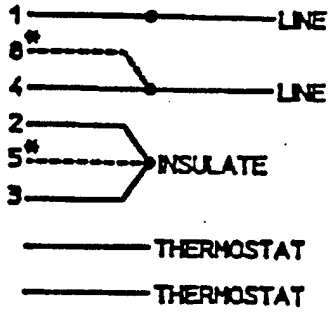
TO REVERSE ROTATION, INTERCHANGE THE EXTERNAL CONNECTIONS TO ANY TWO LEADS.



MOTOR WIRING DIAGRAM FOR R5125Q-50 & R4P115N-50



LOW VOLTAGE

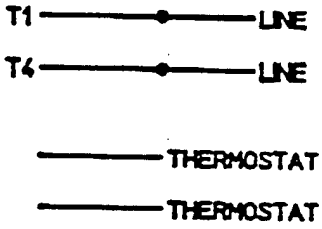


HIGH VOLTAGE

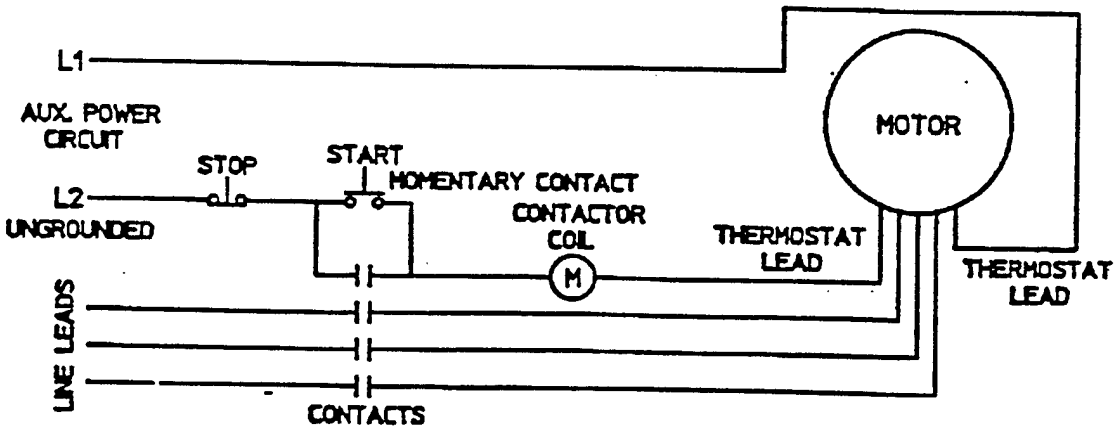
* R5125Q-50 BLOWERS PRODUCED AFTER SEPTEMBER 1992 (SER. NO. 0992) DO NOT HAVE MOTOR LEADS 5 & 8.

MOTOR WIRING DIAGRAM FOR R6130Q-50 & R6P155Q-50

CONNECT THERMOSTAT TO MOTOR PROTECTION CIRCUIT



CONNECTION FOR THERMOSTAT MOTOR PROTECTION

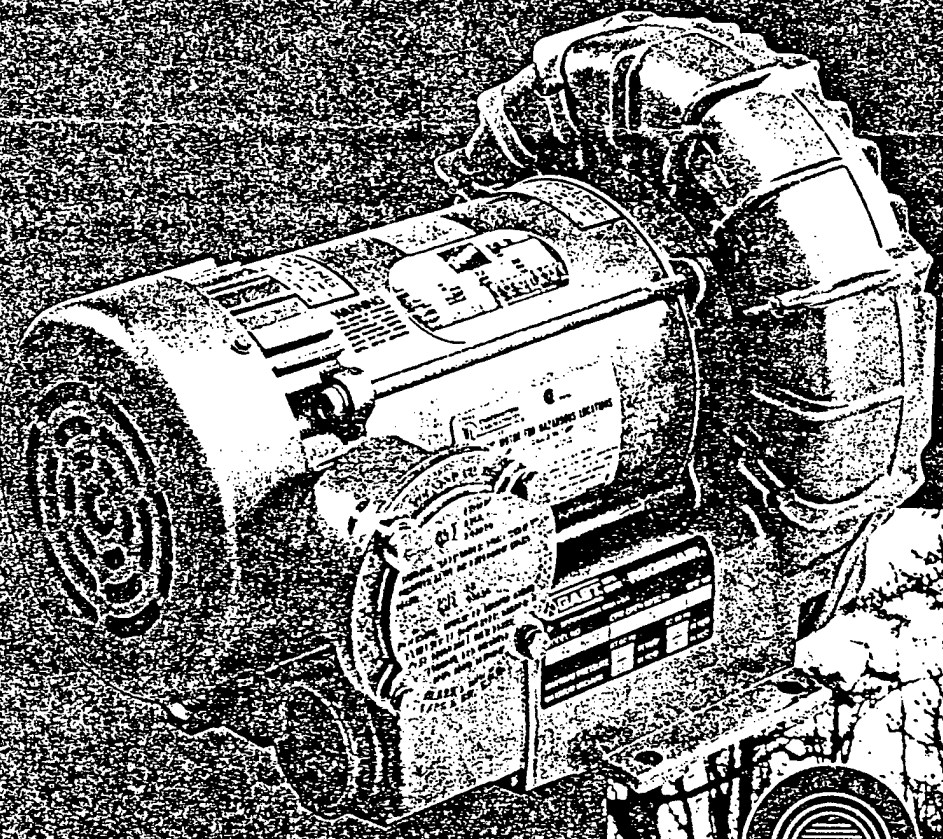


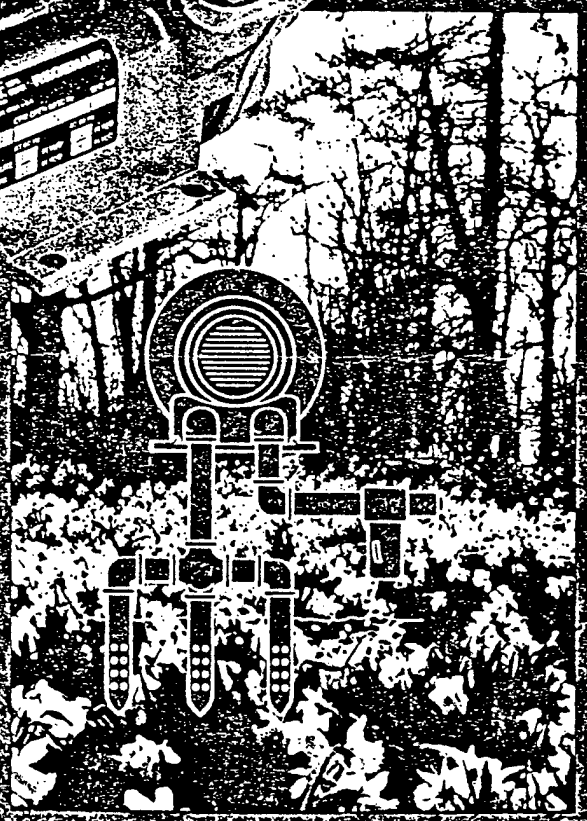
TERMOSTATS TO BE CONNECTED IN SERIES WITH CONTROL AS SHOWN. MOTOR FURNISHED WITH AUTOMATIC THERMOSTATS RATED A.C. 115-600V. 720VA

AK811 rev. E

Blowers for

SOIL VAPOR EXTRACTION





GAST

Your Warranty

REGARDLESS OF CAUSE, if a product you buy from this catalog does not work right, Gast will repair or replace it once, at no charge, for up to one year from the date of shipment from the factory.

In the course of repair or replacement, Gast may send you written recommendations on how to prevent a problem from happening again. Gast reserves the right to withdraw this warranty if you do not follow these recommendations. Customer is responsible for freight charges both to and from Gast in all cases.

THIS WARRANTY DOES NOT APPLY TO ELECTRIC MOTORS, ELECTRICAL CONTROLS AND GASOLINE ENGINES, WHICH GAST OBTAINS FROM OTHER MANUFACTURERS. A MOTOR OR ENGINE CARRIES ONLY THE WARRANTY OF THE COMPANY THAT MAKES IT. THIS WARRANTY IS EXCLUSIVE AND IS IN LIEU OF ALL OTHER WARRANTIES, WHETHER WRITTEN, ORAL OR IMPLIED, INCLUDING THE WARRANTY OF MERCHANTABILITY AND OF FITNESS FOR ANY PARTICULAR PURPOSE. GAST'S LIABILITY IS IN ALL CASES LIMITED TO THE REPLACEMENT PRICE OF ITS PRODUCT. GAST SHALL NOT BE LIABLE FOR ANY OTHER DAMAGES, WHETHER CONDSEQUENTIAL, INDIRECT, OR INCIDENTAL, ARISING FROM THE SALE OR USE OF ITS PRODUCTS.

Gast's sales personnel may modify this warranty, but only by signing a specific, written description of any modifications.

Gast Manufacturing Corporation

Customer Sales & Service
2550 Meadowbrook Road
Benton Harbor, MI 49022
Ph: 616/926-6171
Fax: 616/925-8288

Corporate Headquarters
Post Office Box 97
Benton Harbor, MI 49023
Ph: 616/926-6171
Fax: 616/927-0808

Eastern Sales Office
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Carlstadt, NJ 07072
Ph: 201/933-8484
Fax: 201/933-5545

Midwestern Sales Offices
755 North Edgewood
Wood Dale, IL 60191
Ph: 708/860-7477
Ph: 800/800-8715
Fax: 708/860-1748

European Sales Office
Halifax Road, Cressex Estate
High Wycombe, Bucks HP 12 3SN
Ph: 44 494 523571
Fax: 44 494 436588
Telex 83488

GAST

Printed on recycled paper

GAST REGENAIR® Blowers FOR SOIL VAPOR

designed to supply up to 420 cfm (714m 3/hr), 7 in Hg/224 mbar (90" H_2O) or 4 psi/249 mbar (100" H_2O)

The Gast reputation for quality and customer satisfaction is renowned throughout the world. Since 1921 we have been supplying air moving products that have set the industry standard of excellence. Our regenerative blowers for soil vapor extraction are no exception. Designed to extract vapors from contaminated soils, these models are used in conjunction with site-supplied special filters which clean the contaminants before venting them to the atmosphere. Since this process can take months or even years, Gast environmental blowers are a perfect solution; the only wearing part is the bearing, which is rated for up to 25,000 hours of service. Also, each of our motor-mounted models comes with a Class 1 Group D explosion-proof motor as a standard feature. Combining this quality with the strongest warranty in the business and a vast national and international distribution network providing product and technical support, we think you'll find our special Gast Regenair® blowers to be the right choice for your soil vapor extraction needs.

