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DRAFT INTERIM PILOT TEST RESULTS FOR SITE ST14 FUEL LOADING AREA NAS FORT WORTH TX

7/1/1993

ES ENGINEERING AND SCIENCE

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NAVAL AIR STATION FORT WORTH JRB CARSWELL FIELD TEXAS

ADMINISTRATIVE RECORD COVER SHEET

AR File Number 156

D R A F T
Report on Interim Pilot Test Results
Site ST14, Fuel Loading Area
Carswell AFB, Texas

July 1993

AU380

ES
ENGINEERING-SCIENCE, INC.

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15[illegible]2

July 19, 1993

Chris Hobbins
Brooks Air Force Base
Bldg 624W, AFCEE/ESRR
San Antonio, Texas 78235

Subject: Bioventing pilot test draft report (A004-scientific report)
Site ST14
Carswell AFB, Texas

Dear Chris:

Enclosed are six copies of the subject draft report. Please review and send us any comments you may have so we may prepare the final. The analytical data report (A003) will be completed for overnight shipment tomorrow.

Call me or Brian Vanderglas of this office if you have any questions or comments. Thanks.

Sincerely,

J. David Highland, P.E.
Project Manager

enclosure

xc: Doug Downey, ES Denver
Brian Vanderglas

D R A F T
Report on Interim Pilot Test Results
Site ST14, Fuel Loading Area
Carswell AFB, Texas

Contract F41624-92-D-8036

Prepared for

Air Force Center for Environmental Excellence
Brooks AFB, Texas

Prepared by

Engineering-Science, Inc.
Austin, Texas

July 1993

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FIGURES

TABLES

DRAFT

REPORT ON INTERIM PILOT TEST RESULTS SITE ST14, FUEL LOADING AREA CARSWELL AFB, TEXAS

Initial bioventing pilot tests were completed at site ST14 at Carswell Air Force Base (AFB), Texas, during the period of May 24, 1993 through June 17, 1993. The purpose of this report is to describe the results of the initial pilot tests at site ST14 and to make specific recommendations regarding extended testing to determine the long-term impact of bioventing on onsite contaminants. This test was performed concurrently with a site characterization investigation to delineate the extent of contaminated soils at the site. Descriptions of the history, geology, and contamination at each site are contained in the bioventing pilot test work plan.

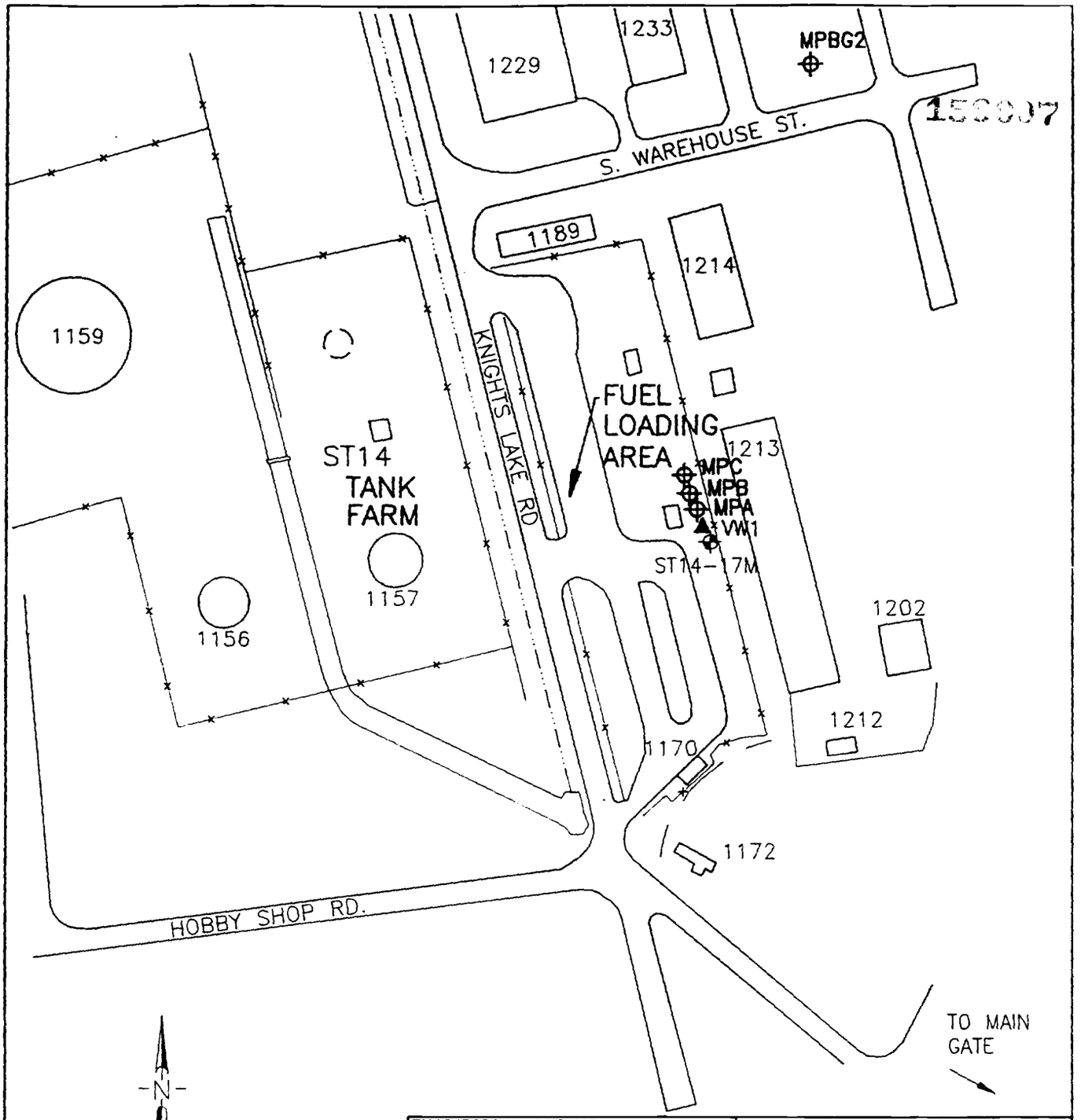
PILOT TEST DESIGN AND CONSTRUCTION

Installation of an air injection vent well (VW) and three vapor monitoring points (MPs) began on May 24, 1993, and was completed on May 27, 1993. A background monitoring point (MPBG2) was constructed on June 15, 1993, during site characterization studies at the site. Drilling services were provided by Profile Field Services, Inc., of Austin, Texas. Well installation and soil sampling were directed by Brian Vanderglas, the Engineering-Science, Inc. (ES), site manager, and Marc Harder, the ES site geologist. The following sections describe the final design and installation of the bioventing pilot system at this site.

One VW, three MPs (MPA, MPB, and MPC), a background monitoring point (MPCMPBG2), and a pilot blower unit were installed at the site. Figures 1 and 2 depict the locations of the VW and MPs. The locations of the VW and MPs were changed from those in the work plan because of potential hazards from nearby underground utilities. Figure 3 shows general hydrogeologic cross section of the VW and MPs.

AIR INJECTION VENT WELL

The air injection VW was constructed following procedures described in the Air Force Center for Environmental Excellence (AFCEE) bioventing protocol document (Hinchee et al., 1992). Figure 4 shows construction details for the VW. The VW was installed in predominantly clayey soils where hydrocarbon contamination was indicated at all sampling depths. These soils had some gravel with increasing sand content as depth in the borehole increased. Groundwater was



LEGEND

ST14-02 MONITOR WELL
VW1 VENT WELL
MPA MONITOR POINT

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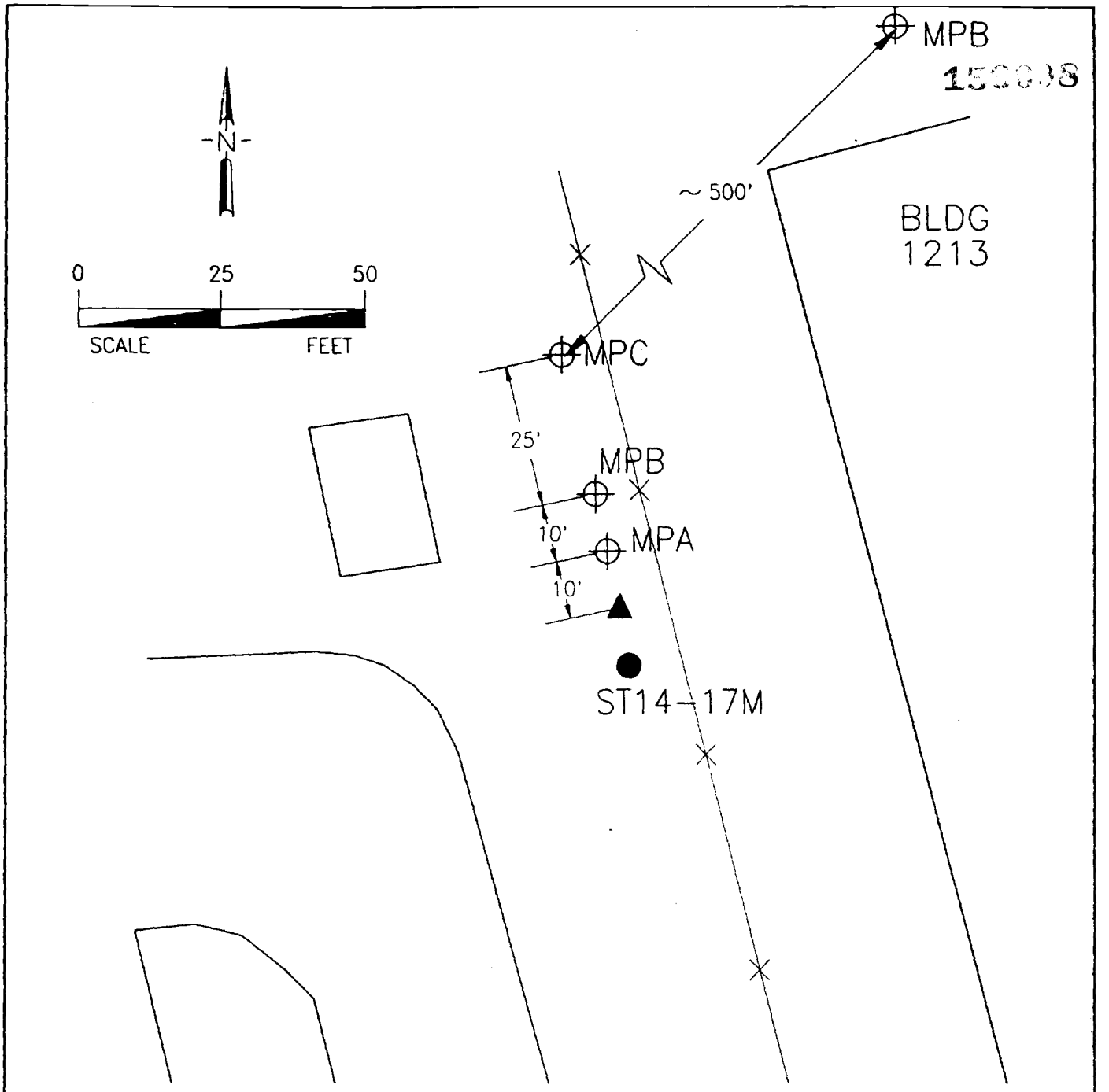
DESIGNED BY:	CARSWELL AIR FORCE BASE FORT WORTH, TEXAS PN:FY7624-93-08030 FY:93	
DRAWN BY:		
REVIEWED BY: B.R. VANDERGLAS	FIGURE 1 SITE ST14 LAYOUT	
SUBMITTED BY: J.D. HIGHLAND		
PLOT SCALE: AS NOTED	DWG. CODE:	CONTRACT DATE: APRIL 30,1992
DESIGN FILE: SITECARS		CALL ORDER NO.: 0004
PLOT DATE: 7/15/93	SHEET 1 OF 1	CONTRACT NO.: F41624-92-D-8036
		SHEET REFERENCE NUMBER 1



LEGEND

- ▲ PROPOSED CENTRAL VENT WELL (AIR INJECTION)
- ST14-17M ● EXISTING MONITORING WELLS
- MPC ⊕ PROPOSED VAPOR MONITORING POINT
- FENCE
- 1213 BUILDING

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DRAWN BY:	FIGURE 2 AS-BUILT SITE PLAN
REVIEWED BY: B.R. VANDERGLAS	
SUBMITTED BY: J.D. HIGHLAND	SITE ST14