MODEL R4 SERIES
48" H_2O MAX. VAC., 51" H_2O MAX. PRESSURE
92 CFM OPEN FLOW

MODEL R5 SERIES
60" H_2O MAX. VAC., 65" H_2O MAX. PRESSURE
160 CFM OPEN FLOW

MODEL R6 SERIES
70" H_2O MAX. VAC., 75" H_2O MAX. PRESSURE
215 CFM OPEN FLOW

MODEL R6P SERIES
85" H_2O MAX. VAC., 100" H_2O MAX. PRESSURE
280 CFM OPEN FLOW

MODEL R7 SERIES
90" H_2O MAX. VAC., 90" H_2O MAX. PRESSURE
420 CFM OPEN FLOW

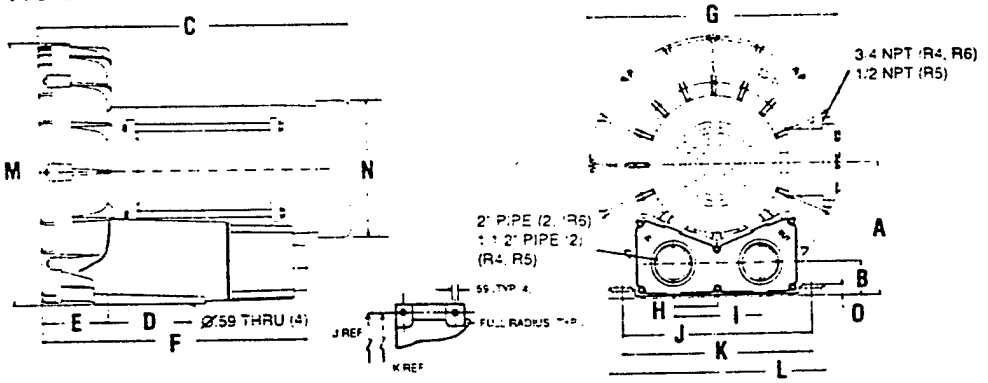
PRODUCT FEATURES
- Explosion-proof motors UL (class 1, group D)
- Sealed air stream
- Rugged construction
- Low maintenance

Product Dimensions

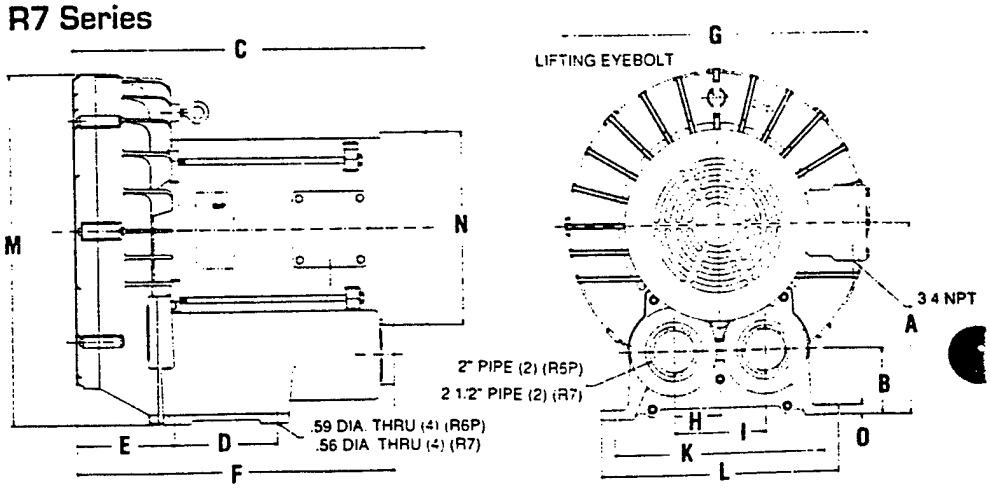
Model	Metric (mm) A	B	C	D	E	F	G	H	U.S. Imperial (inches) I	J	K	L	M	N	O
R4110N-50	157	43	389	95	72	316	313	50	101	225	227	254	293	175	11
	6.18	1.68	15.30	3.75	2.85	12.44	12.31	1.98	3.96	8.86	8.93	10.00	11.73	6.88	.44
R4310P-50	157	43	356	95	72	316	313	50	101	225	227	254	293	175	11
	6.18	1.68	14.03	3.75	2.84	12.44	12.31	1.98	3.96	8.86	8.93	10.00	11.73	6.88	.44
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
R6P1550Q-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.

R4 Series
R5 Series
R6 Series



R6P Series
R7 Series



More models may be available – please consult factory

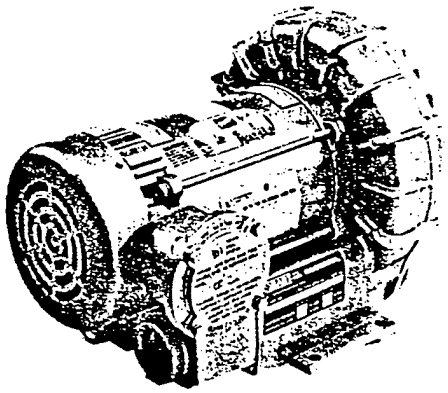
EXTRACTION...

Product Specifications

Model Number	Hz	Motor Specs	Full Load Amps	HP	RPM	Max Vac "H_2O	Max Vac mbar	Max Pressure "H_2O	Max Pressure mbar	Max Flow cfm	Max Flow m^3h	Net. Wt lbs.
R4110N-50	50	110/220-240-50-1*	9.2/5.2-4.6	0.6	2850	35	87	38	95	74	126	60
	60	115/208-230-60-1*	11.4/6.2-5.6	1.0	3450	48	120	51	127	92	156	
R4310P-50	50	220/380-50-3*	3.2/1.6	0.6	2850	35	87	38	95	74	126	58
	60	208-230/460-60-3*	3.4-3.3/1.65	1.0	3450	48	120	51	127	92	156	
R5125Q-50	60	115/230-60-1	25/12.5	2.0	3450	60	149	55	137	160	272	77
R5325R-50	50	190-220/380-415-50-3	5.0-4.4/2.5-2.6	1.5	2850	47	117	50	125	133	226	75
	60	208-230/460-60-3	6.0-5.6/2.8	2.0	3450	60	149	65	162	160	272	
R6130Q-50	50	220-240-50-1	14.7-13.5	2.5	2850	65	162	75	187	182	309	129
	60	230-60-1	16.3	3.0	3450	70	174	60	149	215	365	
R6P155Q-50	50	220-240-50-1	20.8-19.1	4.0	2850	65	162	80	199	235	399	243
	60	230-60-1	29.9	5.5	3450	85	212	95	237	280	476	
R6P355R-50	50	190-220/380-415-50-3	14.9-11/7.45-5.8	4.5	2850	65	162	80	199	232	394	233
	60	208-230/460-60-3	20-18/9	6.0	3450	85	212	100	249	280	476	
R7100R-50	50	190-220/380-415-50-3	20.8-18.9/10.4-9.5	8	2850	72	179	80	199	350	595	297
	60	208-230/460-60-3	26.5-24/12	10	3450	90	224	90	224	420	714	

*Models have automatic reset thermal protection.

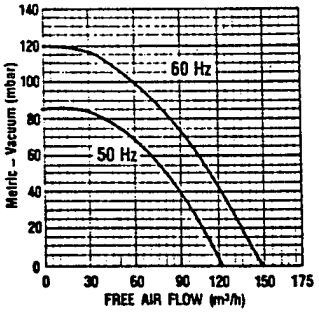
Product Performance
(Metric/U.S. Imperial)

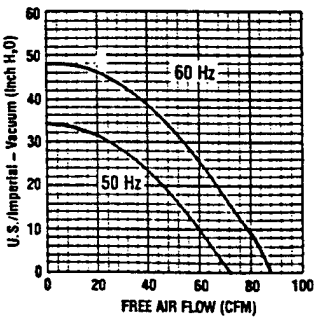


NOTE: These units with explosion-proof motors are designed specifically for qualified OEMs in the soil vapor extraction industry. They are not intended to be applied for other uses without written acknowledgment from an authorized employee of Gast Manufacturing Corporation.

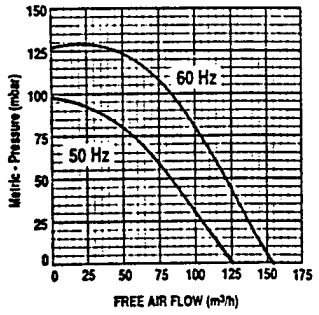
Model R4 Series

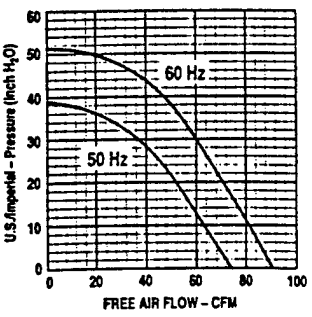
Vacuum





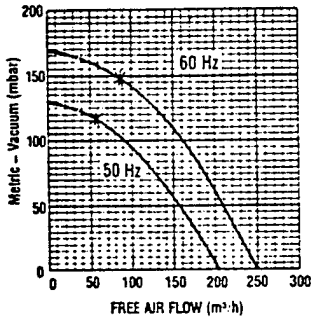
Pressure



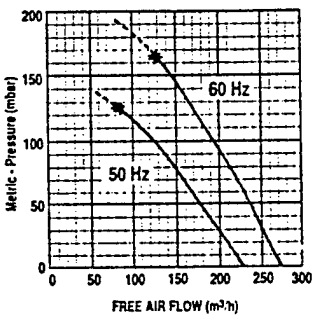


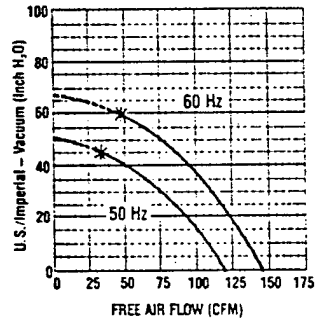
Model R5 Series

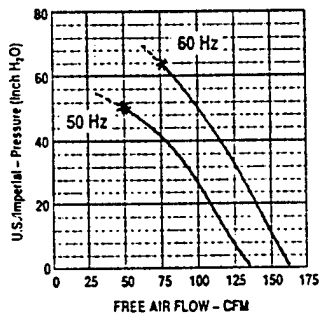
Vacuum



Pressure

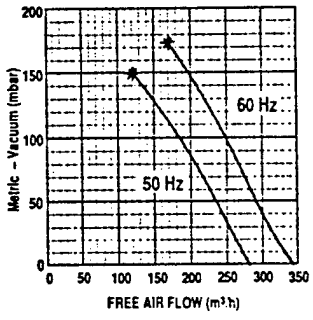




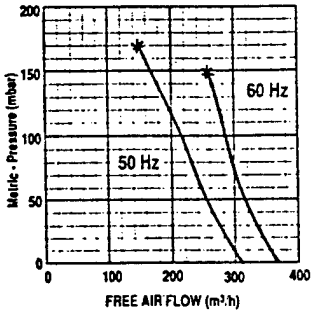


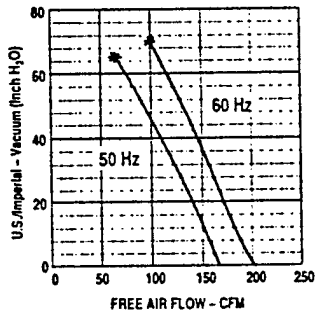
Model R6 Series

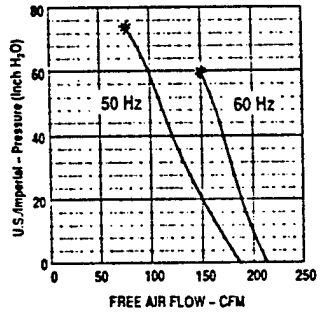
Vacuum



Pressure

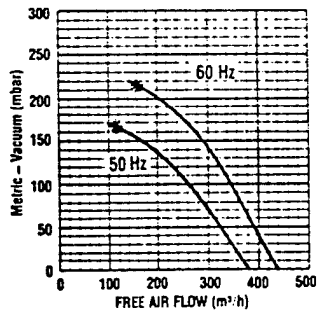




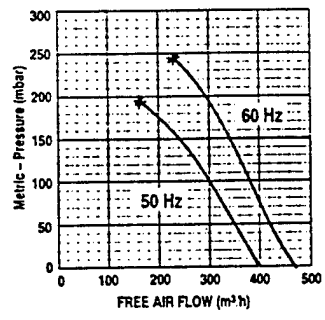


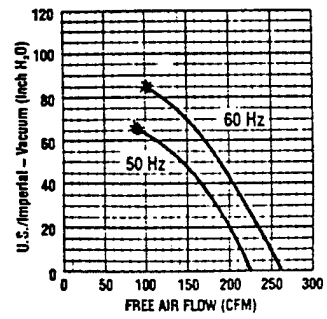
Model R6P Series

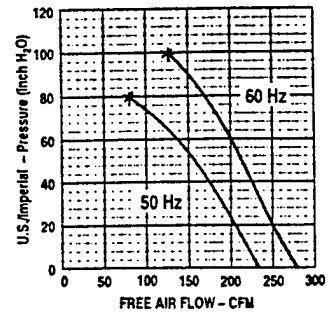
Vacuum



Pressure

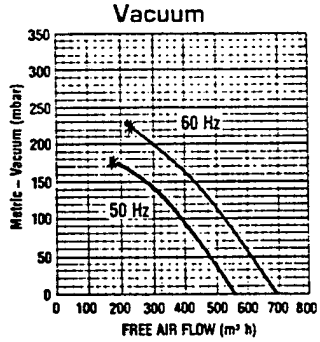




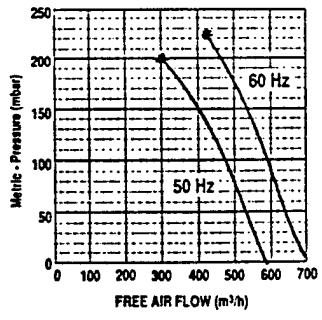


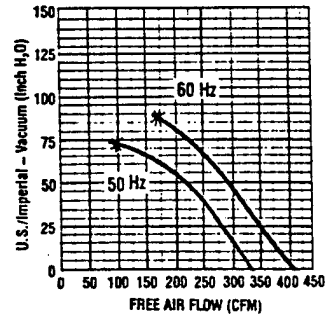
Model R7 Series

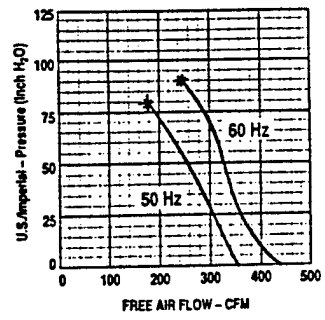
Vacuum



Pressure





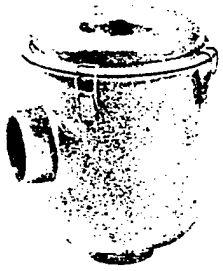


* Recommended maximum duty. ------- Intermittent duty only.