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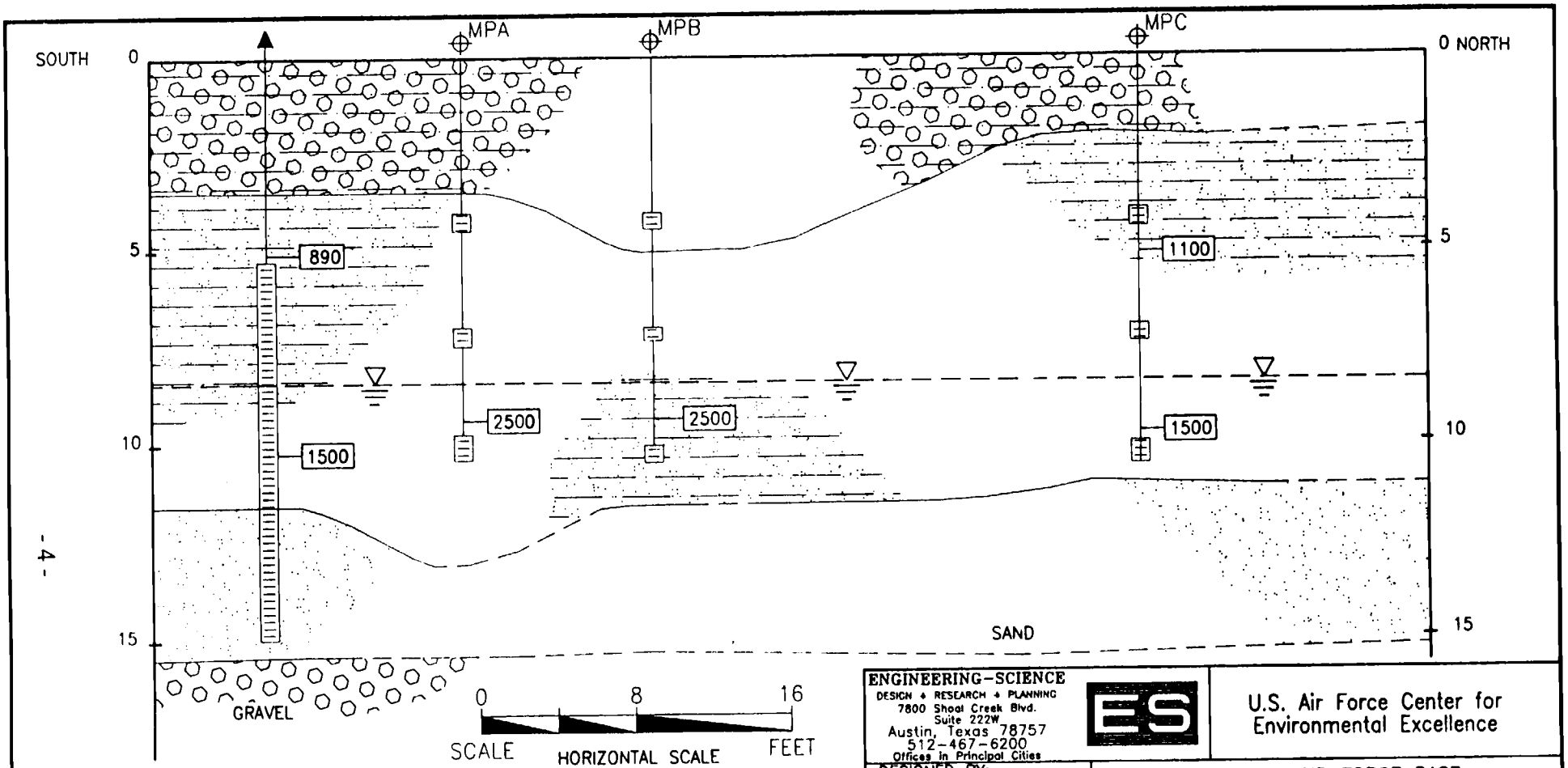
DESIGN FILE: SITECARS		CALL ORDER NO.: 0004	
PLOT DATE: 7/15/93	SHEET 1 OF 1	CONTRACT NO.: F41624-92-D-8036	



LITHOLOGICAL DESCRIPTION

PLASTIC CLAY WITH GRAVEL

SANDY CLAY

CLAYEY SAND

LEGEND

MPA MONITORING POINT

INJECTION VENT WELL

1500 LABORATORY RESULTS FOR TPH (MG/KG)

GROUNDWATER LEVEL

GEOLOGIC CONTACT (DASHED WHERE INFERRED)

SCREENED INTERVAL FOR MP & VW

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SUBMITTED BY:

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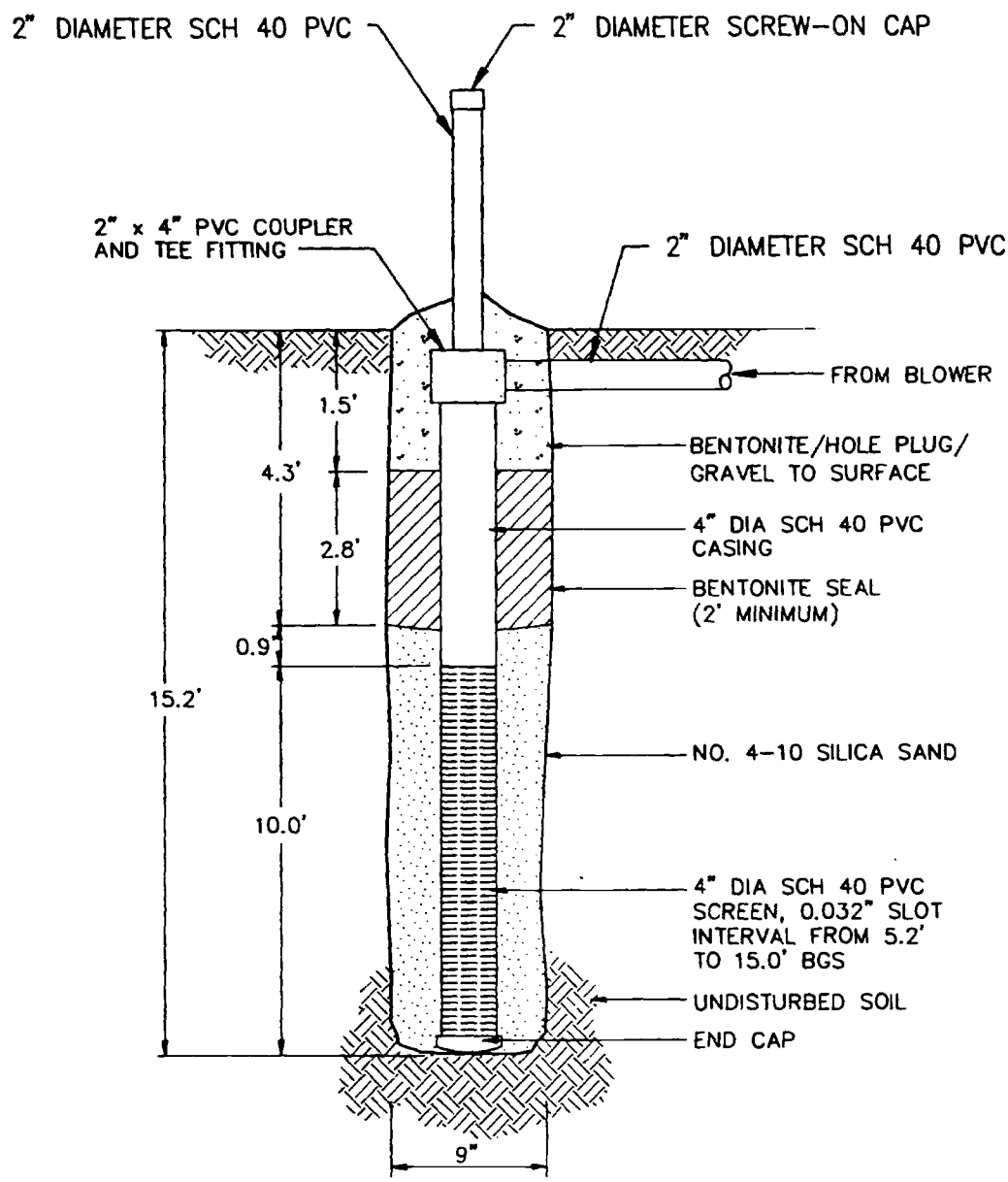
FIGURE 3
HYDROGEOLOGIC CROSS SECTION

SITE ST14

PLOT SCALE: NTS	DWG. CODE:	CONTRACT DATE: APRIL 30,1992	SHEET 1 REFERENCE NUMBER 3
DESIGN FILE: CARAIRI		CALL ORDER NO.: 0004	
PLOT DATE: 7/19/93	SHEET 3 OF	CONTRACT NO.: F41624-92-D-8036	



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DESIGNED BY:	CARSWELL AIR FORCE BASE FORT WORTH, TEXAS PN:FY7624-93-08030 FY:93	
DRAWN BY:		
REVIEWED BY: B.R. VANDERGLAS	FIGURE 4 AS-BUILT INJECTION VENT WELL CONSTRUCTION DETAIL SITE ST14	
SUBMITTED BY: J.D. HIGHLAND		

PLOT SCALE: NTS	DWG. CODE:	CONTRACT DATE: APRIL 30,1992	SHEET REFERENCE NUMBER 4
DESIGN FILE: DETLCARS		CALL ORDER NO.: 0004	
PLOT DATE: 7/15/93	SHEET 1 OF 1	CONTRACT NO.: F41624-92-D-8036	

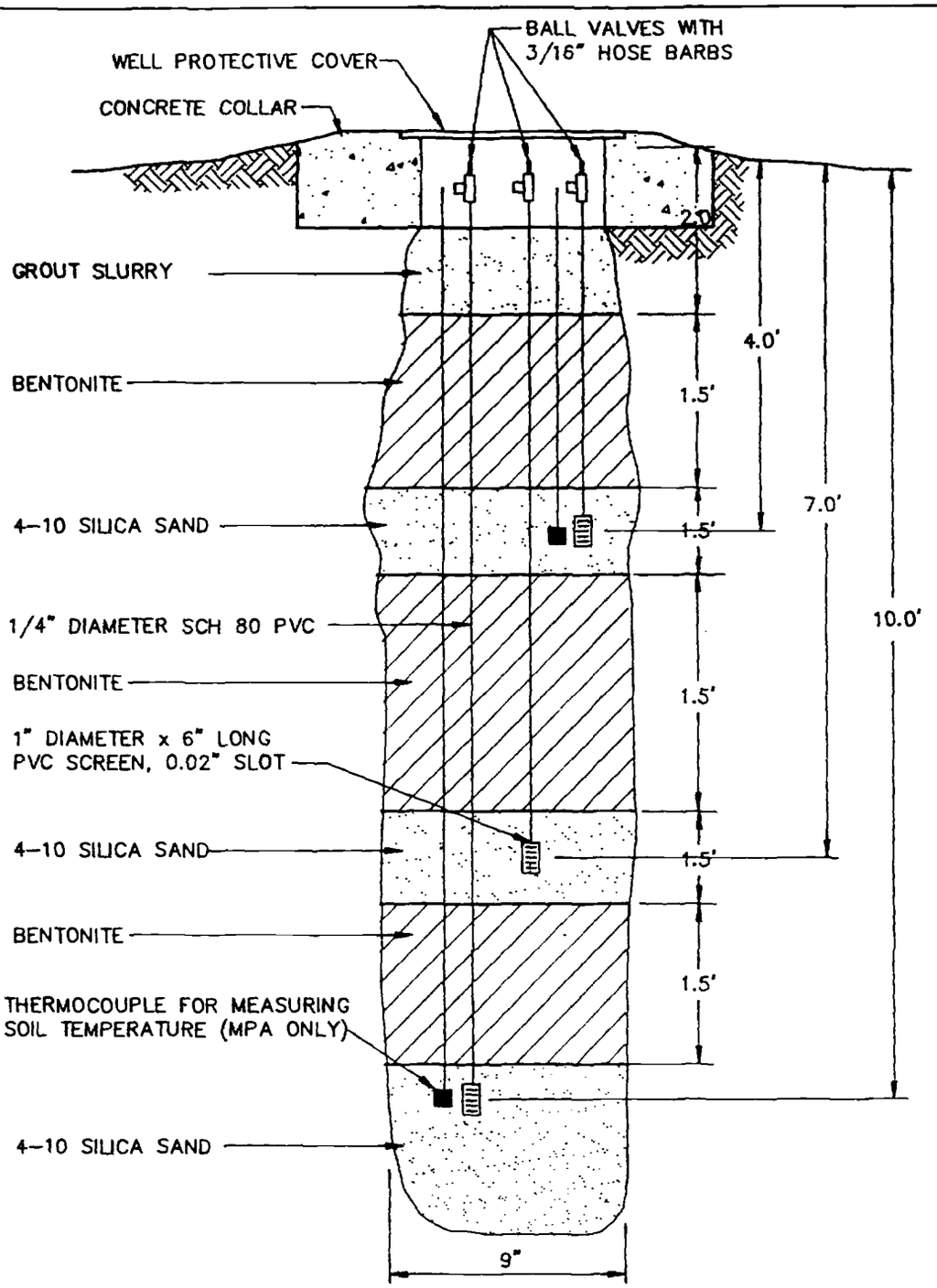
encountered at approximately 11.0 feet below ground surface (bgs) in each borehole. The static water level rose to 8.5 feet bgs in the boreholes during well completion. The VW was constructed using 4-inch-diameter, schedule 40 polyvinyl chloride (PVC) casing, with 10 feet of 0.04-inch slotted PVC screen installed from 5 to 15 feet bgs. The annular space between the well casing and borehole was filled with 4-10 silica sand from the bottom of the borehole to approximately 1 foot above the well screen. Approximately 2.8 feet of ¼-inch bentonite pellets was placed above the sand and hydrated in place. After the *in situ* respiration testing was completed the well casing was cut off approximately 12 inches below the surface, and the casing was connected to a PVC pipe coupler to reduce the pipe from 4-inch diameter to 2-inch diameter. The coupler is a tee fitting that enables the vent well to extend vertically above the surface in the event access to the cased well is required. A second 2-inch-diameter pipe extends from the tee fitting horizontally beneath the surface to the blower. This pipe slopes slightly toward the vent well to allow drainage of moisture in the pipe into the well and away from the blower.

Monitoring Points

At Site ST14, the MP screens were installed at 4.0-, 7.0-, and 10.0-foot depths. The three MPs (MPA, MPB, and MPC) and the background MP (MPBG2) were constructed as shown in Figure 5. Each MP monitoring interval was constructed using approximately a 6-inch section of 1-inch-diameter PVC well screen and a 0.25-inch-diameter schedule 80 PVC riser pipe extending to near the ground surface. At the top of each riser, a ball valves and a $^3/_{16}$-inch hose bib were installed. The screen, PVC riser, and ball valve were joined together using a solvent-free epoxy glue. The top of each MP was completed with a flush-mounted metal well protector set in a concrete base. Thermocouples were installed at the 4- and 10-foot depths at MPA to measure soil temperature variations. The background MP (MPBG2) is located near building 1237 South Warehouse Road and 15 feet east of West Warehouse Road, approximately 500 feet north-northwest from the injection vent well.

Blower Unit

During the initial pilot test, a portable 3-horsepower Roots™ 22U-RAI positive-displacement blower unit was used. A 1-horsepower Gast™ R4110-50 regenerative blower unit was installed at site ST14 and connected to the air injection VW for the extended pilot test. The fixed unit is energized by 240-volt, single-phase, 30-amp line power from a newly installed underground power line and aboveground breaker attached to building 1213. The power is provided by the base. The configuration, instrumentation, and specifications for this blower system are shown on Figure 6. The blower is currently transporting air at a flow rate of approximately 15 actual cubic feet per minute (acfm) for the extended pilot test. A portion of this flow is bled off through the gate valve. After blower installation and startup, ES engineers provided base personnel with an operation and maintenance (O&M) manual, including maintenance instructions, equipment specifications, and monitoring forms. A copy of the O&M instructions is in appendix A.