Blower Accessories

In-line Filters

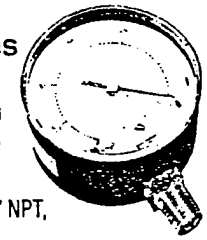
The impeller of a blower passes very close to the housing. It is always wise to have an inlet or in-line filter to ensure troublefree life.



Model No.	R4	R5	R6,R6P	R7
Part No.	AJ151D	AJ151E	AJ151G	AJ151H
Replacement Element	AJ135E	AJ135F	AJ135G	AJ135C
Micron	10	10	10	10

Vacuum and Pressure Gauges

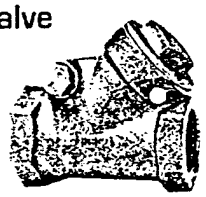
To monitor the system performance so as not to exceed maximum duties. Using two (one on each side of the filter) is a great way to know when the filter needs servicing.



- Vacuum Gauge, Part #AJ497, 2 5/8" Dia., 1/4" NPT, 0-60 in. H_2O and 0-150 mbar
- Vacuum Gauge, Part #AE134, 2 5/8" Dia., 1/4" NPT, 0-160 in. H_2O and 0-400 mbar
- Pressure Gauge, Part #AJ496, 2 5/8" Dia., 1/4" NPT, 0-60 in. H_2O and 0-150 mbar
- Pressure Gauge, Part #AE133, 2 5/8" Dia., 1/4" NPT, 0-160 in. H_2O and 0-400 mbar
- Pressure Gauge, Part #AE133A, 2 5/8" Dia., 1/4" NPT, 0-200 in. H_2O

Horizontal Swing Type Check Valve

Designed to prevent back-wash of fluids that would enter the blower. Also prevents air back-streaming if needed. They can be mounted with their discharge either vertical or horizontal. Valve will open with 3" of water pressure.



Model No.	R4,R5	R6,R6P	R7
Part No.	AH326D	AH326F	AH326G
	1 1/2" NPT	2" NPT	2 1/2" NPT

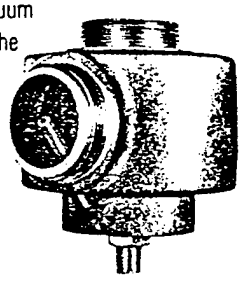
Moisture Separator

The purpose of the moisture separator is to remove liquids from the gas stream in a soil vapor extraction process. This helps protect the blower from corrosion and a build up of mineral deposits.

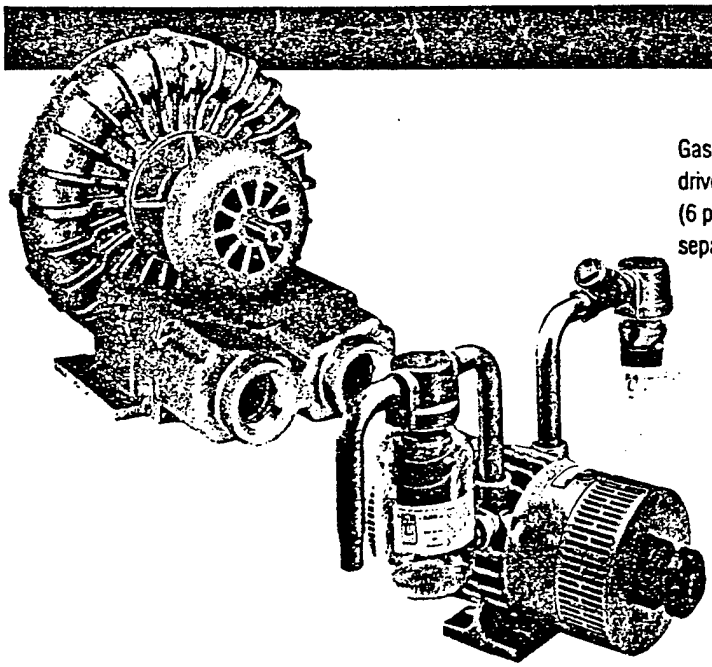
MODEL	LIQUID CAPACITY GALLONS	USED ON
RMS160	10	R4, R4P, R5
RMS200	19	R4, R4P, R5, R6
RMS300	19	R5, R6, R6P
RMS400	40	R6P, R7

Relief Valve

By setting a relief valve at a given pressure/vacuum you can be assured that no harm will come to the blower or products in your application from excessive duties.



- Pressure/Vacuum Relief Valve, 1 1/2" NPT, Adjustable 30 - 170 in. H_2O, 200 cfm max. Part #AG258



Gast also offers other models that are ideal for soil sparging. Our separate drive blowers are available in 4 sizes to 15 hp, pressures to 170" H_2O (6 psi). Rotary vane compressors are available in motor mounted or separate drive styles up to 5 hp, pressures to 20 psi.

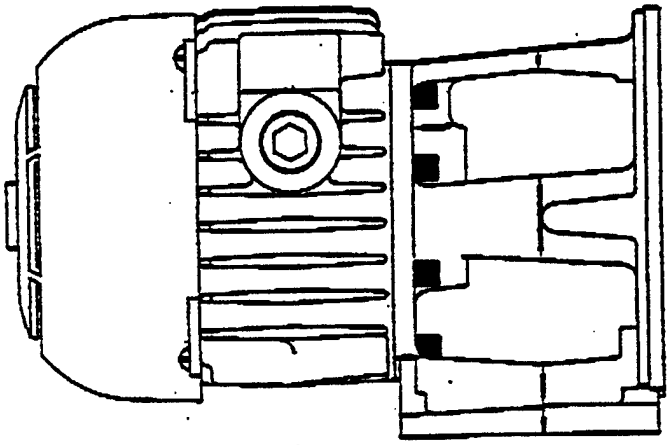
APPENDIX B
ROTARY-VANE BLOWER INFORMATION

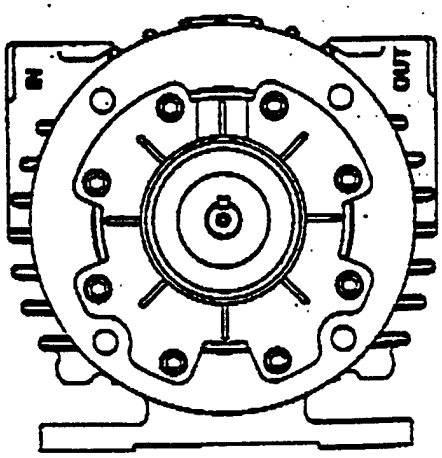
70-230
G360PL
7-89

GAST MANUFACTURING CORPORATION
P. O. BOX 97, BENTON HARBOR, MICHIGAN 49022
PHONE 616-926-6171

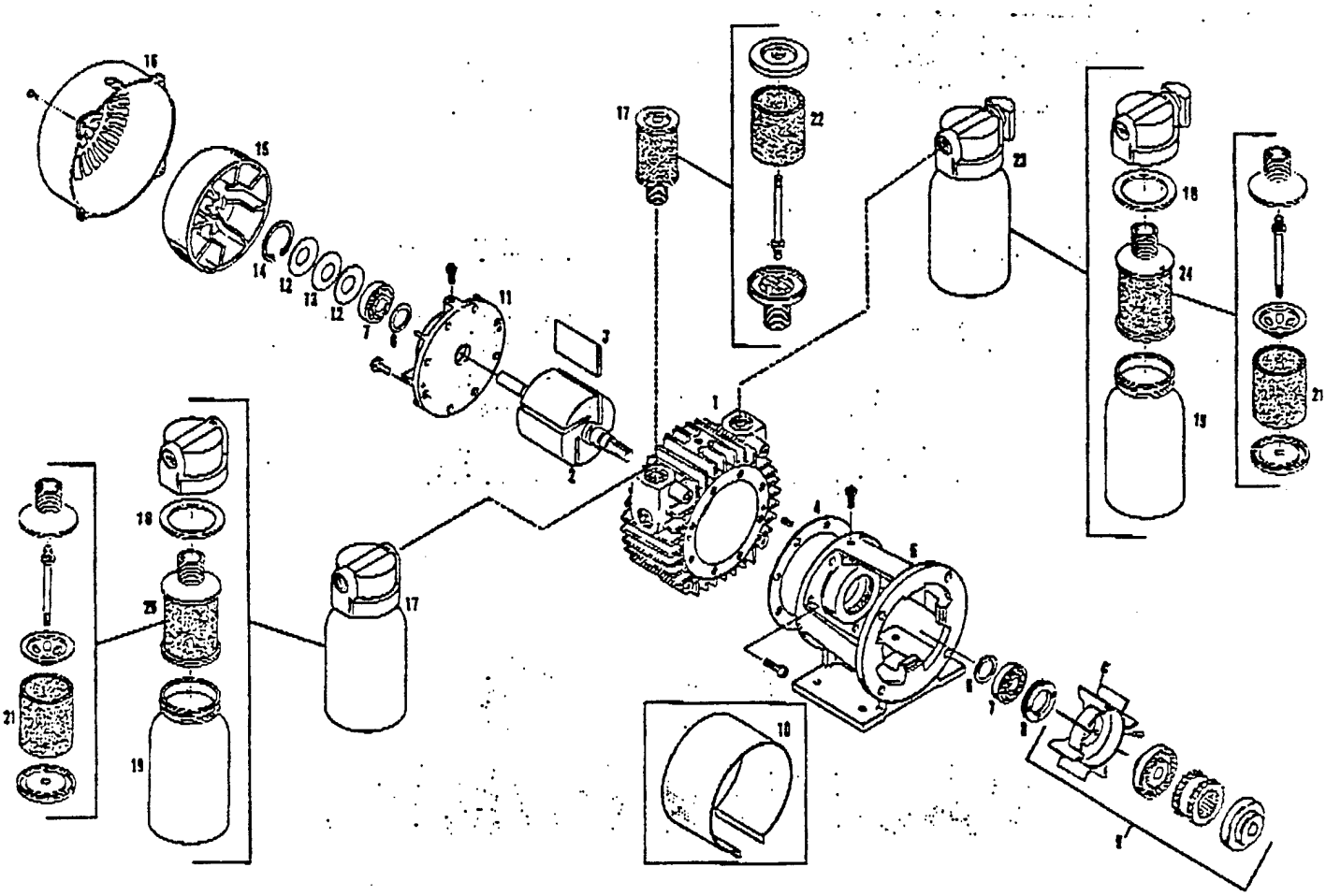
PARTS LIST and OPERATING INSTRUCTIONS 1067, 2067, and 2567

OIL LESS VACUUM PUMPS and COMPRESSORS





WARNING: UNIT SHOULD NOT PUMP EXPLOSIVE GASES OR BE USED IN EXPLOSIVE AMBIENTS.