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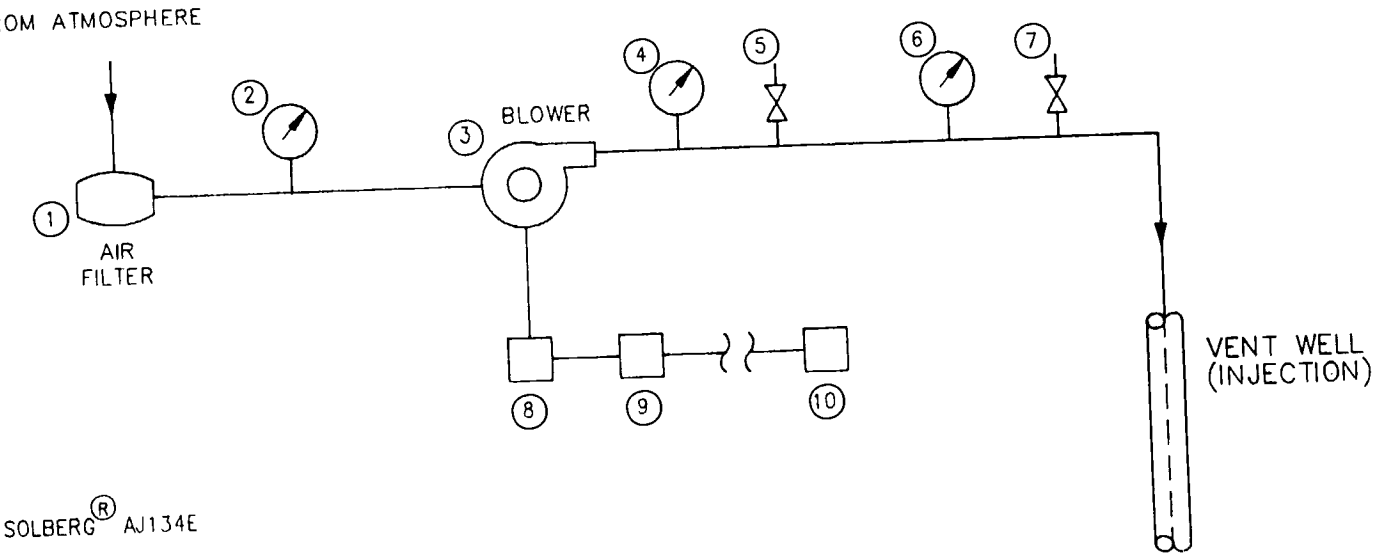
DESIGNED BY:	CARSWELL AIR FORCE BASE FORT WORTH, TEXAS PN:FY7624-93-08030 FY:93	
DRAWN BY:	FIGURE 5 AS-BUILT MONITORING POINT CONSTRUCTION DETAIL	
REVIEWED BY: B.R. VANDERGLAS		
SUBMITTED BY: J.D. HIGHLAND	SITE ST14	
PLOT SCALE: NTS	DWG. CODE:	CONTRACT DATE: APRIL 30,1992 / SHEET REFERENCE NUMBER 5
DESIGN FILE: DETLCARS		CALL ORDER NO.: 0004
PLOT DATE: 7/15/93	SHEET 1 OF 1	CONTRACT NO.: F41624-92-D-8036



LEGEND

1. INLET AIR FILTER – SOLBERG® AJ134E
2. VACUUM GAUGE (0–60 IN. H_2O)
3. BLOWER – GAST® 1HP R4110-50
4. PRESSURE GAUGE (0–100 IN H_2O)
5. AUTOMATIC PRESSURE RELIEF VALVE, SET TO RELEASE AT 58 IN H_2O PRESSURE
6. TEMPERATURE GAUGE (0–250°F)
7. MANUAL PRESSURE RELIEF (BLEED) VALVE – 1 1/2" GATE
8. STARTER – FURNAS® 14CSD33DA NEMA 3, NO START/STOP, OVERLOAD SET AT 6 AMPS
9. DISCONNECT SWITCH – 240V/SINGLE PHASE/30 AMP, FUSED DISCONNECT (GENERAL DUTY)
10. BREAKER BOX – 30 AMP

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FIGURE 6
AS-BUILT BLOWER SYSTEM FOR AIR INJECTION

SITE ST14

PLOT SCALE: NTS	DWG. CODE:	CONTRACT DATE: APRIL 30,1992	SHEET REFERENCE NUMBER 6
DESIGN FILE: CARAIRI		CALL ORDER NO.: 0004	
PLOT DATE: 7/16/93	SHEET 6 OF	CONTRACT NO.: F41624-92-D-8036	

PILOT TEST SOIL AND SOIL GAS SAMPLING RESULTS

Sampling Results

Soils at this site consist primarily of highly plastic clays with some interbedded gravel and silt near the surface. Sand content in soils generally increase with depth at the site, and soils are predominantly sands and gravels at approximately 11.5 to 12 feet and below. Groundwater was encountered at a depth of approximately 11.5 feet bgs in the VW, but the static water level rose to approximately 8.5 feet bgs in the open borehole. A thin film of oily product was observed on top of the water table in all the boreholes for VW1, MPA, MPB, and MPC. More detailed hydrogeologic information regarding site ST14 can be found in the hydrogeologic cross section (Figure 3) and the geologic boring logs (appendix B).

Contaminated soils were identified based on visual appearance, odor, and results of total hydrocarbons analyzer (Porta FID II, model PFII/7788 from Heathtech) field screening for volatile organic compounds (VOCs). Heavily contaminated soils were encountered approximately 3 to 12 feet bgs in the VW and all MP boreholes. Contamination concentrations generally increased with depth.

Soil samples for laboratory analysis were collected continuously using split core barrel samplers. Soil samples were screened for VOCs using the flame ionization detector (FID) to determine the presence of contamination and to select soil samples for laboratory analysis. Soil samples for laboratory analysis were collected form MPA and MPB at depths bgs of 9 to 10 feet bgs, from the VW at depths of 5 to 6 feet, and 10 to 11 feet, from MPC at depths of 6 to 7 feet, and from background monitoring point (MPBG2) at 10 to 10.5 feet.

Soil gas samples were collected from the completed VW and at 4 feet bgs from MPA, and at 7 feet bgs at MPC. Soil gas samples were collected using 3-liter Tedlar™ bags and vacuum chambers. After the samples were collected with Tedlar™ bags, they were transferred to 1-liter SUMMA™ canisters and shipped to the air testing laboratory, Air Toxics Ltd.

Soil samples were picked up every other day by a courier representing NDRC Laboratories. NDRC Laboratories conducted chemical and physical analysis on the soil samples. One soil sample from each boring was analyzed for total recoverable petroleum hydrocarbons (TRPH); benzene, toluene, ethyl benzene and xylenes (BTEX); iron; alkalinity; total Kjeldahl nitrogen (TKN); and several physical parameters (see Table 1). In boreholes in which two samples were collected (MPC and VW1), the sample collected nearest the surface was analyzed only for TRPH and BTEX. Soil gas samples were shipped via Federal Express™ to Air Toxics Ltd. in Rancho Cordova, California, for total volatile hydrocarbon (TVH) and BTEX analysis. The results of all of these analyses are in Table 1. Chain-of-custody forms are provided in appendix C.

Exceptions to Test Protocol Procedures

Procedures described in the protocol document (Hinchee et al., 1992) were used to complete the pilot test at site ST14, with the following exception. An FID

Table 1
Site ST14
Soil and Gas Analytical Results
Carswell AFB, Texas

Analyte (units)*	Sample Location - Depth (feet below ground surface)							
	VW1:10-11	VW1:5-6	MPA:9-10	MPB:9-10	MPC:6-7	MPC:10-11	MPBG2:10	MPA:4
Soil hydrocarbons:								
TRPH (mg/kg)	1,500	890	2,500	2,500	1,100	1,500	47	NT
Benzene (mg/kg)	.27	0.41	1.8	2.8	<.5	<0.2	<.002	NT
Toluene (mg/kg)	.53	0.58	3.7	4.1	2	10	<.002	NT
Ethyl benzene (mg/kg)	1.40	0.79	5.3	7	3.7	2.6	<.002	NT
Xylenes (mg/kg)	8.80	4.20	36	26	24	17	<.002	NT
Soil gas hydrocarbons:								
TVH (ppmv)	NT**	23,000	NT	NT	28,000	NT	NT	21,000
Benzene (ppmv)	NT	ND†	NT	NT	ND	NT	NT	ND
Toluene (ppmv)	NT	ND	NT	NT	ND	NT	NT	ND
Ethyl benzene (ppmv)	NT	6.4	NT	NT	7.9	NT	NT	4.4
Xylenes (ppmv)	NT	19	NT	NT	21	NT	NT	11.0
Soil inorganics:								
Phosphorus (mg/kg)	97.2	NT	114	96.2	NT	73.1	85.8	NT
Alkanlinity (mg/kg as $CaCo_3$)	350	NT	350	450	NT	250	1,550	NT
TKN (mg/kg)	350	NT	280	224	NT	420	238	NT
Soil physical parameters:								
Moisture (% wt)	15.3	NT	25.3	23	NT	16.3	15.7	NT
pH (units)	8.9	NT	8.6	9	NT	8.9	8.3	NT
Gravel (% >2.0 mm)	<0.1	NT	<0.1	<0.1	NT	<0.1	<0.1	NT
Sand (% 0.75-2.0 mm)	20.5	NT	7.5	6	NT	38.6	24.5	NT
Silt (% .05-0.75 mm)	60.6	NT	65.8	60.4	NT	49.5	57	NT
Clay (% <0.005 mm)	18.9	NT	26.8	33.6	NT	11.9	18.5	NT
Soil temperature, 6-9-93 (°F)	NT	NT	64.3	NT	NT	NT	NT	69.8
Soil temperature, 6-15-93 (°F)	NT	NT	64.9	NT	NT	NT	NT	72.8

* TRPH = total recoverable petroleum hydrocarbons; mg/kg = milligrams per kilogram; TVH = total volatile hydrocarbons; ppmv = parts per million, volume per volume; $CaCO_3$ = calcium carbonate; TKN = total Kjeldahl nitrogen; °F = degrees Fahrenheit.

** NT = not tested at this location.

† ND = not detected.

rather than a GasTech® hydrocarbon analyzer was used to field screen the soil samples and monitor the breathing zone during drilling and soil sampling activities. Also, more than one sample was collected from some borehole since this pilot test is part of a site characterization investigation to determine the extent of soil contamination at the site.

PILOT TEST RESULTS

Initial Soil Gas Chemistry

Before air injection began, all MPs and the VW were purged, and initial oxygen, carbon dioxide, and TVH concentrations were sampled using portable gas analyzers, as described in the technical protocol document (Hinchee et al., 1992). Table 2 summarizes the initial soil gas chemistry at site ST14. The results strongly indicate that biological fuel degradation has depleted the oxygen supply in the vadose zone soils. Three of the six sampling points at site ST14 were under anaerobic conditions, and soil gas at the remaining three sampling points contained oxygen at low levels ranging from 0.8 percent to 3.8 percent. In contrast, the background MP, installed in uncontaminated soil approximately 500 feet northeast of the site, contained oxygen at levels ranging from 13.2 percent (7 feet depth) to 20.6 percent (4 foot depth). Carbon dioxide was present at elevated concentrations, ranging from 9.8 to 11.0 percent, in all initial soil gas samples collected at site ST14. The background MP carbon dioxide levels ranged from 9.0 to 0.05 percent. The ambient oxygen and carbon dioxide levels of MPGB2 at 4 feet bgs suggest that short-circuiting between this interval and the surface has occurred, which indicates an inadequate seal between the surface and this MP depth. High hydrocarbon concentrations measured in the initial soil gas testing possibly indicate the volatilization of fuel from the free product layer into the pore space of the vadose zone soils at site ST14.

Air Permeability

An air permeability test was conducted at site ST14 according to protocol document procedures. Air was injected into the VW for approximately 3.5 hours at a rate of approximately 28 acfm and an average pressure of approximately 7 pounds per square inch (psi). The pressure response at each MP is listed in Table 3. The pressure measured at all MPs achieved steady-state conditions within 45 minutes. Since more than 10 minutes was required to achieve steady state in all of the monitoring points, the dynamic method of determining soil gas permeability was selected. As discussed in the technical protocol document (Hinchee et al., 1992), the dynamic method of determining soil gas permeability that is coded in the HyperVentilate™ model is appropriate for soils which reach steady state in more than approximately 10 minutes. Two depths from both MPA (10 feet from injection point, VW1) and MPC (45 feet from injection point, VW1) were used to calculate relative air permeability of the soils. No response was observed in the 4-foot interval of MPB (20 feet from injection point, VW1). This may be due to the moist, highly plastic, and tightly consolidated clayey soils in which the monitoring point was constructed.

Table 2
Site ST14
Initial Soil Gas Chemistry
Carswell AFB, Texas

MP	Depth	O_2(%)	CO_2(%)	Field TVH* (ppmv)	Lab TVH (ppmv)	Lab TRPH (mg/kg)
VW	5-8.5	3.8	10.1	294,000	23,000	890
A	4	0.8	10.4	546,000	21,000	NT**
A	7	0.0	10.8	<200,000	NT	NT
A	10	NS†	NS	NS	NS	2,500
B	4	0.0	11.0	290,000	NT	NT
B	7	NS	NS	NS	NT	NT
B	10	NS	NS	NS	NS	2,500
C	4	0.0	10.3	200,000	NT	NT
C	7	2.2	9.8	212,000	28,000	1,100
C	10	NS	NS	NS	NS	1,500
BG2	4	20.6	0.05	NT	NT	
BG2	7	13.2	9.0	NT	NT	
BG2	10	NS	NS	NS	NS	

* Estimated value using dilution method.
** NT = not tested at this location.
† NS = not sampled due to saturated moisture conditions at MP depth interval.