REF. NO.	DESCRIPTION	PART ONTY.	1067-V1□□	1067-P1□2	2067-V1□□	2067-P1□2	2567-V1□□	2567-P1□2
1	Body	1	AH345	AH345	AH191	AH191	AH355	AH355
2	Rotor Assembly	1	AH428	AH428	AH192	AH192	AH192	AH192
* 3	Vane	4	AH430	AH430	AH195	AH195	AH195	AH195
* 4	Body Gasket	1	AH567	AH567	AH567	AH567	AH567	AH567
5	Foot Bracket	1	AH208	AH208	AH208	AH208	AH208	AH208
* 6	Deflector	2	AH193	AH193	AH193	AH193	AH193	AH193
* 7	Ball Bearing (Drive & Dead)	2	AC894	AC894	AC894	AC894	AC894	AC894
8	End Cap, Drive	1	AB339A	AB339A	AB339A	AB339A	AB339A	AB339A
9	Fan Coupling Assembly	1	AH198	AH198	AH198	AH198	AH198	AH198
10	Fan Guard	1	AH194	AH194	AH194	AH194	AH194	AH194
11	End Plate Dead	1	AH205	AH205	AH205	AH205	AH205	AH205
12	Belleville Springs	2	AB337	AB337	AB337	AB337	AB337	AB337
13	Washer	1	AB338	AB338	AB338	AB338	AB338	AB338
14	Snap Ring	1	AB335	AB335	AB335	AB335	AB335	AB335
15	Fan	1	AC3268	AC3268	AC3268	AC3268	AC3268	AC3268
16	Fan Guard	1	AC1028	AC1028	AC1028	AC1028	AC1028	AC1028
17	Intake Filter Assembly	1	AA900C	AA905F	AA900D	AA905G	AA900D	AA905G
18	Gasket	2	AA405		AA405		AA405	
19	Jar	2	AA401		AA401		AA401	
20	Filter Assembly	1	AC435-1		AC435-1		AC435-1	
* 21	Cartridge	2	AC393	AC393	AC393		AC393	
* 22	Filter Felt	1		D3448		D3448		D3448
23	Muffler	1	AA900F		AA900F		AA900F	
24	Muffler Assembly	1	AC434-1		AC434-1		AC434-1	
	Service Kit		K386	K386	K350	K357	K350	K357

* Denotes parts in service kit.
When corresponding or ordering spare parts, please give complete model and serial numbers.

OPERATING AND MAINTENANCE INSTRUCTIONS

CONSTRUCTION: The end plate, body, rotor and foot bracket are all cast iron. Consequently any moisture that accumulates in the pump will tend to corrode the interior especially if it stands idle. The vanes are made of hard carbon and are precision ground. They should last 5,000 to 10,000 hours depending upon the degree of vacuum pressure at which the pump is run.

STARTING: CAUTION: *NEVER LUBRICATE THIS OILLESS AIR PUMP.* The carbon vanes and grease packed motor bearings require no oil. If the motor fails to start or slows down when under load shut the unit off and unplug. Check that the supply voltage agrees with the motor post terminals and the motor data name plate. CAUTION: ALL DUAL VOLTAGE MOTORS ARE SHIPPED FROM THE FACTORY WIRED FOR THE HIGH VOLTAGE. If the pump is extremely cold allow it to warm to room temperature before starting. If anything appears to be wrong with the motor return the complete pump to an authorized Gast service facility.

To minimize noise and vibration the unit should be mounted on a solid surface that will not resonate. Use of shock mounts or vibration isolation material is recommended. Inlet or discharge noise can be minimized by attaching the muffler. The unit should not be allowed to operate in ambient air temperatures in excess of 40°C (104°F). If the motor fails to start or slows down when under load shut the unit off and unplug. Check that the supply voltage agrees with the motor post terminal setup and the motor data name plate.

FILTRATION: Care must be taken to insure that any particles (dirt, chips, foreign material) often found in new plumbing not be allowed to enter the unit. Liquid, moisture vapor, or oil based contaminates will affect pump performance and must be filtered from entering the pump.

Dirty filters restrict air flow and if not corrected could lead to possible motor overload, poor performance and early pump failure. Check filters periodically and clean when necessary by removing felts and washing in Gast flushing solvent (part number AH255). Dry with compressed air and replace.

FLUSHING: Should excessive dirt, foreign particles, moisture, or oil be permitted to enter the pump the vanes will act sluggish or even break. Flushing the pump should remove these materials. First remove the filter & muffler clean with solvent & dry with compressed air.

DISASSEMBLY: Begin by removing the fan guard and fan. The dead end plate may be removed using a wheel puller. The vanes and body area can then be inspected for damage or further cleaning. Unless scoring is visible do not remove drive end plate and top clearance will be maintained. If further repair is required remove the spanner nut before using a wheel puller to remove the drive end plate. Both bearings are a press fit on the shaft.

REASSEMBLY: First attach the drive end plate (but do not tighten bolts) and press the bearing on the shaft (be sure to properly support the inner race). If required top clearance (between rotor & body) should then be set (for 1067 models it is .0015 and for 2067 and 2567 it is .003). Now replace the dead end plate and bearing. Then the bellville springs, washer and snap ring should be replaced. With a dial indicator on the dead end shaft to show any movement, install spanner nut (with adhesive to keep from vibrating loose) until indicator moves .002–.0025. Check shaft for ease of rotation.

HAZARD PREVENTION:

WARNING: MAKE SURE THE ELECTRIC MOTOR IS PROPERLY GROUNDED AND THE WIRING IS DONE BY A QUALIFIED ELECTRICIAN FAMILIAR WITH NEMA MG2 SAFETY STANDARDS, NATIONAL ELECTRIC CODE AND ALL LOCAL SAFETY CODES.

WARNING: THE ELECTRIC MOTOR MAY BE THERMALLY PROTECTED AND WILL AUTOMATICALLY RESTART WHEN THE PROTECTOR RESETS.

WARNING: WHEN SERVICING ALL POWER TO THE MOTOR MUST BE DE-ENERGIZED AND DISCONNECTED. ALL ROTATING COMPONENTS MUST BE AT A STAND STILL.

WARNING: DO NOT USE KEROSENE OR OTHER COMBUSTIBLE SOLVENTS OR OPERATE PUMP IN EXPLOSIVE AMBIENTS.

Performance Data

Model	Vacuum			Maximum Vacuum
	0" HG	10" HG	20" HG	
1067	8.5 CFM	5.0 CFM	2.0	26" HG
2067	16.0	9.0	3.0	27"
2567	20.0	13.0	5.0	27"

Model	Pressure			
	0 PSI	5 PSI	10 PSI	15 PSI
1067	8.5 CFM	7.5 CFM	7.0 CFM	6.5 CFM
2067	17.0	14.0	12.0	11.0
2567	21.0	19.0	17.0	16.0

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England 23571
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616/926-6171
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Cerritos, Ca. 90701
213-404-2721
FAX 213-404-7975

Wainbee, Ltd.
121 City View Drive
Rexdale, Ontario, Canada M9W 5A9
416/243-1900
FAX 416-243-2336

Wainbee, LTD.
215 Brunswick Blvd.
Pointe Claire, Montreal
Canada H9R 4R7
514/697-8810
FAX 514-697-3070

Note: All general correspondence should be directed to Gast Mfg Corp, P.O. Box 97, Benton Harbor, MI 49022

ACCESSORIES

CHECK VALVES—vacuum		
	AE236	⅛" NPT, male
	AJ550	⅛" NPT, female
	AJ550A	¼" NPT, female

CHECK VALVES—vacuum swing		
	AH325A	¾" NPT
	AH325B	1" NPT

CORDS—ELECTRIC		
	AA816	½" ½" ¾" hp, 115V without switch, 10 ft.
	AA819	½" ¾" hp, 230V without switch, 10 ft.
	AA826	½" ¼" ¼" hp, 115 V with switch, 10 ft.

FILTERS—no jars		
	AC433	¾" female NPS, 10 m icron
	AC433	½" male NPS, 10 m icron
	AC436	¾" male NPS, 10 micron
	AA908B	¾" female NPS, 80 micron
	AA905F	½" male NPS, 80 micron
	AA905G	¾" male NPS, 30 micron
	B300A	⅛" male NPS, 80 micron
	B343B	¼" male NPS, 80 micron
	AD750	1" male NPS, 30 micron

FILTERS—glass jar		
	AA617G	⅛" NPS, 2 oz., 80 micron
	AA922H	¼" NPS, ¾" oz., 80 micron
	AD560	1" NPS, 2 qt., 60 micron
	AB599	¾" NPS, 1 pt., 10 micron
	AB599D	¾" NPS, 1 pt., 80 micron
	AB600	½" NPS, 1 pt., 80 micron
	AB600F	½" NPS, 1 pt., 10 micron
	AB601B	¾" NPS, 1 pt., 10 micron
	AB601C	¾" NPS, 1 pt., 80 micron
	AA600C	½" NPS, 1 qt., 10 micron
	AA600E	½" NPS, 1 qt., 80 micron
	AA900D	¾" NPS, 1 qt., 10 micron
	AA900J	¾" NPS, 1 qt., 80 micron
	V400G	¼" NPS, 8 oz., 80 micron
	V500D	¾" NPS, 8 oz., 30 micron
	V400C	⅛" NPS, 8 oz., 30 micron

FILTERS—metal jar		
	AB609D	⅛" NPS, ½" pt., 10 micron
	AB612	½" NPS, ½" pt., 10 micron
	AB609B	¾" NPS, ½" pt., 10 micron
	AB609	¼" NPS, ½" pt., 80 micron
	AB608	½" NPS, ½" pt., 80 micron
	AB850C	¾" NPS, 1 qt., 10 micron
	AB850G	¾" NPS, 1 qt., 80 micron
	AB665	½" NPS, 1 qt., 80 micron
	AB665B	½" NPS, 1 qt., 10 micron

FILTERS—plastic jar		
	AA922N	⅛" NPS, ¾" oz.
	V400H	¼" NPS, 8 oz.
	V500N	¾" NPS, 8 oz.

FLUSHING SOLVENT		
	AH255	1 qt.

FOOT SUPPORT ASSEMBLIES		
	AC135	0211, 0322, 0522
	AE240	⅛"-¼" hp piston pumps
	AE241	½"-¾" piston pumps
	AE245	1" hp piston pumps

GAUGES—pressure		
	AA842	⅛" NPS, 0-30 psi
	AA844B	¼" NPS, 0-30 psi 0-2kg/cm²
	AA808	⅛" NPS, 0-160 psi (back mount)
	AA807	⅛" NPS, 0-160 psi (back mount)
	AP583	¼" NPS, 0-100 psi, heavy duty (bosom mount)

GAUGES—vacuum		
	AA840	¼" NPS, 0-30" Hg, 0-760 m/m Hg
	AA841	⅛" NPS, 0-30" Hg

HANDLES—carrying		
	AP555	for ½" and ¾" hp units

MUFFLERS—glass jar		
	AB599B	¾" NPS, 1 pt., 10 micron, for oil-less pumps
	AB600C	½" NPS, 1 pt., 80 micron, for oil-less pumps
	AB600J	½" NPS, 1 pt., 30 micron, for oil-less pumps
	AD560	1" NPS, 2 qt., 60 micron
	AB850B	1" NPS, 2 qt., 60 micron, with tubing for quieter operation
	AA900F	¾" NPS, 1 qt., 10 micron, for oil-less pumps
	AA900G	¾" NPS, 1 qt., 80 micron, for oil-less pumps
	AA922B	⅛" NPS, ¾" oz., 80 micron, for oil-less pumps
	AA922G	same as AA922 but with silencing tube
	AA617F	⅛" NPS, 2 oz., 80 micron, for oil-less pumps

MUFFLERS—metal jar		
	AB612A	½" NPS, ½" pt., 10 micron
	AB609B	¼" NPS, ½" pt., 10 micron
	AB609A	¾" NPS, ½" pt., 10 micron
	AB665C	½" NPS, 1 qt., 10 micron
	AB650D	¾" NPS, 1 qt., 10 micron

MUFFLERS—plastic jar		
	AA922P	⅛" NPS, ¾" oz.
	V425M	¼" NPS, 8 oz.
	V525G	¾ NPS, 8 oz.

OVERLOADS—motor		
		External thermal protector, specify motor number and make

PAINT		
	AE564A	Gast blue-gray, 16 oz. aerosol can

RELIEF VALVES—pressure		
	AA203	⅛" NPS, flow below 2 cfm
	AA206	¼" NPS, flow below 2 cfm
	AA800	¾" NPS, flow below 10 cfm
	AA307	¾" NPS, flow above 10 cfm
	AP570S	¼" NPS, 0-100 psi
	AF720	¼" NPT, 0-100 psi
	AE960	1" NPT, 0-100 psi

RELIEF VALVES—vacuum		
	AA204	⅛" NPS, flow below 2 cfm
	AA207	⅛" NPS, flow below 2 cfm
	AA840A	¾" NPS, flow from 2-15 cfm
	AA308	¾" NPS, flow above 10 cfm
	AE961	1" NPS, for 4865, 8565

SWITCH—vacuum		
	AE285	¼" NPS

TRAPS—vacuum		
	AA673	⅜" NPS, 8 oz.
	AA673B	½" NPS, 2 oz.
	AA675C	¼" NPS, 2 oz.