Table 3
Site ST14
Pressure Response During the Air Permeability Test
Carswell AFB, Texas

Elapsed Time (min)	Location: Depth (ft):	Pressure Response in MP (inches of water) MPA 4	MPA 7	MPB 4	MPC 4	MPC 7
0*		-0.05**	0.00	-0.10	0.20	0.20
0.5		0.00	0.85	-0.30	0.15	0.20
1.0		0.10	2.20	-0.30	0.15	0.20
2.0		0.45	3.50	-0.35	0.30	0.25
3.0		0.75	4.55	-0.35	0.20	0.25
4.0		1.00	6.00	-0.40	0.55	0.35
5.0		1.40	7.20	-0.50	0.80	0.70
6.0		2.30	8.40	-0.50	1.05	1.10
7.0		--†	--	-0.50	1.40	1.35
8.0		2.75	9.40	--	1.70	1.70
9.0		--	--	--	2.10	2.10
10.0		3.90	>10.00	--	2.25	2.25
12.0		4.85	11.00	0.00	2.65	2.60
22.0		8.00	11.70	-0.30	3.10	3.05
37.0		9.70	12.20	-0.40	3.50	3.50
54.0		11.70	12.80	--	--	--
92.0		12.20	13.00	+0.25	3.60	3.60
120.0		12.10	13.10	+0.25	3.60	3.65
152.0		12.10	13.10	+0.40	3.60	3.65

* Pressure readings taken prior to initiating field test (blower start up).
** Negative sign indicates vacuum pressure at MP.
† Denotes no reading taken at this time.

A constant injection flow rate of 28 afcm and a screened interval thickness of 3.5 feet (5 feet bgs top of screen to 8.5 feet bgs to water level in vent well) were used to calculate, a soil gas permeability of 26.4 and 30.8 darcy for the 10-foot radial distance at 4 and 7 feet, respectively. The soil gas permeability for the 45-foot radial distance at 4 and 7 feet is 94.2 and 93.4 darcy, respectively. An average of 61.2 darcy was calculated for this site. The HyperVentilate® cards depicting these calculations are in appendix D. This value is approximately one order of magnitude higher than would be expected for the predominantly clayey soils at the site; however, the presence of gravel throughout the soil profile and increasing sand content with depth appears to have increased the average permeability at this site. A radius of pressure influence of at least 45 feet was observed at all depths. Given the steady-state pressure responses from 10 and 45 feet from the vent well, and assuming a linear relationship, the estimated radius of influence for this site at 28 acfm appears to be 60 feet.

Oxygen Influence

The depth and radius of oxygen influence in the subsurface resulting from air injection into the central VW during pilot testing is the primary design parameter for full-scale bioventing systems. Optimization of full-scale and multiple VW systems requires pilot testing to determine the volume of soil that can be oxygenated at the given flow rate and VW screen configuration.

Table 4 describes the change in soil gas oxygen levels that occurred during the 3.5-hour air injection test at the site, and the air injection period which extended at a lower flow rate (24 acfm) for an additional 17 hours. The relatively brief (3.5 hours) air injection period at 28 acfm produced changes in soil gas oxygen levels at a distance of at least 45 feet from the central VW at both monitored depth intervals and in MPA and MPC and at the one monitored depth interval in MPB. Significant increases in the oxygen concentration were measured at each MP interval. Considering measured pressure response, which is an indicator of long-term oxygen transport, it is anticipated that the radius of influence for a long-term bioventing system at this site will exceed 45 feet at all depths. Monitoring during the extended pilot test at this site will better define the effective treatment radius.

In Situ Respiration Rates

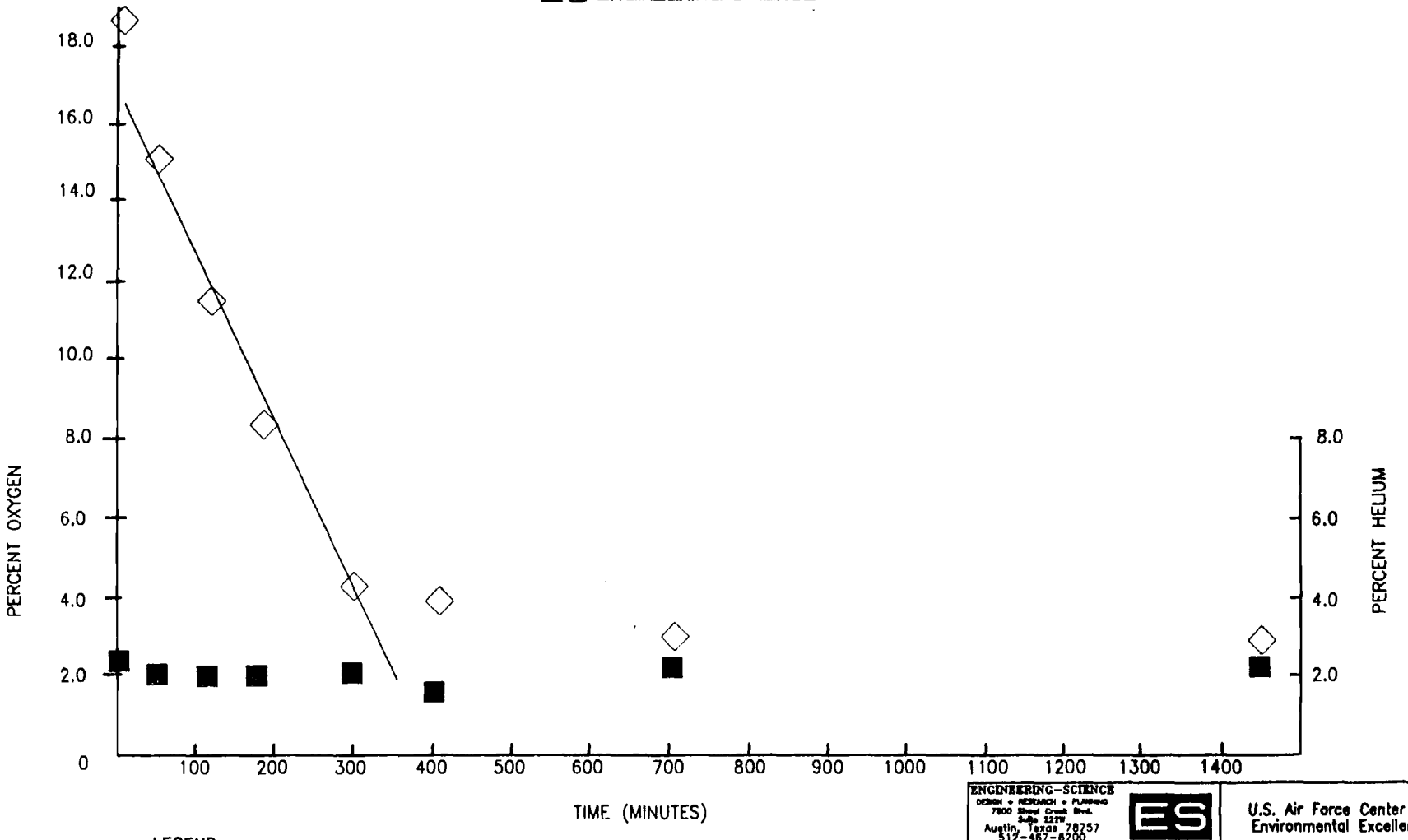
In situ respiration testing was performed at site ST14 according to protocol document procedures. Air was injected into the VW and MP screens MPA-4, MPA-7, MPB-4, MPC-4, and MPC-7 for 16 hours at a rate of approximately 1 acfm per screened interval to deliver oxygen to contaminated soils. At the end of the 16-hour period, air injection ceased, and changes in soil gas composition were monitored over time. Oxygen, TVH, and carbon dioxide were measured over a period of 72 hours following the air injection period. The observed rates of oxygen utilization were then used to estimate the aerobic fuel degradation rates at site ST14. Figures 7 through 11 present the results of *in situ* respiration testing at the site, and Table 5 is a summary of the observed oxygen utilization rates.

Table 4
Site ST14
Influence of Air Injection at Vent Well
on Monitoring Point Oxygen Levels
Carswell AFB, Texas

MP	Distance from VW (ft)	Depth (ft)	Initial O_2 (%)	O_2 (%)*	Final O_2 (%)**
A	10.0	4	3.2	18.0	19.4
A	10.0	7	0.0	17.9	20.4
A	10.0	10	NS†	NS	NS
B	20.0	4	0.0	12.3	17.7
B	20.0	7	NS	NS	NS
B	20.0	10	NS	NS	NS
C	45.0	4	0.0	1.3	11.1
C	45.0	7	0.0	2.0	12.7
C	45.0	10	NS	NS	NS

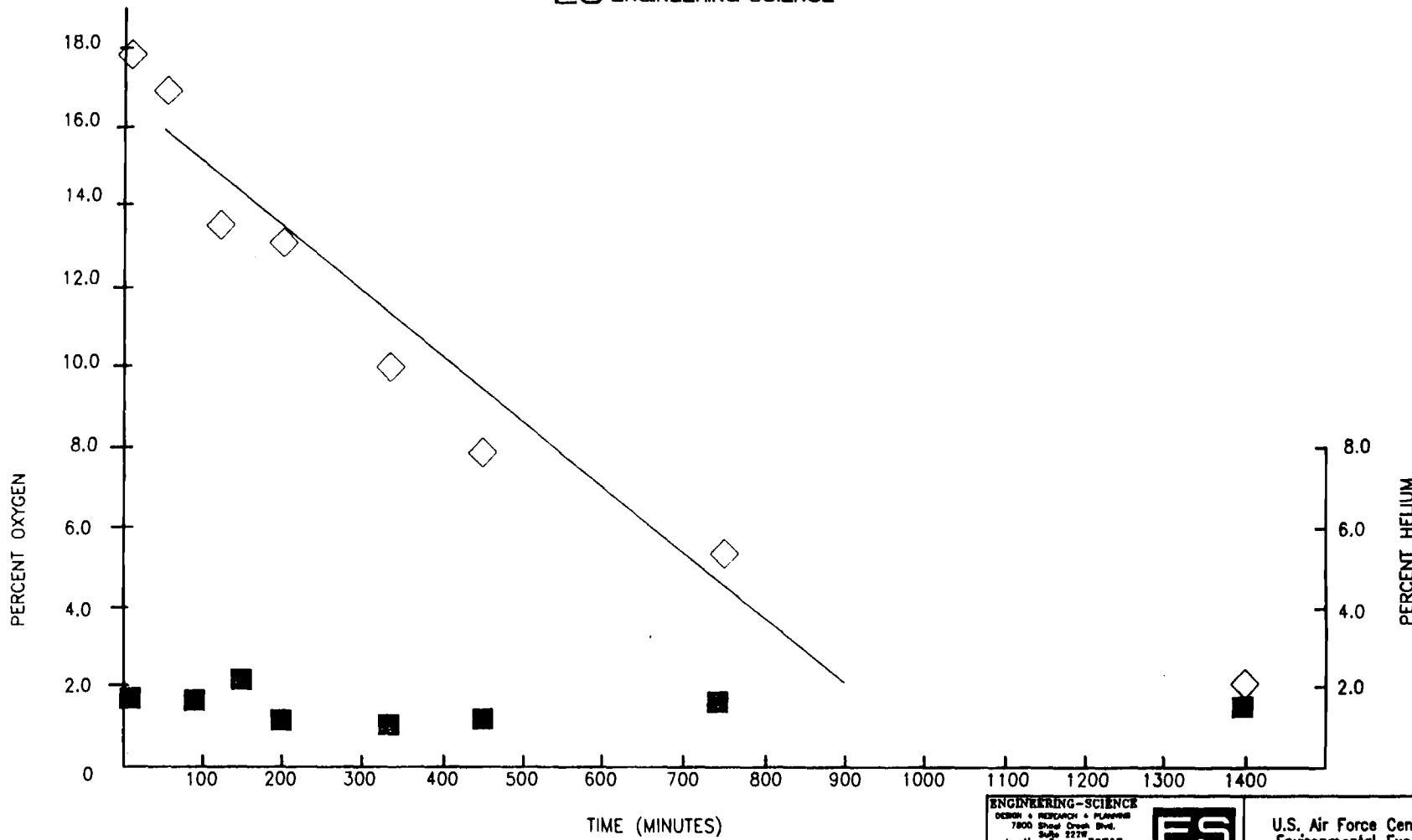
* Duration of air injection = 3.5 hours.
** Duration of air injection = 3.5 hours at 28 acfm, and 17 hours at 24 acfm.
† NS = not sampled due to water levels at 8.5 feet bgs.

ES ENGINEERING-SCIENCE



ENGINEERING-SCIENCE DESIGN • RESEARCH • PLANNING 7800 Shoal Creek Blvd. Suite 227W Austin, Texas 78757 512-467-6200 Offices in Principal Cities	ES	U.S. Air Force Center for Environmental Excellence
DESIGNED BY: BRV DRAWN BY: CLG REVIEWED BY: SUBMITTED BY:	CARSWELL AIR FORCE BASE FORT WORTH, TEXAS PN:FY7624-93-08030 FY:93 FIGURE 7 RESPIRATION TEST VENT WELL SITE ST14	
PLOT SCALE: DESIGN FILE: RESPTEST PLOT DATE: 7/19/93	DWG. CODE: SHEET 7 OF 7	CONTRACT DATE: APRIL 30,1992 CALL ORDER NO.: 0004 CONTRACT NO.: F41624-92-D-8036
		SHEET REFERENCE NUMBER 7

ES ENGINEERING-SCIENCE



LEGEND

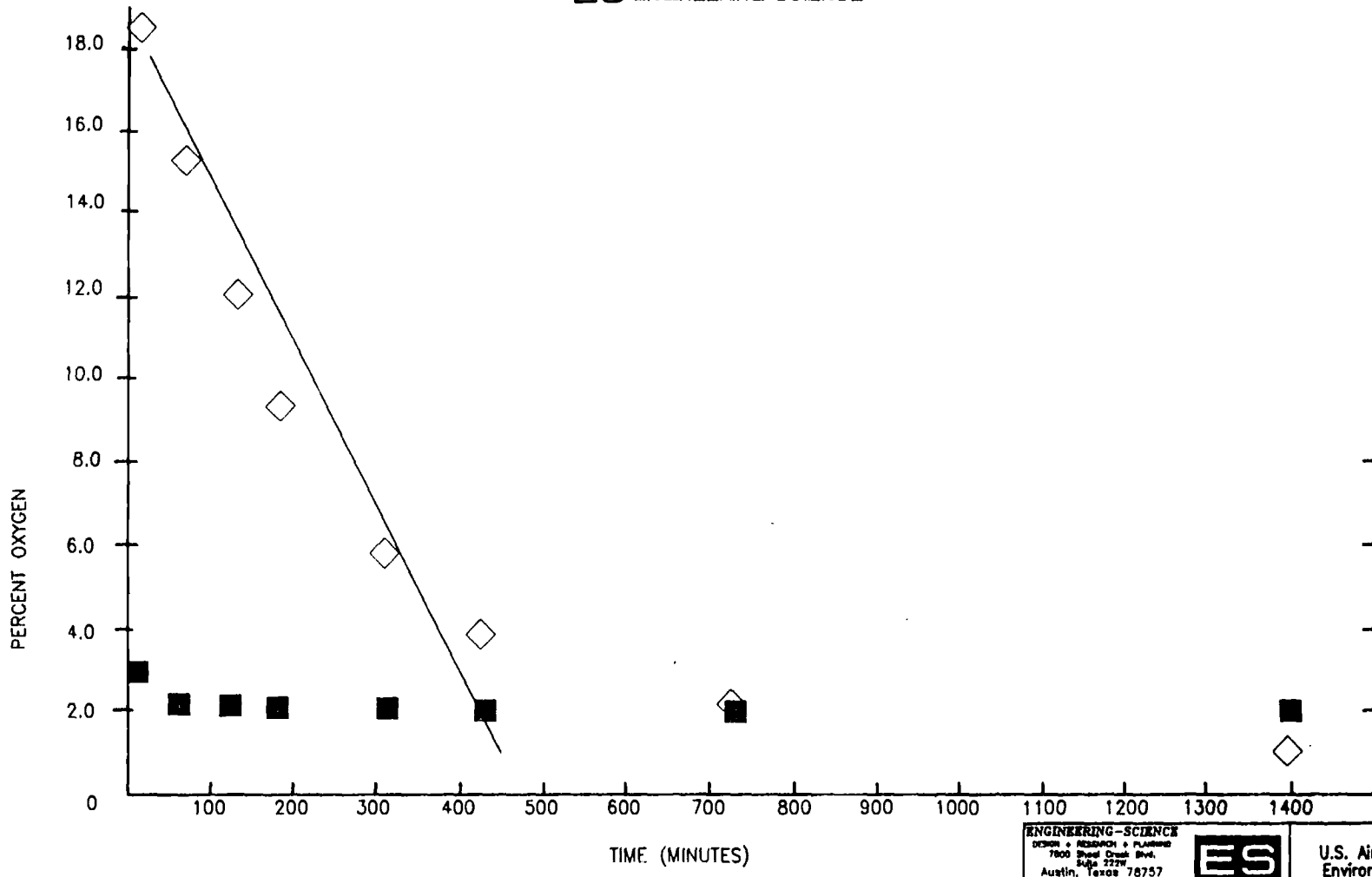
◇ PERCENT OXYGEN

——— −0.016%/MIN (SLOPE); K_O = 23.0%/DAY (OXYGEN UTILIZATION RATE)

■ PERCENT HELIUM

ENGINEERING-SCIENCE DESIGN & RESEARCH & PLANNING 7800 Shoal Creek Blvd. Suite 227W Austin, Texas 78757 512-467-6200 Offices in Principal Cities	ES	U.S. Air Force Center for Environmental Excellence	
DESIGNED BY: BRV	CARSWELL AIR FORCE BASE FORT WORTH, TEXAS PN:FY7624-93-08030 FY:93		
DRAWN BY: CLG	FIGURE 8 RESPIRATION TEST MPA-4		
REVIEWED BY:			
SUBMITTED BY:	SITE ST14		
PLOT SCALE:	DWG. CODE:	CONTRACT DATE: APRIL 30,1992	SHEET REFERENCE NUMBER 8
DESIGN FILE: RESPTEST		CALL ORDER NO.: 0004	
PLOT DATE: 7/19/93	SHEET 8 OF	CONTRACT NO.: F41624-92-D-8036	

ES ENGINEERING-SCIENCE



LEGEND

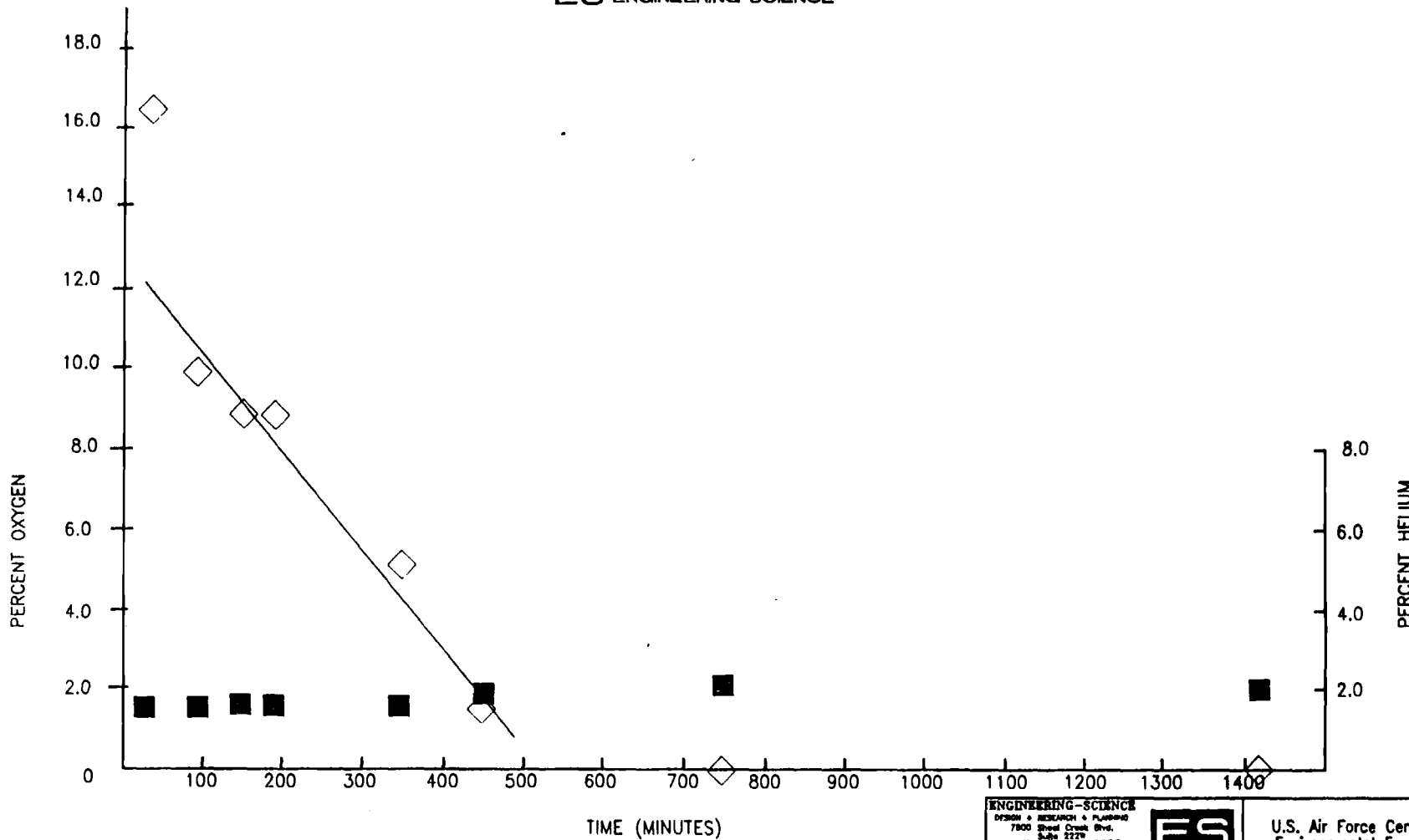
◇ PERCENT OXYGEN

——— −0.040%/MIN (SLOPE); K_O = 57.6%/DAY (OXYGEN UTILIZATION RATE)

■ PERCENT HELIUM

ENGINEERING-SCIENCE DESIGN • RESEARCH • PLANNING 7800 Shoal Creek Blvd. Suite 222W Austin, Texas 78757 512-487-6200 Offices in Principal Cities	ES	U.S. Air Force Center for Environmental Excellence
DESIGNED BY: BRV DRAWN BY: CLG REVIEWED BY: SUBMITTED BY:	CARSWELL AIR FORCE BASE FORT WORTH, TEXAS PN:FY7624-93-08030 FY:93 FIGURE 9 RESPIRATION TEST MPA-7 SITE ST14	
PLOT SCALE: DESIGN FILE: RESPTEST PLOT DATE: 7/19/93	DWG. CODE: SHEET 9 OF	CONTRACT DATE: APRIL 30,1992 CALL ORDER NO.: 0004 CONTRACT NO.: F41624-92-D-8036
		SHEET REFERENCE NUMBER 9

ES ENGINEERING-SCIENCE



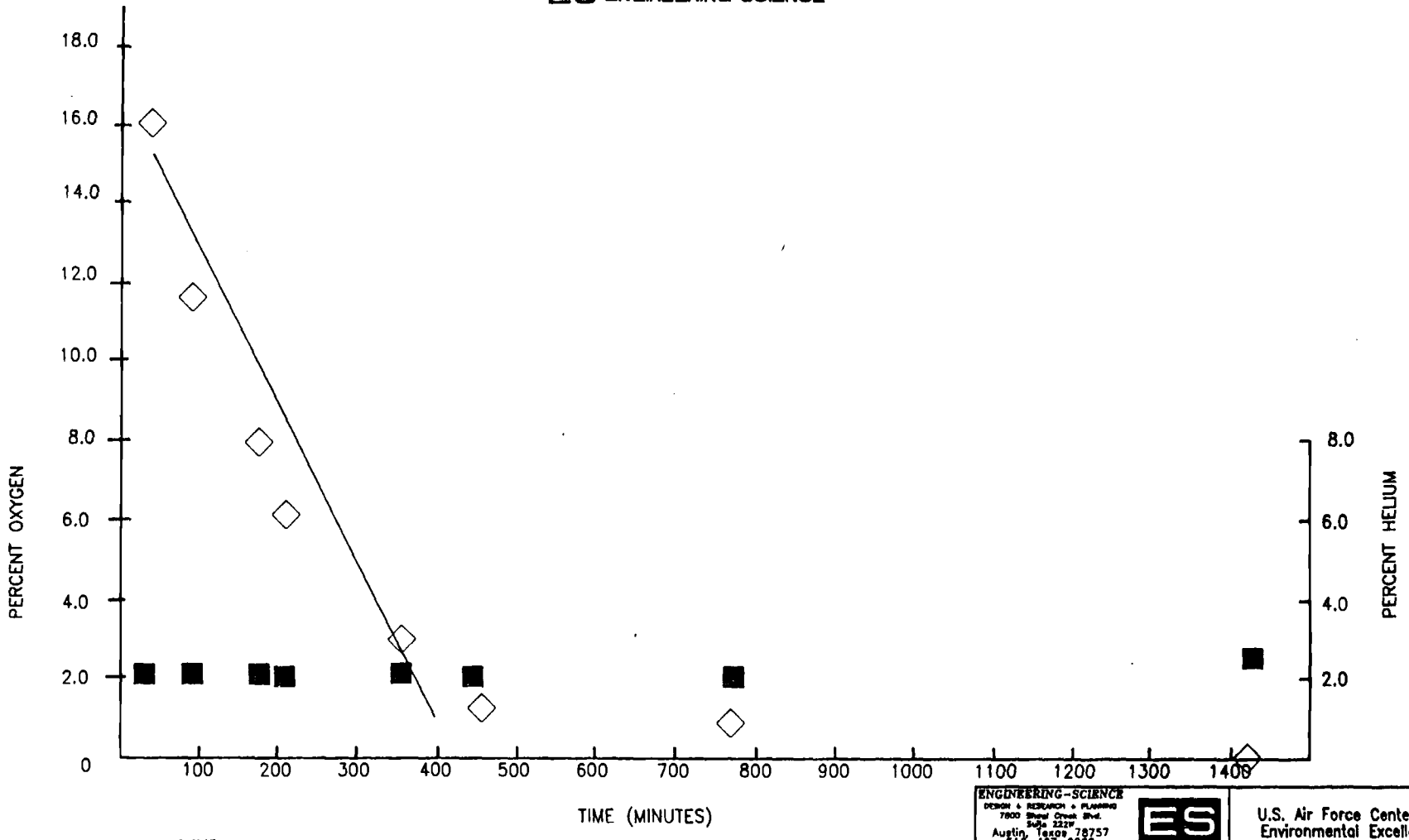
LEGEND

◇ PERCENT OXYGEN

——— −0.025%/MIN (SLOPE); K_0 = 36%/DAY (OXYGEN UTILIZATION RATE)

■ PERCENT HELIUM

ENGINEERING-SCIENCE DESIGN & RESEARCH & PLANNING 7800 Shoal Creek Blvd. Suite 222S Austin, Texas 78757 512-467-6200 Offices in Principal Cities	ES	U.S. Air Force Center for Environmental Excellence
DESIGNED BY: BRV	CARSWELL AIR FORCE BASE FORT WORTH, TEXAS PN:FY7624-93-08030 FY:93	
DRAWN BY: CLG	FIGURE 10 RESPIRATION TEST MPB-4 SITE ST14	
REVIEWED BY:		
SUBMITTED BY:		
PLOT SCALE:	DWG. CODE:	CONTRACT DATE: APRIL 30,1992
DESIGN FILE: RESPTEST		CALL ORDER NO.: 0004
PLOT DATE: 7/19/93	SHEET 10 OF	CONTRACT NO.: F41624-92-D-8038
		SHEET REFERENCE NUMBER 10



LEGEND

◇ PERCENT OXYGEN

——— −0.040%/MIN (SLOPE); K_O = 57.6%/DAY (OXYGEN UTILIZATION RATE)

■ PERCENT HELIUM

ENGINEERING-SCIENCE DESIGN & RESEARCH & PLANNING 7800 Shoal Creek Blvd. Suite 222W Austin, Texas 78757 512-467-6200 Offices in Principal Cities	ES	U.S. Air Force Center for Environmental Excellence
DESIGNED BY: BRV	CARSWELL AIR FORCE BASE FORT WORTH, TEXAS PN:FY7624-93-08030 FY:93	
DRAWN BY: CLG	FIGURE 11 RESPIRATION TEST MPC-7 SITE ST14	
REVIEWED BY:		
SUBMITTED BY:		
PLOT SCALE:	DWG. CODE:	CONTRACT DATE: APRIL 30,1992
DESIGN FILE: RESPTEST		CALL ORDER NO.: 0004
PLOT DATE: 7/19/93	SHEET 1 OF 1	CONTRACT NO.: F41624-92-D-8038
		SHEET REFERENCE NUMBER 11

Table 5
Site ST14
Oxygen Utilization Rates
Carswell AFB, Texas

MP	O_2 Loss* (%)	Test Duration (min)	O_2 Utilization* Rate (% min)
VW	13.5	300	0.045
MPA-4	12.0	750	0.016
MPA-7	18.0	450	0.040
MPB-4	11.25	450	0.025
MPC-7	16.0	400	0.040

* Values based on linear regression (Figures 7 through 11).