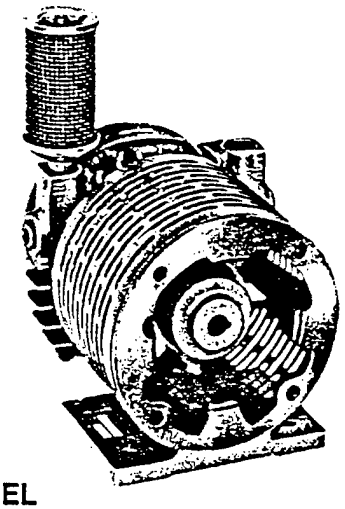
TROUBLE SHOOTING GUIDE FOR ROTARY VANE PUMPS

REASONS FOR PROBLEM	Low Vac.	Low Press.	High Vac.	High Press.	Pump Overheating	Motor Overload
Filter dirty	X	X	at pump		X	X
Muffler dirty		X		at pump	X	X
Vac. line collapsed	X		at pump		X	X
Relief valve set too high			X	X	X	X
Relief valve set too low	X	X				
Plugged vacuum or pressure line	X	X	at pump	at pump	X	X
Vanes sticking	X	X				
Running at too high RPM			X	X	X	X
Vanes worn (replace)	X	X				
Shaft seal worn (replace)	X	X				
Dust or offset powder in pump	X	X			X	X
Motor not wired correctly	X	X			X	

Separate Drive Rotary Vane 8.5, 17.0 and 21.0 cfm

GAST

Oilless 1067, 2067, 2567 Series



MODEL 1067 SERIES
15 PSI MAX. PRESSURE, 8.50 CFM OPEN FLOW

MODEL 2067 SERIES
15 PSI MAX. PRESSURE, 17.00 CFM OPEN FLOW

MODEL 2567 SERIES
15 PSI MAX. PRESSURE, 21.00 CFM OPEN FLOW

PRODUCT FEATURES

- Oilless operation
- Close coupled easy motor mounting
- Rugged construction/low maintenance
- Essentially pulse free service

INCLUDES

- Filter AA905F (1067), AA905G (2067/2567)
- Fan/coupling assembly AH198
- Fan guards AC102C, AH194

RECOMMENDED ACCESSORIES

- Pressure relief valve AA600 (1067), AA307 (2067/2567) (U.S. version)
- Pressure gauge AA644B (U.S. version)
- Repair kit K356 (1067)
- Repair kit K350 (2067/2567)

Important Notice:

Pictorial and dimensional data is subject to change without notice.

EUROPEAN MODEL
Product Dimensions Metric (mm)

Model	A	B	C	D	E	F	G	H	I	J	K	L	M	N
1067	195	100	144	72	288	180	102	11	125	165	241	142	19	80
2067	195	100	144	72	289	180	102	11	125	165	284	164	19	80
2567	195	100	144	72	289	180	102	11	125	165	284	164	19	80

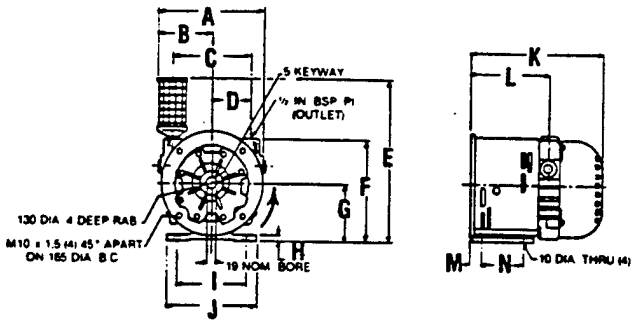
U.S. MODEL
Product Dimensions Metric (mm) U.S. Imperial (inches)

Model	A	B	C	D	E	F	G	H	I	J	K	L	M	N
1067	195	145	287	180	132	102	11	124	165	241	142	495	21	76
1067	7.69	5.69	11.31	7.09	5.19	4.0	.44	4.88	6.50	9.50	5.59	19.50	.84	3.00
2067	194	145	287	180	132	102	11	124	165	284	164	584	21	76
2067	7.63	5.69	11.31	7.09	5.19	4.0	.44	4.88	6.50	11.19	6.44	23.00	.84	3.00
2567	194	145	287	180	132	102	11	124	165	284	164	584	21	76
2567	7.63	5.69	11.31	7.09	5.19	4.0	.44	4.88	6.50	11.19	6.44	23.00	.84	3.00

Dimensions for reference only.

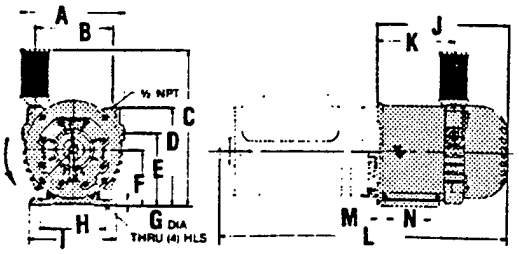
METRIC MODEL

INLET
2067/2567 ¾ IN. BSP.
1067 ½ IN. BSP.



U.S./IMPERIAL MODELS
NEMA 56, C FACE

INLET
2067/2567 ¾ NPT
1067 ½ NPT



Product Specifications

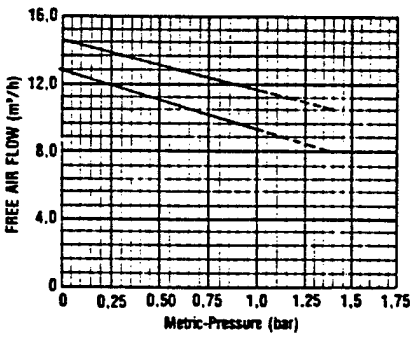
Model Number	Motor	RPM		HP	kW	Net Wt.	
		60 cycle	50 cycle			lbs.	kg
1067-P102	Not included	1725	1425	1	0,75	34	15,40
1067-P104 (metric)	Not included	1725	1425	1	0,75	34	15,40
†1067-P106-G561X (like 1067-P102 plus motor)	110/220-240; 115/208-230; 50/60-1	1725	–	1	0,75	65	29,5
2067-P102	Not included	1725	1425	1	0,75	47	21,3
2067-P104 (metric)	Not included	1725	1425	1	0,75	47	21,3
†2067-P106-G561X (like 2067-P102 plus motor)	110/220-240; 115/208-230; 50/60-1	1725	–	1	0,75	92	41,7
2567-P102	Not included	1725	1425	2	1,5	46	20,9
2567-P104 (metric)	Not included	1725	1425	2	1,5	46	20,9
2567-P106-G475 (like 2567-P102 plus motor)	230/460-60-3	1725	–	2	1,5	81	36,8

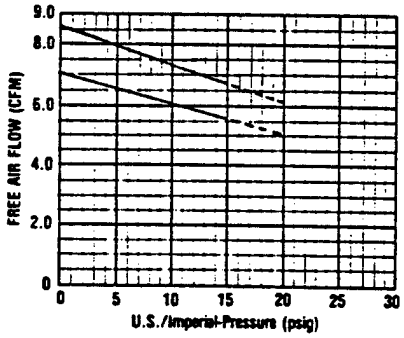
†Motor includes Thermotector.

Product Performance (Metric U.S. Imperial)

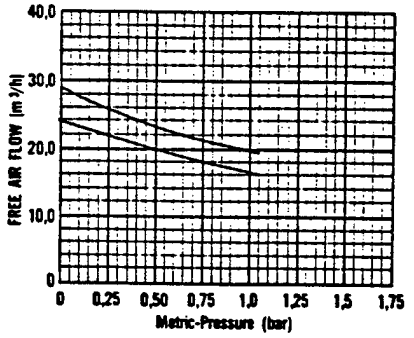
Black line on curve is for 60 cycle performance.
Blue line on curve is for 50 cycle performance.

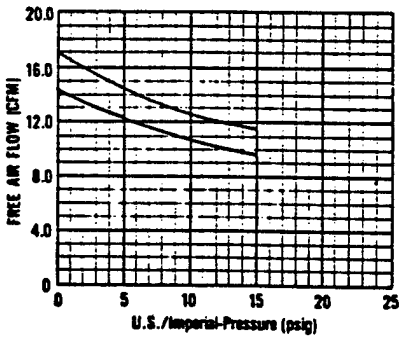
Model 1067



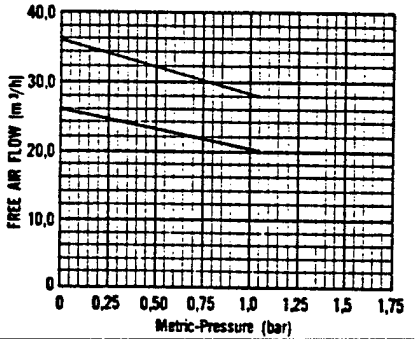


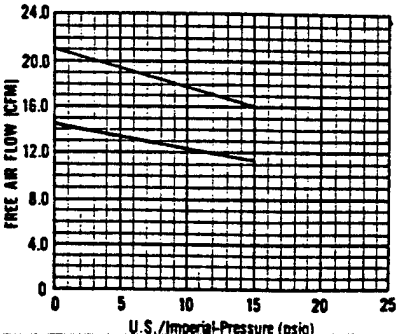
Model 2067





Model 2567





APPENDIX C
DATA COLLECTION SHEETS

BLOWER MAINTENANCE RECORD (INJECTION)

Site: Site 11, AGE Maintenance Area

Location: Beale AFB, CA

		WEEKLY				MONTHLY				
	Date	Blower Running ? ** (Y/N)	Inlet Vacuum[1] (in. H_2O)	Outlet Pressure[2] (in. H_2O)	Outlet Temp.[3] (°F)	Check Filters ? (Y/N)	Clean/Replace Filters ? (Y/N)	FAXed log ? (Y/N)	Comments	Init.
Ex:	06/11/93	Y	2.5	45	120	Y	Y	Y	excessive dirt on paper filter	MGP

** If blower is not running, immediately contact Fred Stanin, Engineering–Science, (510) 769–0100.

[1] If inlet vacuum exceeds 20 inches of water, shut blower down and contact Engineering–Science.

[2] If outlet pressure exceeds 50 inches of water, shut blower down and contact Engineering–Science.

[3] If outlet temperature exceeds 160°F, shut blower down and contact Engineering–Science.

NOTE: Once a month, this sheet must be FAXed to: Fred Stanin, Engineering–Science, (510) 769–9244.

BLOWER MAINTENANCE RECORD (INJECTION)

Site: _____

Location: _____

		WEEKLY				MONTHLY				
	Date	Blower Running ? ** (Y/N)	Inlet Vacuum[1] (in. H_2O)	Outlet Pressure[2] (in. H_2O)	Outlet Temp.[3] (°F)	Check Filters ? (Y/N)	Clean/Replace Filters ? (Y/N)	FAXed log ? (Y/N)	Comments	Init.
Ex:	06/11/93	Y	2.5	45	120	Y	Y	Y	excessive dirt on paper filter	MBP

** If blower is not running, immediately contact Fred Stanin, Engineering–Science, (510) 769–0100.

[1] If inlet vacuum exceeds ____ inches of water, shut blower down and contact Engineering–Science.

[2] If outlet pressure exceeds ____ inches of water, shut blower down and contact Engineering–Science.

[3] If outlet temperature exceeds 160°F, shut blower down and contact Engineering–Science.

NOTE: Once a month, this sheet must be FAXed to: Fred Stanin, Engineering–Science, (510) 769–9244.

BLOWER MAINTENANCE RECORD (INJECTION)

Site:_____

Location: _____

		WEEKLY				MONTHLY				
	Date	Blower Running ? ** (Y/N)	Inlet Vacuum[1] (in. H_2O)	Outlet Pressure[2] (in. H_2O)	Outlet Temp.[3] (°F)	Check Filters ? (Y/N)	Clean/Replace Filters ? (Y/N)	FAXed log ? (Y/N)	Comments	Init.
Ex:	06/11/93	Y	2.5	45	120	Y	Y	Y	excessive dirt on paper filter	MGP

** If blower is not running, immediately contact Fred Stanin, Engineering–Science, (510) 769–0100.

[1] If inlet vacuum exceeds ____ inches of water, shut blower down and contact Engineering–Science.