An average 2.5-percent mixture of helium in air was injected during the 16-hour injection period into the screened intervals of all the tested MPs and the VW, and the loss of helium was measured for 72 hours following air injection. Because helium is a conservative, inert gas, the change in helium concentrations over time can be useful in determining if oxygen diffusion is responsible for a portion of the oxygen lost from each MP. Figures 7 through 11 also compare oxygen utilization and helium retention at each measuring point. Helium concentrations remained relatively constant throughout the test, while oxygen levels steadily dropped to below 1 percent after air injection ceased. Because the measured helium levels remained relatively constant, and since all oxygen loss was observed at all points, and because helium will diffuse approximately three times faster than oxygen, the measured oxygen loss can be attributed primarily to bacterial respiration rather than diffusion of faulty MP construction.

Calculations based on pilot test results indicate that, at site ST14, an estimated 959 to 9,886 milligrams (mg) of fuel per kilogram (kg) of soil can be degraded each year. This value was calculated as described in the protocol document (Hinchee et al., 1992) This value is the average of the fuel consumption rates calculated for every point at which a respiration test was conducted. The air-filled porosities as calculated for each sampling point ranged from 0.06 to 0.11 liters of air per kilogram of soil. The point-specific fuel consumption rates were calculated using observed oxygen utilization rates, estimated air-filled porosities, and a conservative ratio of 3.5 mg of oxygen consumed for every 1 mg of fuel biodegraded. Oxygen loss was rapid and linear at every sampling point during approximately the initial 500 minutes of the *in situ* respiration test. The oxygen utilization rates observed at site ST14 ranged from 0.016 percent per minute (%/min) to 0.045 %/min (Table 5), demonstrating that hydrocarbon contamination is spread uniformly through the pilot test area.

At all sampling points, the oxygen utilization rates appeared to decrease over time (Figures 7 and 11). This apparent decrease has been observed at other fuel spill sites where an oxygen source is in close proximity to contaminated soils. Site ST14 is unpaved, and initial oxygen levels in the vent well, MPA-4, and MPC-7 ranged from 0.8 to 3.8 percent (Table 2), suggesting the potential for oxygen diffusion from the surface. As oxygen is rapidly consumed by fuel-degrading bacteria in deeper contaminated soils, the oxygen diffusion gradient between the contaminated soil and the atmosphere becomes substantial. As a result, oxygen begins to diffuse from the atmosphere into the contaminated soils. This inward oxygen diffusion temporarily masks the actual bacterial oxygen uptake rates. Because fuel biodegradation generally consume oxygen at a rate that exceeds diffusion, the oxygen concentrations soon return to zero in contaminated soils once supplied air is cut off.

Potential Air Emissions

Soil concentrations of BTEX compounds detected were less than 50 mg/kg; however, the free product present at Site ST14 will continue to generate additional VOCs (Table 1). Thus, the long-term potential for air emissions from full-scale bioventing operations at this site is moderate. Initial emissions should be minimal

because accumulated vapors will move slowly outward from the air injection point and will be biodegraded as they move horizontally through the soil. The low permeability clays near the surface provide a cover at the site which will also encourage horizontal movements and increased biodegradation. During the air permeability test, air was injected at 28 acfm. Hydrocarbon-analyzer air monitoring of the breathing zone at the site for health and safety purposes did not indicate that hydrocarbon concentrations had increased above 1 part per million volume (ppmv) during the test.

RECOMMENDATIONS

Initial bioventing tests at this site indicate that oxygen had been depleted in the contaminated soils, and that air injection is an effective method of stimulating aerobic fuel biodegradation. It is recommended that air injection continue at this site to determine the long-term radius of oxygen influence and the effect of time, available nutrients, and changing temperatures on fuel biodegradation rates.

A 1-horsepower regenerative blower has been installed at the site for continuous air injection. In December 1993, additional tests at the site should be conducted to sample and analyze the soil gas and conduct a repeat respiration test. If a bioventing system for a full-scale remediation of the site has not been installed by June 1994, a final respiration test should be conducted, at which time soil and soil gas samples can be collected from the site to determine the degree of remediation achieved during the first year of *in situ* treatment. It is important to note that without some form of free product removal, soils will be subject to recontamination as groundwater levels rise.

Based on the results of this 1-year study, AFCEE will recommend one of two options:

1. Upgrade the pilot-scale system, if necessary, and continue operation of the bioventing system for full-scale remediation of the site. Evaluate the need for integrating bioventing with free product recovery. AFCEE can assist the base in obtaining regulatory approval for upgrading and continued operation.
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 vent well and MPs.

REFERENCES

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

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) _____

Blower (regenerative, rotary vane) _____

Blower Model _____

Motor (Hp) _____

Knock-Out Chamber (yes, no) _____

Sampling Port (yes, no) _____

Inlet Temperature Gauge (range) _____

Inlet Pressure/Vacuum Gauge (range) _____

Inlet Filter (part no.) _____

Outlet Temperature Gauge (range) _____

Outlet Pressure/Vacuum Gauge (range) _____

Pressure/Vacuum Relief Valve Set @ (give unit of measure) _____

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 _____ a _____ blower system has been installed.

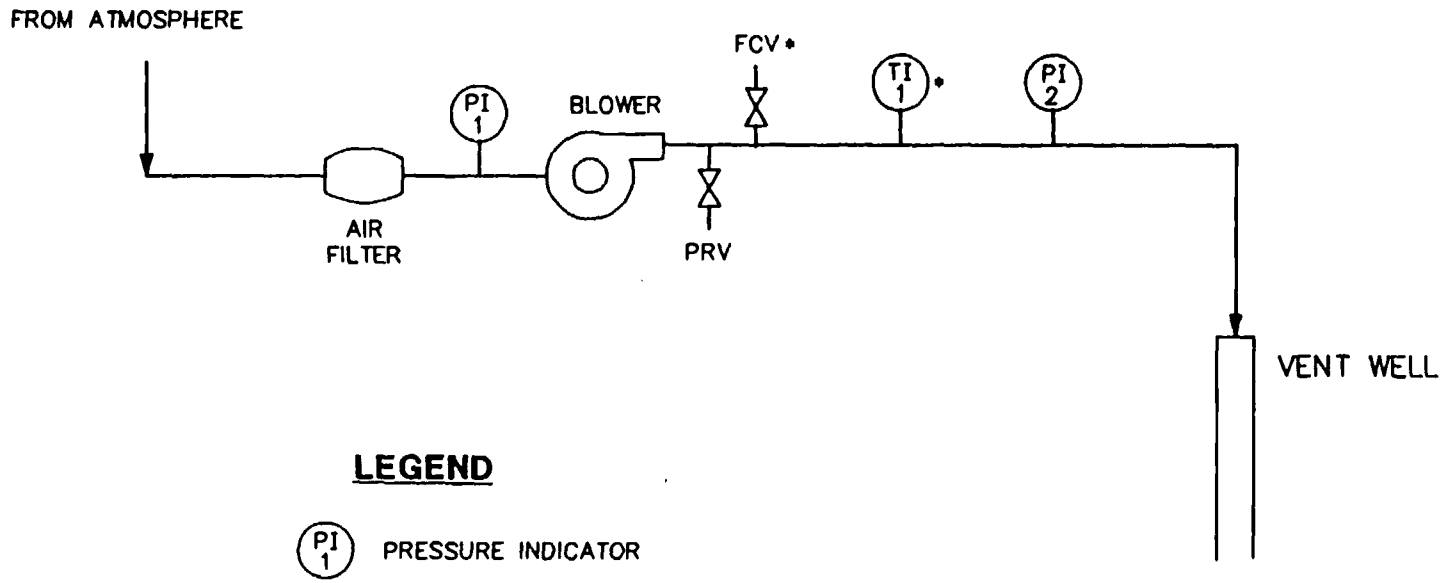
3.2 SYSTEM DESCRIPTION

3.2.1 Blower System

A _____ blower powered by a _____ horsepower direct-drive motor is the workhorse of the bioventing system. This blower is rated at a flow rate of ___ standard cubic feet per minute (scfm) at a pressure of _____ ; however, the actual performance of the blower will vary with changing site conditions. As installed, the blower was producing an estimated flow rate of ___ scfm at a pressure of _____. 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 _____ 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

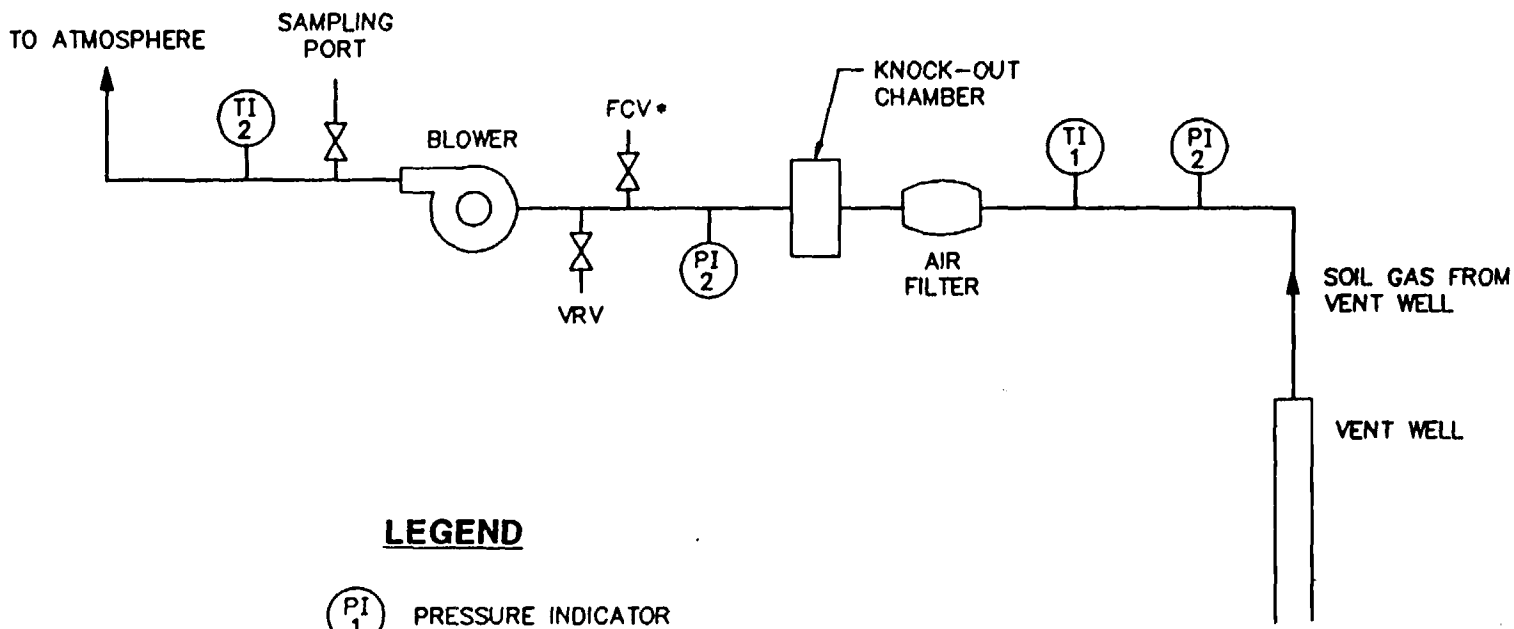
PI 1	PRESSURE INDICATOR
TI 1	TEMPERATURE INDICATOR
FCV	FLOW CONTROL VALVE
PRV	PRESSURE RELIEF VALVE
*	OPTIONAL

FIGURE 3.1

TYPICAL BLOWER SYSTEM INSTRUMENTATION DIAGRAM FOR AIR INJECTION

ENGINEERING-SCIENCE, INC.
Denver, Colorado

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



LEGEND

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

FIGURE 3.1

TYPICAL BLOWER SYSTEM INSTRUMENTATION DIAGRAM FOR AIR EXTRACTION

ENGINEERING-SCIENCE, INC.
Denver, Colorado

93DN0414, 04/02/93 at 11:10

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 _____ and they can be reached at (303) 831-8100. The filter model number is _____, and the number for the replacement element is _____. It is recommended that _____ 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 _____ should be called at (___)_____. 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.