[2] If outlet pressure exceeds ____ inches of water, shut blower down and contact Engineering–Science.

[3] If outlet temperature exceeds 160°F, shut blower down and contact Engineering–Science.

NOTE: Once a month, this sheet must be FAXed to: Fred Stanin, Engineering–Science, (510) 769–9244.

BLOWER MAINTENANCE RECORD (INJECTION)

Site: ______________________

Location: ______________________

		WEEKLY				MONTHLY				
	Date	Blower Running ? ** (Y/N)	Inlet Vacuum[1] (in. H_2O)	Outlet Pressure[2] (in. H_2O)	Outlet Temp.[3] (°F)	Check Filters ? (Y/N)	Clean/Replace Filters ? (Y/N)	FAXed log ? (Y/N)	Comments	Init.
Ex:	06/11/93	Y	2.5	45	120	Y	Y	Y	excessive dirt on paper filter	MBP

** If blower is not running, immediately contact Fred Stanin, Engineering–Science, (510) 769–0100.

1 If inlet vacuum exceeds ____ inches of water, shut blower down and contact Engineering–Science.

2 If outlet pressure exceeds ____ inches of water, shut blower down and contact Engineering–Science.

3 If outlet temperature exceeds 160°F, shut blower down and contact Engineering–Science.

NOTE: Once a month, this sheet must be FAXed to: Fred Stanin, Engineering–Science, (510) 769–9244.

reg_inj
06/17/93

BLOWER MAINTENANCE RECORD (INJECTION)

Site:_____

Location: _____

		WEEKLY				MONTHLY				
	Date	Blower Running ? ** (Y/N)	Inlet Vacuum[1] (in. H_2O)	Outlet Pressure[2] (in. H_2O)	Outlet Temp.[3] (°F)	Check Filters ? (Y/N)	Clean/Replace Filters ? (Y/N)	FAXed log ? (Y/N)	Comments	Init.
Ex:	06/11/93	Y	2.5	45	120	Y	Y	Y	excessive dirt on paper filter	MBP

** If blower is not running, immediately contact Fred Stanin, Engineering–Science, (510) 769–0100.

[1] If inlet vacuum exceeds ____ inches of water, shut blower down and contact Engineering–Science.

[2] If outlet pressure exceeds ____ inches of water, shut blower down and contact Engineering–Science.

[3] If outlet temperature exceeds 160°F, shut blower down and contact Engineering–Science.

NOTE: Once a month, this sheet must be FAXed to: Fred Stanin, Engineering–Science, (510) 769–9244.

reg_inj
06/17/93

APPENDIX C

CHAIN OF CUSTODY FORMS

@ AIR TOXICS LTD.
AN ENVIRONMENTAL ANALYTICAL LABORATORY

11325 SUNRISE GOLD CIRCLE, SUITE 'E'
RANCHO CORDOVA, CA 95742
(916) 638-9892 • FAX (916) 638-9917

CHAIN OF CUSTODY RECORD

PROJECT # DE268.20.04 PO # DE 268.20.04 COLLECTED BY (Signature) [signature]

REMARKS TPH as jet fuel, BTEX – all samples

	FIELD SAMPLE I.D.#	SAMPLING MEDIA (Tenax, Canister etc.)	DATE/TIME	ANALYSIS	VAC./PRESSURE	LAB I.D. #
01A	BE11-VMP1-240	Air (Summa Canister)	5/11/93 1055 am	TO3 (as jet fuel)	1 "Hg	
02A	BE11-VMP3-240	"	" 1120 am	"	0.5 "Hg	
03A	BE11-VW1	"	" 1130 am	"	0.5 "Hg	
04A/B	BE11-BKT1	"	" 1145 am	"	0 "Hg	
05A	BE11-BKT2	"	" 2025	"	0 "Hg	
		Also returning	one unused	Summa canister		

RELINQUISHED BY: DATE/TIME [signature] 5/15/93 - 0950 am

RECEIVED BY: DATE/TIME [signature] FedX

RELINQUISHED BY: DATE/TIME

RECEIVED BY: DATE/TIME [signature] A.T.L. 5/18/93 0925

LAB USE ONLY

SHIPPER NAME	AIR BILL #	OPENED BY: DATE/TIME	TEMP(°C)	CONDITION

REMARKS

Fi[illegible] C.2

CHAIN OF CUSTODY RECORD

ENGINEERING-SCIENCE, INC.
1700 BROADWAY, SUITE 900
DENVER, COLORADO 80290
303-831-8100

AFCEE BIOVENTING PILOT TESTS

Base: Beale AFB

Site: IRP 11

ES Job No.
DE268.20.08

Sampler(s): (Signature)
Henry Pietrzyski

Preservative: NONE | HOLD | AT 4C | NONE

Analysis Required: SW 9045 (PH) | A 403 (ALKA) | SW 7380 (IRON) | SW 846 (MOIST) | SW 8020 (BTEX) | E 418.1 (TRPH) | E 351.2 (TKN) | E 365.3 (PHOS) | UCM (CLASS)

Date	Time	Sample Description	Lab I.D.	No. of Contrs.	Sample Type	Matrix	Remarks
4/19/93	1600	BE11 - VMP1 - 24.5		1	G C	SOIL	
"	1600	BE11 - VMP1 - 24.5		1	G C	SOIL	
4/20/93	1123	BE11 - VW1 - 30		1	G C	SOIL	
"	1123	BE11 - VW1 - 30		1	G C	SOIL	
4/21/93	0805	BE11 - VMP2 - 25.5		1	G C	SOIL	
"	0805	BE11 - VMP2 - 25.5		1	G C	SOIL	
"	0910	BE11 - VMP4 - 22		1	G C	SOIL	
4/21/93	0910	BE11 - VMP4 - 22		1	G C	SOIL	
					G C	SOIL	
					G C	SOIL	
					G C	SOIL	
					G C	SOIL	
					G C	SOIL	
					G C	SOIL	
					G C	SOIL	
					G C	SOIL	

Ship To:

ENGINEERING-SCIENCE LABORATORY
600 Bancroft Way
Berkeley, CA 94710

Attn: Tom Paulson
(510) 841-7353

WO# 4991

Relinquished by: (Signature)	Date / Time	Recieved for Laboratory by: (Signature)	Date / Time
Henry Pietrzyski	4/21/93 1430	[signature]	04/22/93 0900
Relinquished by: (Signature)	Date / Time	Recieved for Laboratory by: (Signature)	Date / Time

Remarks:

G - Grab Sample, C - Composite Sample

Distribution: Original Accompanies Shipment. Copies to: Coordinator Field Files

Federal Express Number:

Airbill Number: 2829295151

ENGINEERING-SCIENCE, INC.
1700 Broadway, Suite 900 • Denver, Colorado
(303) 831-8100

CCRSOIL

ES JOB NO.

PROJECT NAME/LOCATION
4991

PRESERVATIVES REQUIRED

TO:
SEQUOIA LAB

FIELD CONTACT:

ANALYSES REQUIRED

SAMPLERS NAMES & SIGNATURES

10 DAY TAT

DATE	TIME	FIELD SAMPLE IDENTIFIER	E351.2 (TKN)	E365.3 (PHOS)	40M C CLASS	9304 D24		REMARKS
4/19/93	1600	(4991.01B) BE11 - VMP1 - 24.5	X	X	X		01	REPORT TO:
4/20/93	1123	(4991.02B) BE11 - VW1 - 30	X	X	X		02	TOM PAULSON - ESB
4/21/93	0805	(4991.03B) BE11 - VMP2 - 25.5	X	X	X		03	
↓	0910	(4991.04B) BE 11 - VMP4 - 22	X	X	X		04	
		Relinquished By: Erin Vonnes 4/28/93 1200						

FIELD CUSTODY RELINQUISHED BY:

DATE: 4/22/93 TIME: 10:45

SHIPPED VIA: AIRBILL #

ON RECEIPT: CUSTODY SEALS? _____ ; TEMP: _____ °C

DATE: 4/23/93 TIME: 11:

APPENDIX D

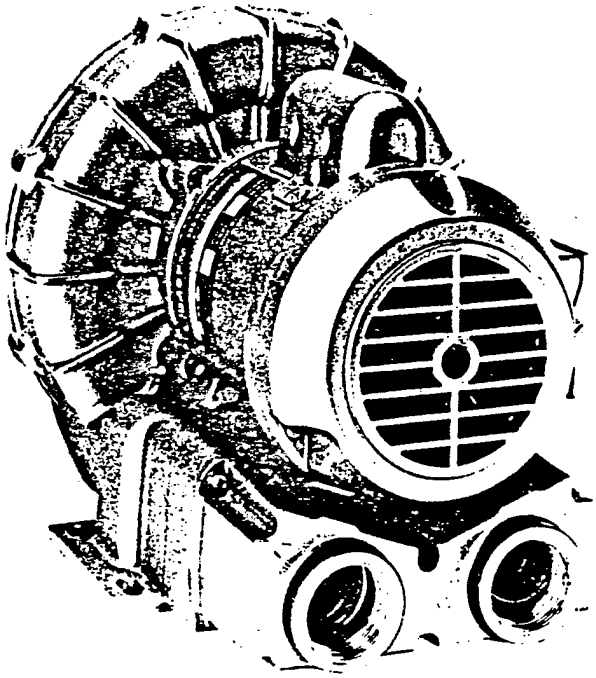
BIODEGRADATION RATE CALCULATIONS

Biodegradation Rate Calculations		*bios11.xls*	
		9/28/93	
Site:	Site 11		
Location:	Beale AFB, CA		
	VMP1-24	VMP2-24	VMP3-30.5
user entered data	isr/lab	isr/lab	isr
Ko, oxygen utilization rate (%/hr)	0.12	0.047	0.18
w, moisture content (%)	23.6%	15.3%	15.0%
Soil type [from boring logs]	dense,clayey/silty SAND	dense, coarse SAND	dense, fine/medium SAND
Sand fraction (% by wt.)	90.7%	84.0%	-
Silt fraction (% by wt.)	6.2%	12.9%	-
Clay fraction (% by wt.)	3.1%	3.1%	-
n, Estimated porosity (-) [from soil descriptions]	0.40	0.40	0.40
TRPH + BTEX contamination (mg/kg)	4.36	1,914	-
TVH contamination (ppmv)	72,000	55,000	-
constants			
unit weight of water (g/cm3)	1.0	1.0	1.0
G, spec. gravity of solids (- or g/cm3)	2.65	2.65	2.65
Do, density of oxygen (mg/L)	1340	1340	1340
C, carbon/oxygen ratio	0.29	0.29	0.29
calculated data			
volume of solids, in 1 L of soil (liters)	0.60	0.60	0.60
volume of voids, in 1 L of soil (liters)	0.40	0.40	0.40
Dry unit weight (g/cm3)	1.59	1.59	1.59
e, void ratio (-)	0.67	0.67	0.67
Sr, degree of saturation	0.94	0.61	0.60
volume of water, in 1 L of soil (liters)	0.38	0.24	0.24
volume of air, in 1 L of soil (liters)	0.02	0.16	0.16
bulk density of soil (kg/L)	1.97	1.83	1.83
A, air filled porosity (liter air/kg soil)	0.013	0.085	0.088
Kb, biodegradation rate (mg TPH/kg soil per year)	**50**	**130**	**530**
Notes:			
1. Soil moisture content of 15% assumed at VMP3-30.5			

Oilless Regenerative Blowers, Motor Mounted to 92 cfm

GAST

REGENAIR® R4 Series



MODEL R4110-2
52" H_2O MAX. PRESSURE, 92 CFM OPEN FLOW

PRODUCT FEATURES

- Oilless operation
- TEFC motor mounted
- Can be mounted in any plane
- Rugged construction/low maintenance
- Can be operated blanked-off

COMMON MOTOR OPTIONS

- 115/208-230V, 60 Hz; 110/220-240V, 50 Hz, single phase
- 208-230/460V, 60 Hz; 190-230/380-415V, 50 Hz, three phase
- 575V, 60 Hz, three phase

RECOMMENDED ACCESSORIES

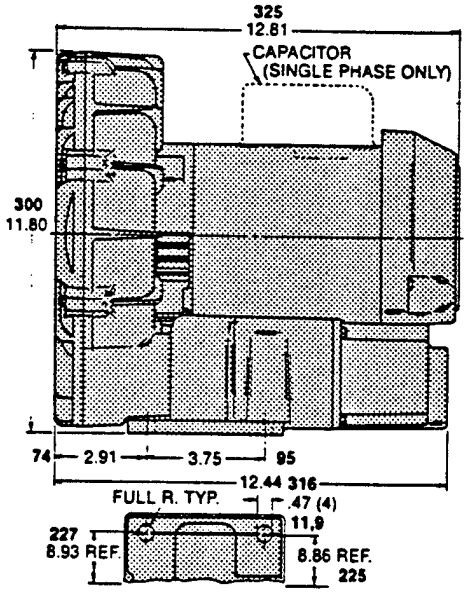
- Pressure gauge AJ496
- Filter AG338
- Muffler AJ121D
- Relief valve AG258

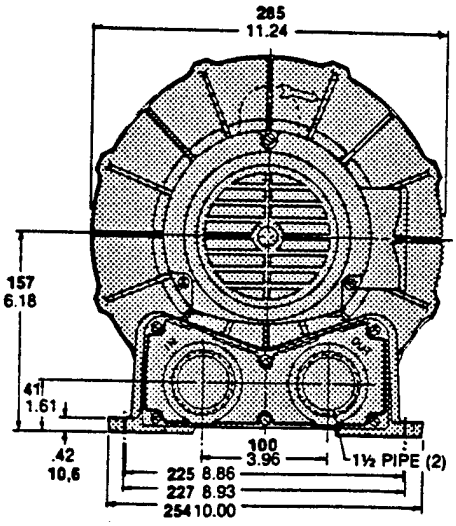
Various brand name motors are used on any model at the discretion of Gast Mfg. Corp.

Important Notice:

Pictorial and dimensional data is subject to change without notice.

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



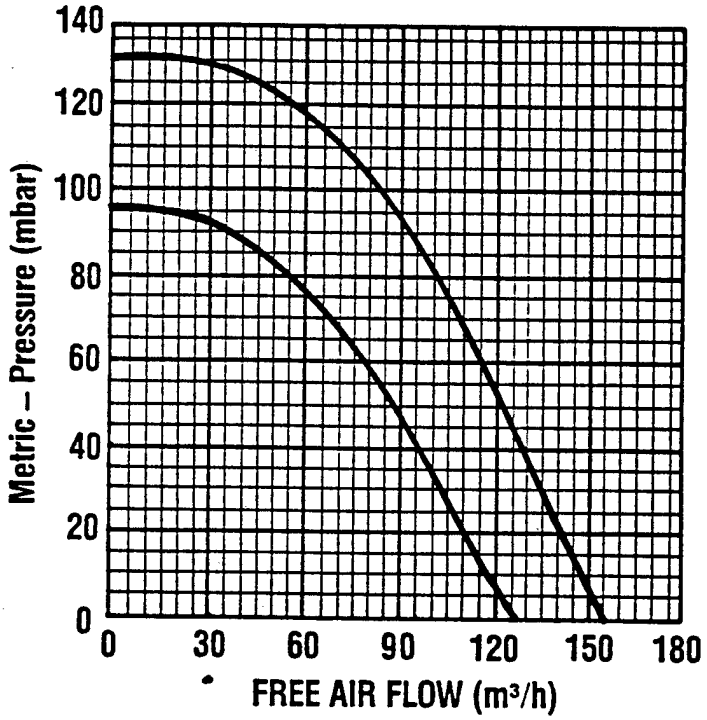


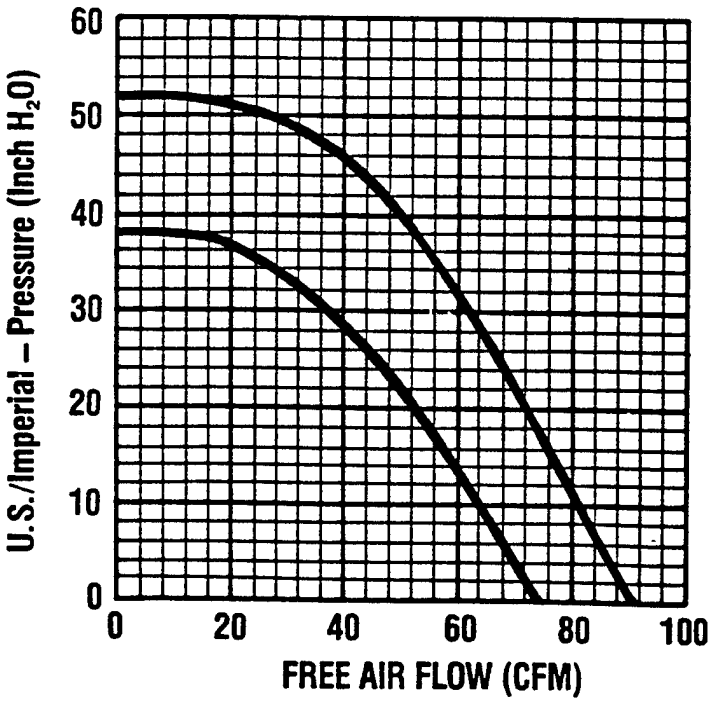
Product Specifications

Model Number	Motor Specs	Full Load Amps	HP	RPM	Max Pressure		Max Flow		Net Wt.	
					"H_2O	mbar	cfm	m^3h	lbs.	kg
R4110-2	110/220-240-50-1	9.0/4.5-5.7	0.6	2850	38	95	74	126	41	18,6
	115/208-230-60-1	9.8/5.2-4.9	1.0	3450	52	130	92	156		
R4310A-2	190-220/380-415-50-3	2.6-3.3/1.3-1.4	0.6	2850	38	95	74	126	41	18,6
	208-230/460-60-3	3.4-3.2/1.6	1.0	3450	52	130	92	156		

Product Performance (Metric U.S. Imperial)

Black line on curve is for 60 cycle performance.
Blue line on curve is for 50 cycle performance.



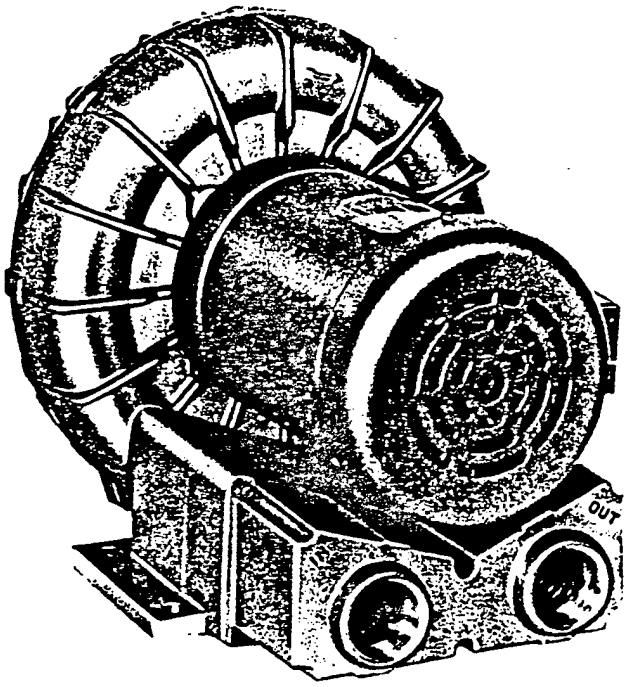


Oilless Regenerative Blowers, Motor Mounted to 160 cfm

GAST

REGENAIR® R5 Series

PRESSURE



MODEL R5325A-2
65" H_2O MAX. PRESSURE, 160 CFM OPEN FLOW

PRODUCT FEATURES

- Oilless operation
- TEFC motor mounted
- Can be mounted in any plane
- Rugged construction/low maintenance

COMMON MOTOR OPTIONS

- 115/208-230V, 60 Hz, single phase
- 208-230/460V, 60 Hz; 190-220/380-415V, 50 Hz, three phase
- 575V, 60 Hz, three phase

RECOMMENDED ACCESSORIES

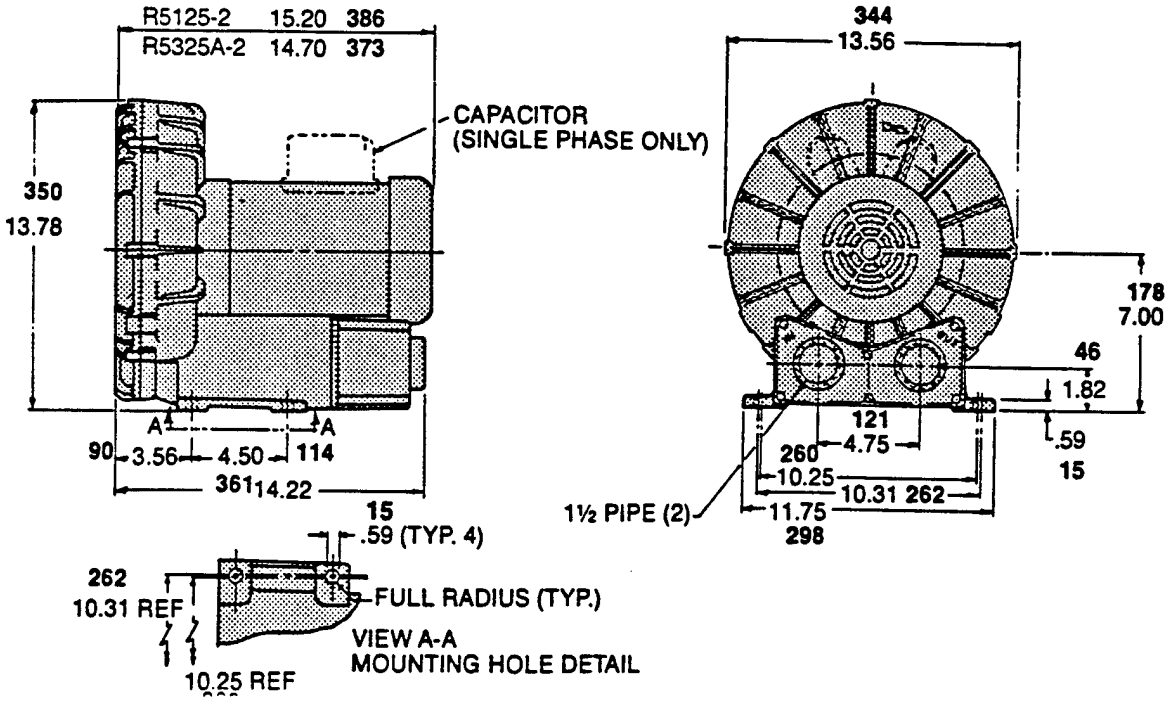
- Pressure gauge AE133
- Filter AG338
- Muffler AJ121D
- Relief valve AG258

Various brand name motors are used on any model at the discretion of Gast Mfg. Corp.

Important Notice:

Pictorial and dimensional data is subject to change without notice.