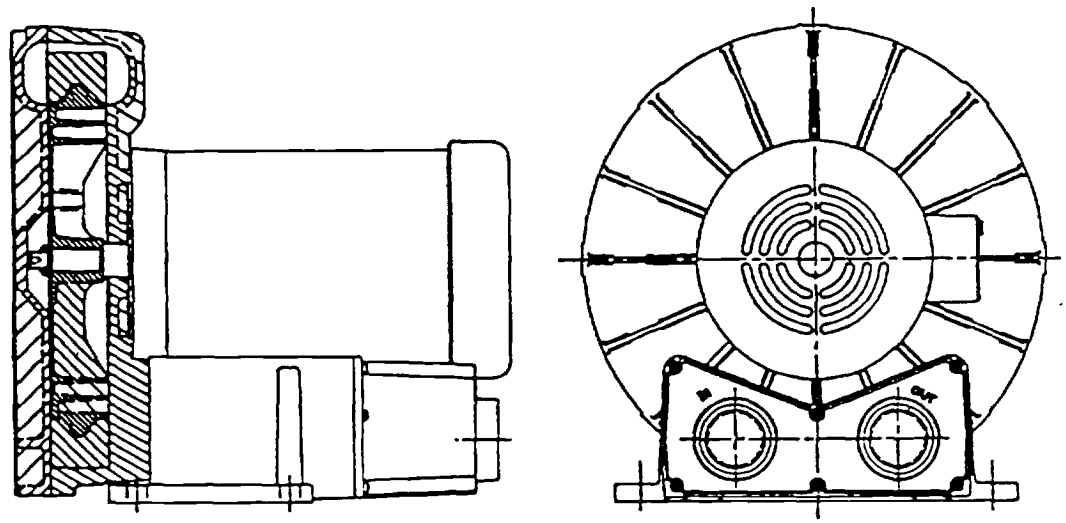
Monitoring Item	Monitoring Frequency
Vacuum/Pressure	Daily during first week, then once per week.
Temperature	Daily during first week, then once per week.

APPENDIX A
REGENERATIVE BLOWER INFORMATION

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

153013

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

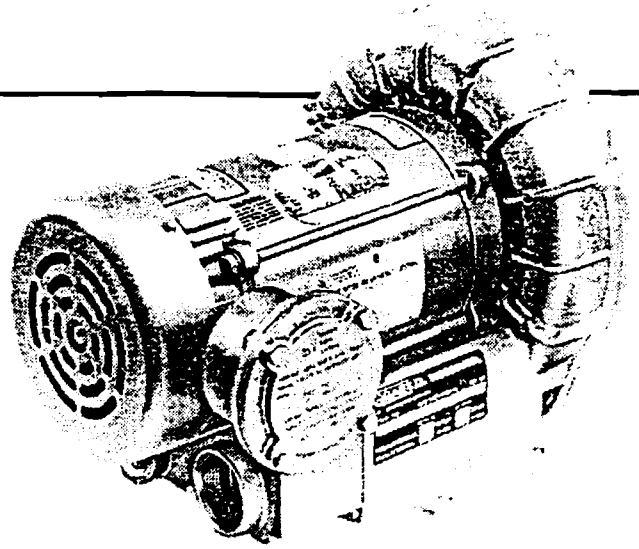
Gast Mfg. Co. Limited.
Halifax Rd, Cressex Estate
High Wycombe, Bucks HP12 3SN
Ph. 44 494 523571
Fax: 44 494 436588

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

For Soil Remediation to 260 cfm

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

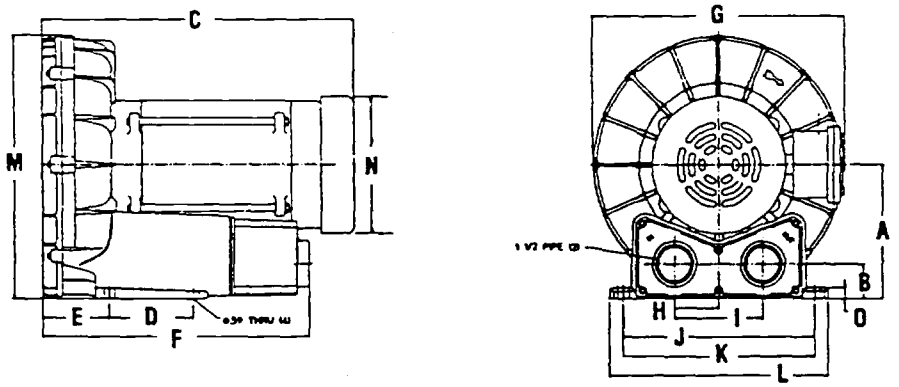
RECOMMENDED ACCESSORIES

- 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

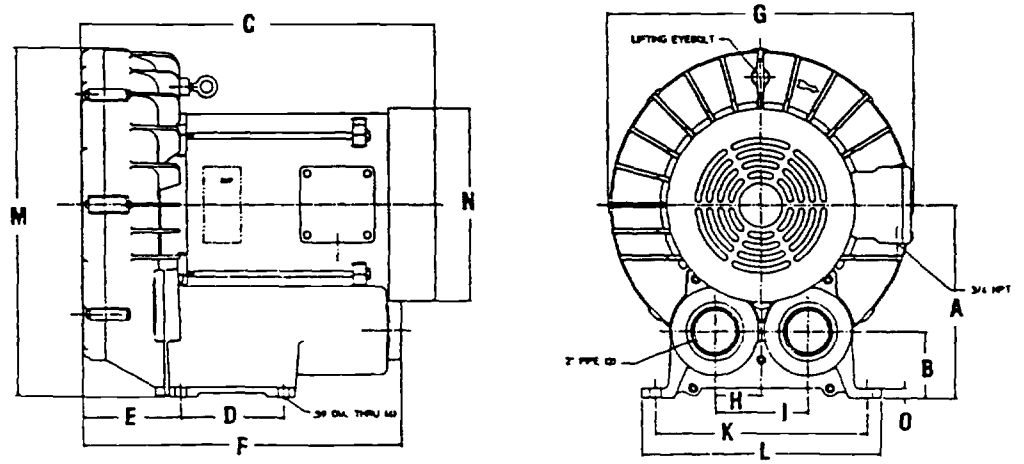
Product Dimensions Metric (mm) U.S. Imperial (Inches)

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

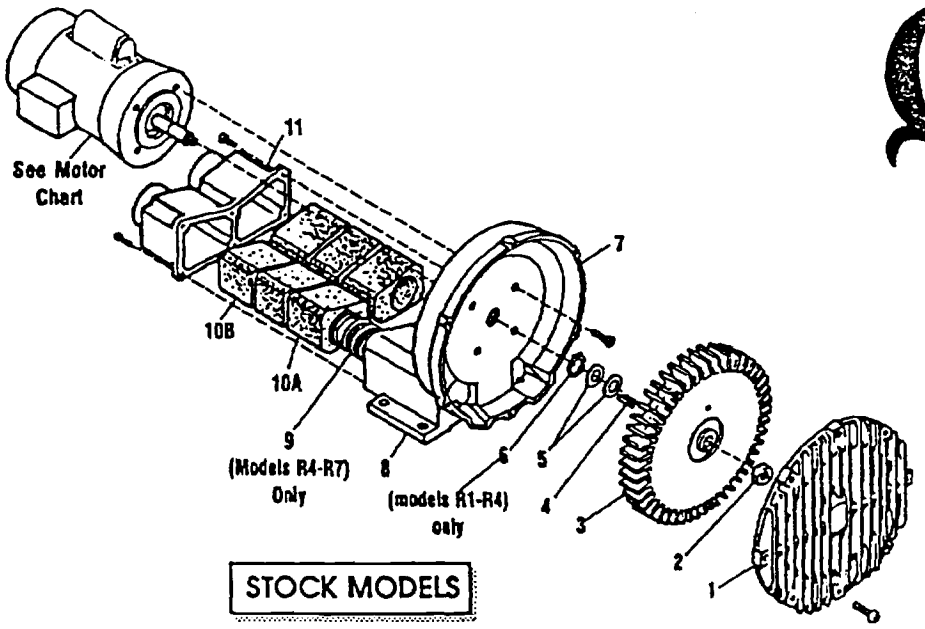
Model R4 Series
Model R5 Series



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 Slopnut	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.	

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.

GAST

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

F2-205/8/92
AK811 Rev. E

150017

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

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.

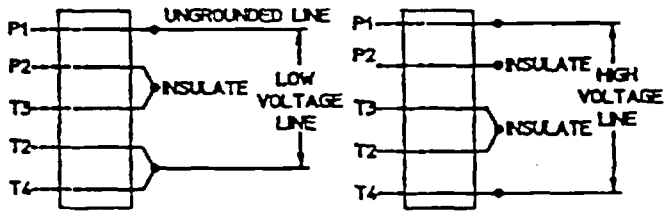
SERVICING

⚠ *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

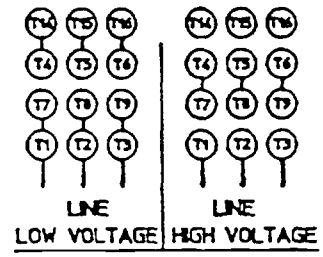


>>■ WARNING

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.

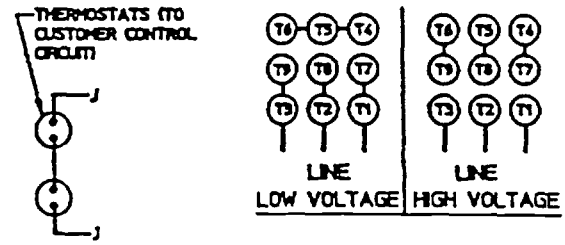


>>■ WARNING

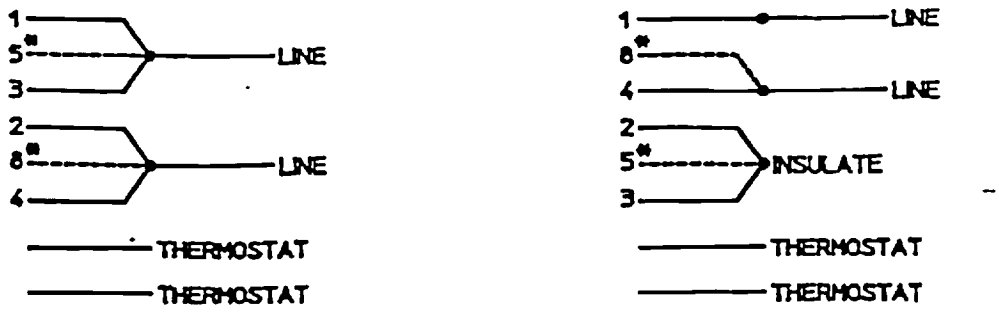
THIS MOTOR IS THERMALLY PROTECTED AND WILL AUTOMATICALLY RESTART WHEN PROTECTOR RESETS. ALWAYS DISCONNECT POWER SUPPLY BEFORE SERVICING.

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

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



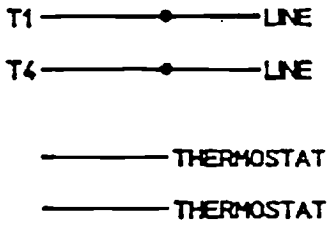
MOTOR WIRING DIAGRAM FOR R5125Q-50 & R4P115N-50



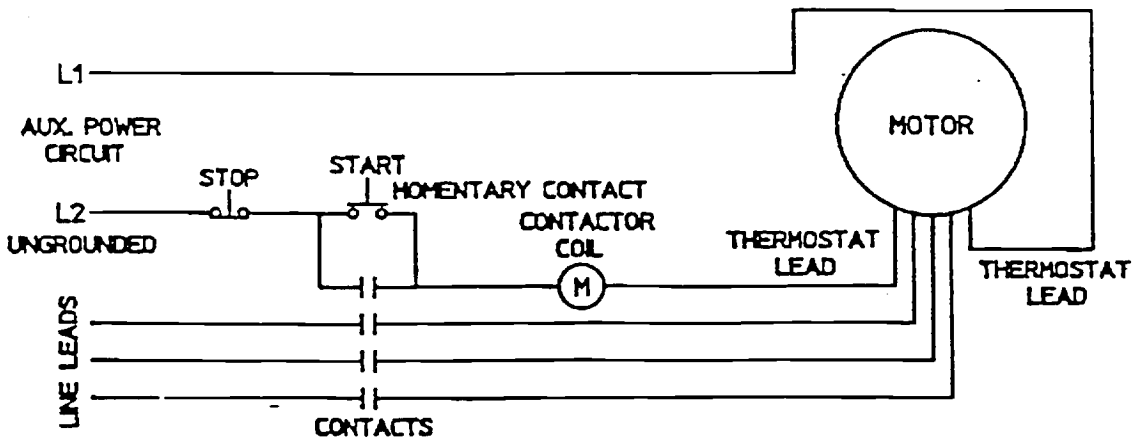
* R5125Q-50 BLOWERS PRODUCED AFTER SEPTEMBER 1992 (SER. NO. 0992) DO NOT HAVE MOTOR LEADS 5 & 8.