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

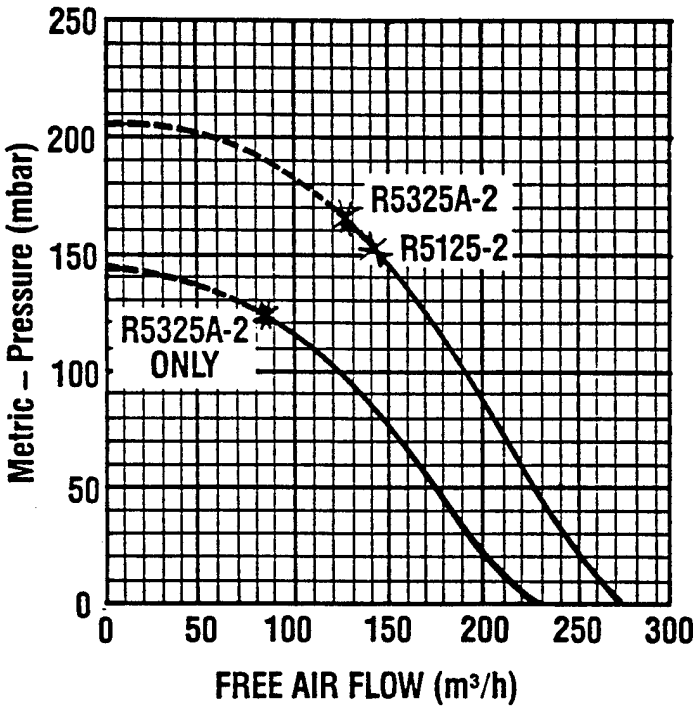


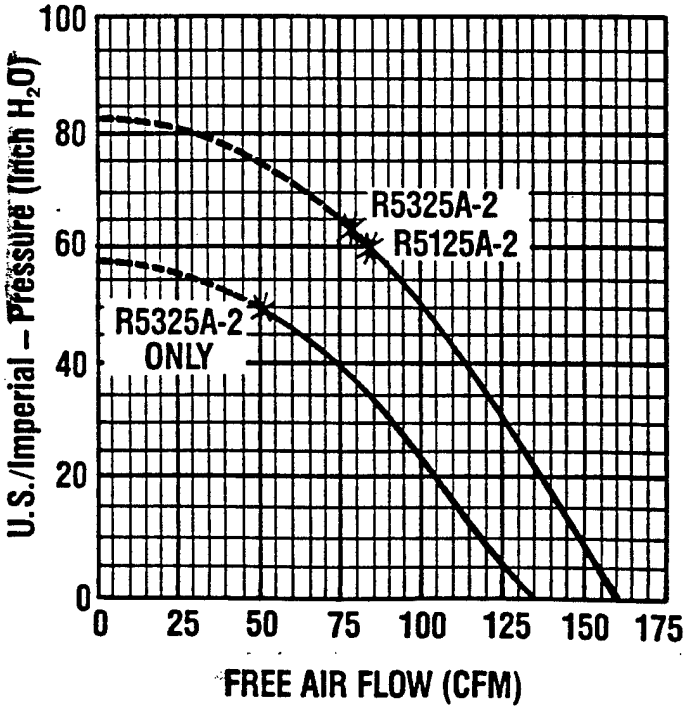
Product Specifications

Model Number	Motor Specs	Full Load Amps	HP	RPM	Max Pressure "H_2O	Max Pressure mbar	Max Flow cfm	Max Flow m^3h	Net Wt. lbs.	Net Wt. kg
R5325A-2	190-220/380-415-50-3	6.6-6.7/3.3-3.5	1.35	2850	50	125	133	226	65	29,5
	208-230/460-3	6.9/3.45	2.5	3450	65	162	160	272		
R5125-2	115/208-230-60-1	22.4/12.4-11.2	2.5	3450	60	149	160	272	73	33,1

Product Performance (Metric U.S. Imperial)

Black line on curve is for 60 cycle performance.
Blue line on curve is for 50 cycle performance.





*Recommended maximum duty.
- - - - Intermittent duty only.

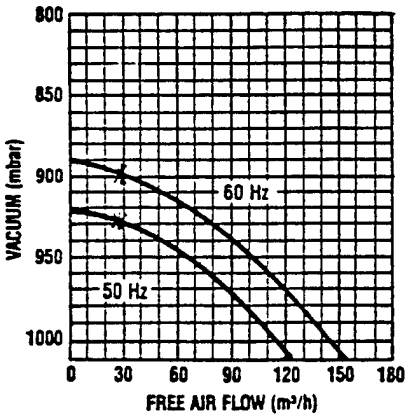
Product Specifications

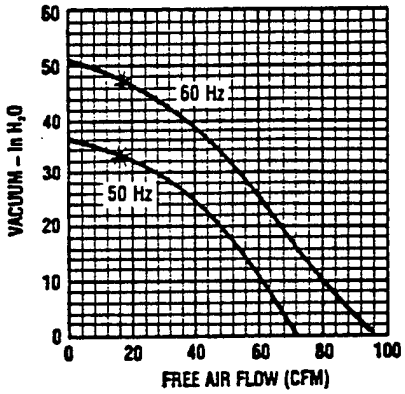
Model Number	Hz	Motor Specs	HP	RPM	Max Vac		Max Flow		Net Wt.	
					"H_2O	mbar	cfm	m^3h	lbs.	kg
R4110N-50	50	110/220-240-50-1	0.6	2850	35	924	72	122	60	28
	60	115/208-230-60-1	1.0	3450	48	895	88	150		
R4310P-50	50	220/380-50-3*	0.6	2850	35	924	72	122	58	27
	60	208-230/460-60-3*	1.0	3450	48	895	88	150		
R5125Q-50	60	115/230-60-1*	2.5	3450	60	865	145	246	77	35
R5325R-50	50	190-220/380-415-50-3*	1.85	2850	47	897	120	204	75	34
	60	208-230/460-60-3*	2.50	3450	60	865	145	246		
R6P355R-50	50	190-220/380-415-50-3*	4.5	2850	70	840	235	400	247	112.
	60	208-230/460-60-3*	6.0	3450	90	790	260	442		

*Motors do not have thermal protection with automatic reset.

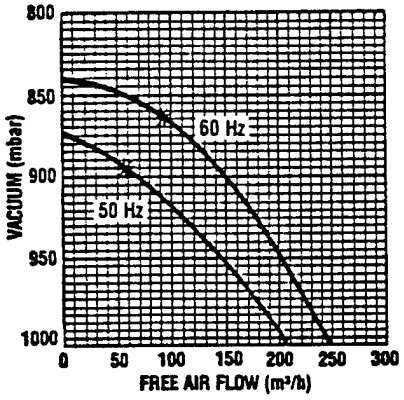
Product Performance (Metric U.S. Imperial)

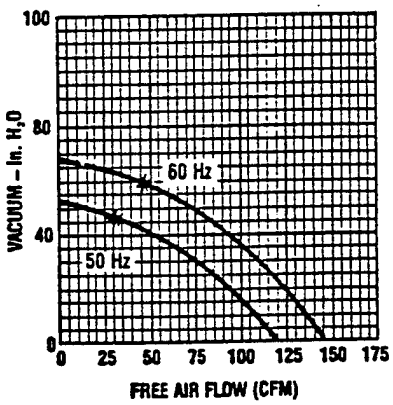
Model R4 Series



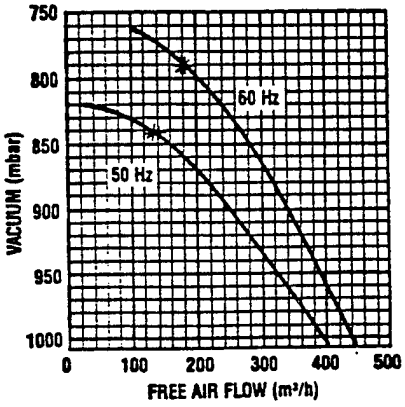


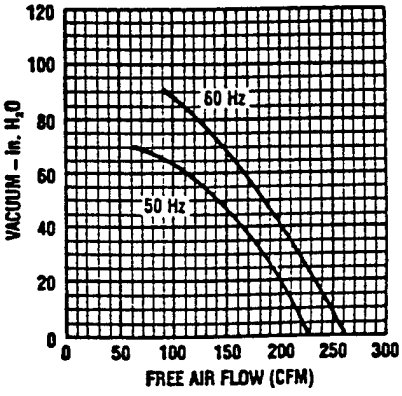
Model R5 Series





Model R6P Series

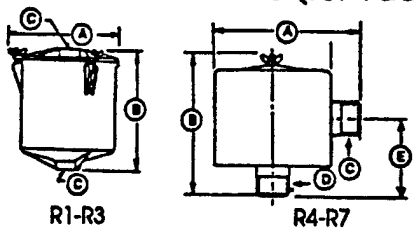




***Minimum flow permissible through the unit for trouble-free, continuous operation.**

REGENAIR ACCESSORIES

Inline Filters (for vacuum)

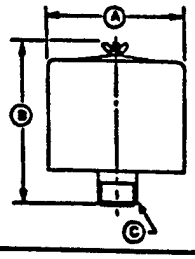


R1-R3 R4-R7

Model Number	R1 & R2	R3	R4, R5 &SDR4	R6P SDR5, SDR6 R6PP, R6PS	R7
Part #	AV460	AV460C	AG337	AJ151G	AJ151H
Dim A	8.25"	8.25"	11.75"	8.00"	16.25"
Dim B	8.875"	8.875"	4.75"	10.25"	27.13"
Dim C	1" FPT	1 1/4"FPT	1 1/2"MPT	2 1/2" MPT	3" MPT
Dim D	-	-	1 1/2" FPT	2 1/2"MPT	3" MPT
Dim E	-	-	2.38	5.50	18.50
Replacement Element	AV469	AV469	AG340	AJ135G	AJ135C
Micron	10	10	25	10	10

MPT = Male Pipe Thread
FPT = Female Pipe Thread

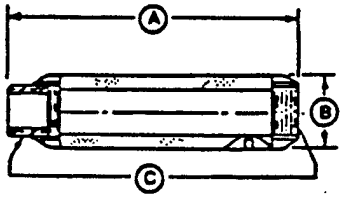
Inlet Filters (for pressure units only)



Model Number	R1 & R2	R3	R4, R5 &SDR4	R6, SDR5 SDR6, R6P R6PP, R6PS	R7
Part #	AJ126B	AJ126C	AG338	AJ126F	AJ126G
Dim A	6.00"	6.00"	10.63"	10.63"	10.00"
Dim B	4.62"*	7.12"*	4.81"*	4.81"*	13.12"*
Dim C	1" MPT	1 1/4" MPT	1 1/2" FPT	2" FPT	2 1/2" MPT
Replacement Element	AJ134B	AJ134C	AG340	AG340	AJ135A
Micron	10	10	25	25	10

All are heavy duty for high amounts of particulates. Inlet filters for REGENAIR blowers are drip-proof when mounted as shown.

Mufflers



Model Number	R2	R3	R4, R5 SDR 4* &SDR5*	R6, SDR6* R6P R6PP, R6PS	R7
Part #	AJ121B	AJ121C	AJ121D	AJ121F	AJ121G
Dim. A	7.46"*	7.94"*	12.75"*	17.05"*	17.44"*
Dim. B	2.38"	2.62"	3.25"	3.63"	4.25"
Dim. C	1" NPT	1 1/4" NPT	1 1/2" NPT	2" NPT	2 1/2" NPT

* For Inlet Only
** Approximately

Pressure-Vacuum Gauge

Pressure Gauge, Part #AJ496, 2 5/8" Diameter, 1/4" NPT, 0-60 Inches H_2O and 0-150 mbar

Pressure Gauge, Part #AE133A, 2 5/8" Diameter, 1/4" NPT, 0-200 Inches H_2O and 0-500 mbar

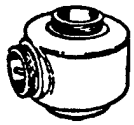
Vacuum Gauge, Part # #AJ497, 2 5/8" Diameter, 1/4" NPT, 0-60 Inches H_2O and 0-150 mbar

Vacuum Gauge, Part #AE134, 2 5/8", Diameter, 1/4" NPT. 0-160 Inches H_2O and 0-400 mbar

Fittings

Pipe Size	1"	1 1/4"	1 1/2"	2"	2 1/2"
Tee	BA415	BA431	BA432	BA433	BA434
Common Elbow	BA220	BA244	BA230	BA247	BA248
Nipple	BA752	BA809	BA783	BA810	BA813
Plastic Male Pipe Hose Barb	AJ117A	AJ117B	-	-	-
Hose I.D.	1.25	1.25	-	-	-
Metal Male Pipe Hose Barb	AJ117D	AJ117F	AJ117C	AJ117G	AJ117H
Hose I.D.	1.00	1.25	1.50	2.50	3.00

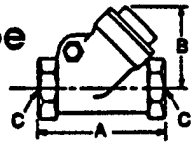
Relief Valve



Pressure/Vacuum Relief Valve, Part #AG258, 1 1/2" NPT, Adjustable 30-170 Inches H_2O. 200 CFM maximum

Silencer for Relief Valve, Part #AJ121D

Horizontal Swing Type Check Valve



Model Number	R1, R2	R3	R4, R5 SDR 4 &SDR5	R6, SDR6 R6P R6PP, R6PS	R7
Part #	AH326B	AH326C	AH326D	AH326F	AH326G
Dim. A	3.57	4.19	4.50	5.25	8
Dim. B	2.32	2.69	2.94	3.82	5.07
Dim. C	1" NPT	1 1/4" NPT	1 1/2" NPT	2" NPT	2 1/2" NPT