MOTOR WIRING DIAGRAM FOR R6130Q-50 & R6P155Q-50

CONNECT THERMOSTAT TO MOTOR PROTECTION CIRCUIT



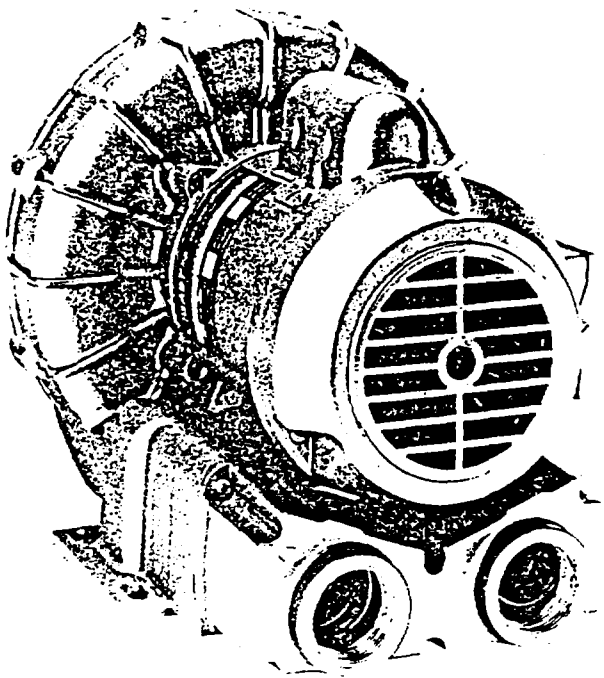
CONNECTION FOR THERMOSTAT MOTOR PROTECTION



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

AK811 rev. E

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

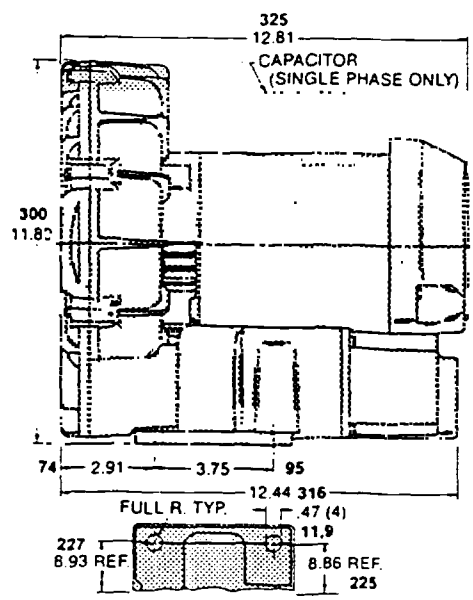
- Pressure gauge AJ496
- Filter AG338
- Muffler AJ121D
- Relief valve AG258

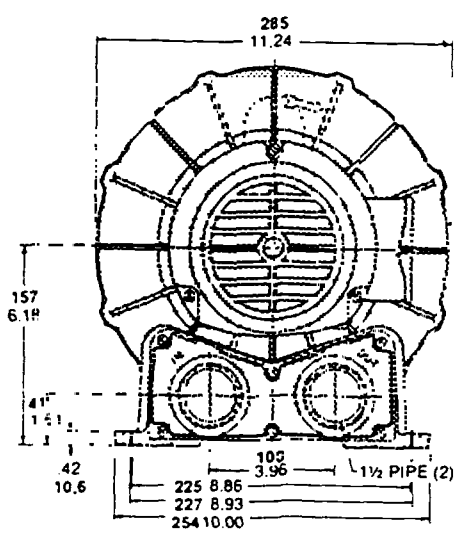
Various brand name motors are used on any model at the discretion of Gast Mfg. Corp.

Important Notice:

Pictorial and dimensional data is subject to change without notice.

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



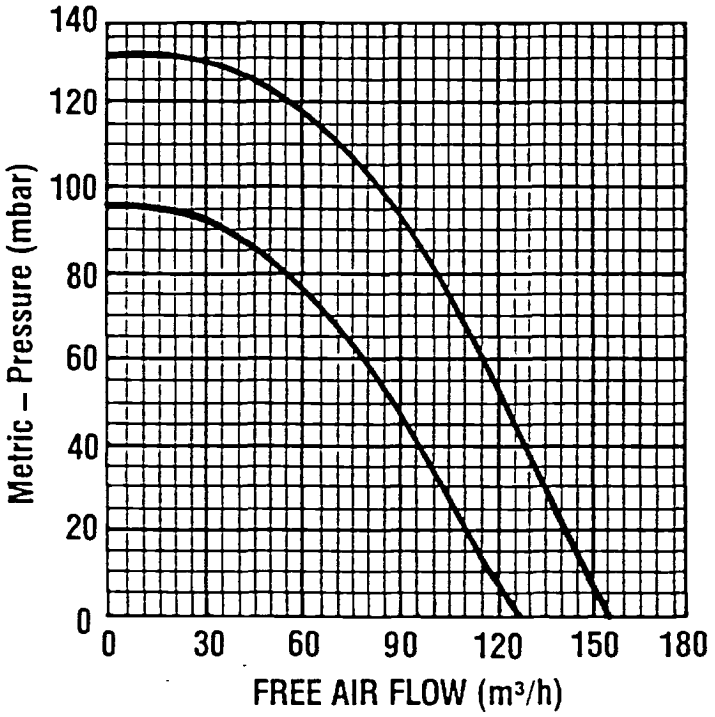


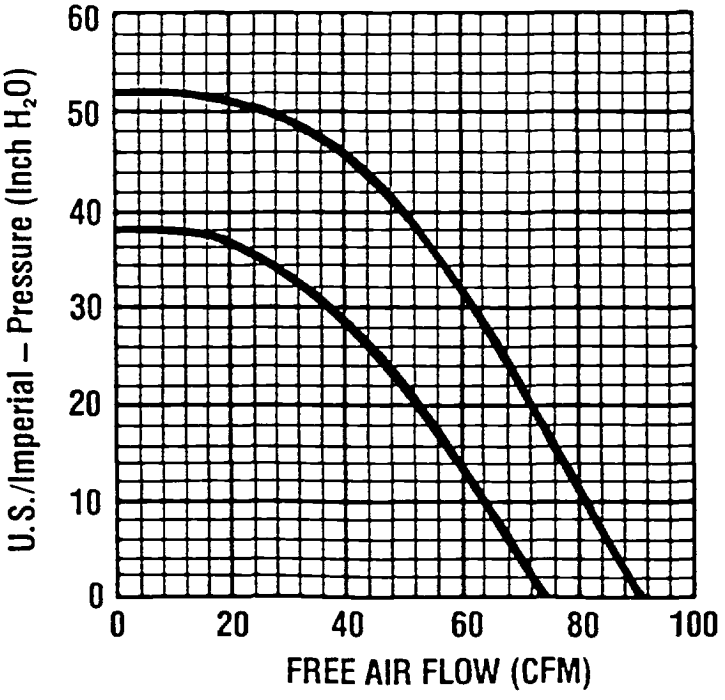
Product Specifications

Model Number	Motor Specs	Full Load Amps	HP	RPM	Max Pressure		Max Flow		Net Wt.	
					"H_2O	mbar	cfm	m³h	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.



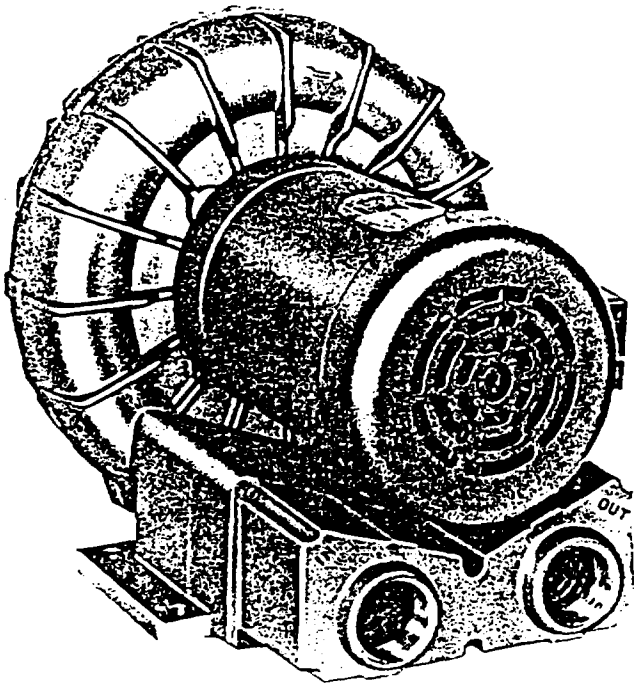


Oilless Regenerative Blowers, Motor Mounted to 160 cfm

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

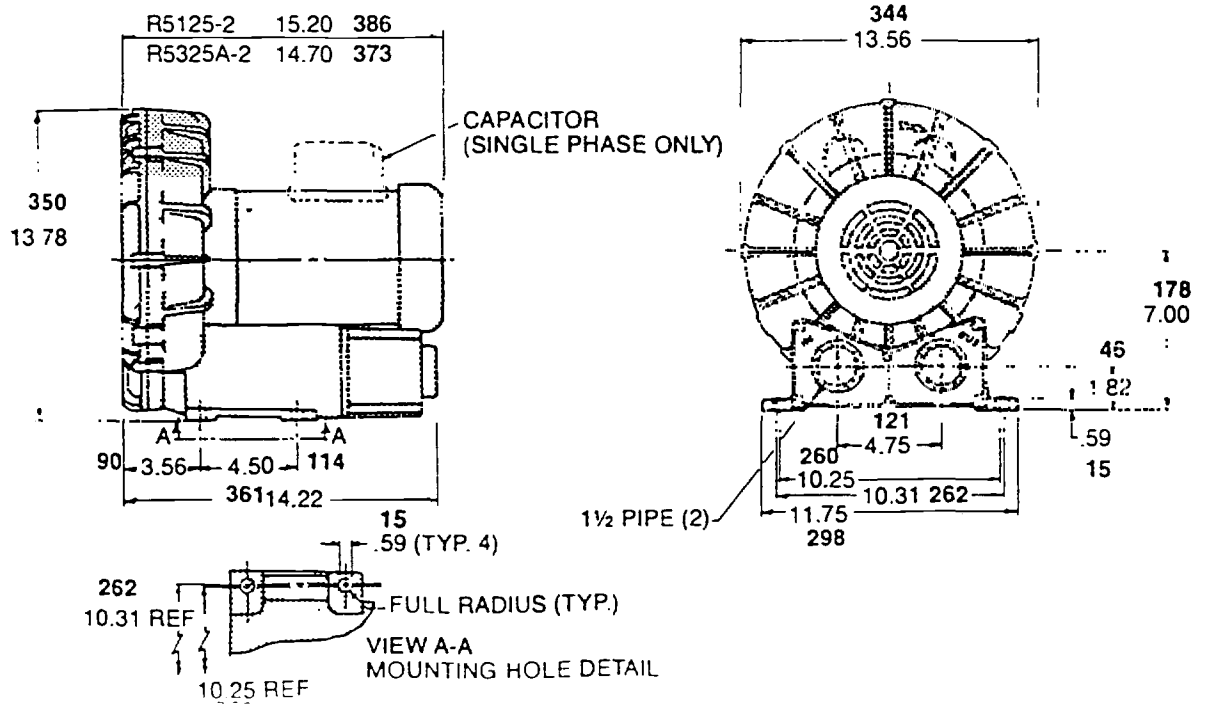
- Pressure gauge AE133
- Filter AG338
- Muffler AJ121D
- Relief valve AG258

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)

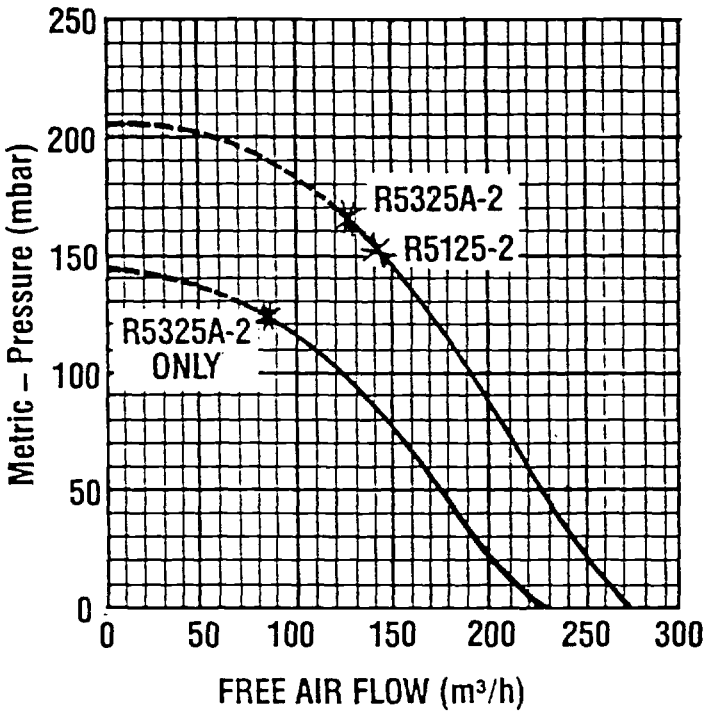


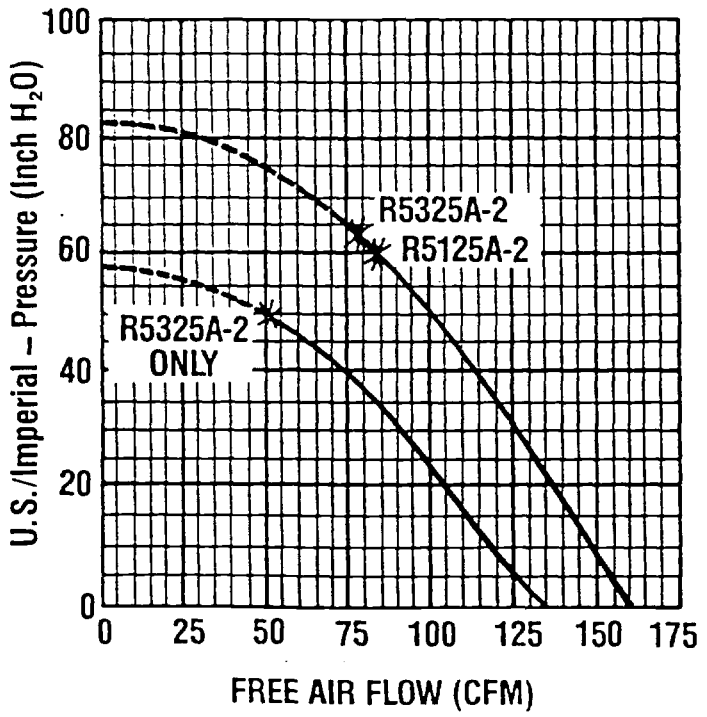
Product Specifications

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.





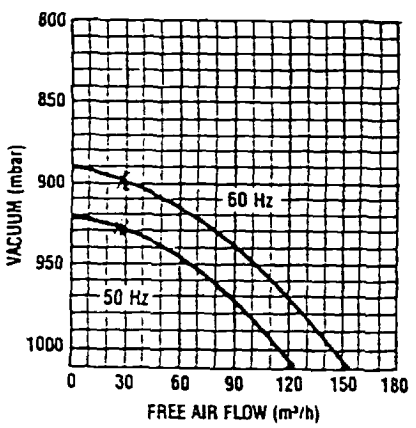
*Recommended maximum duty.
- - - - Intermittent duty only.

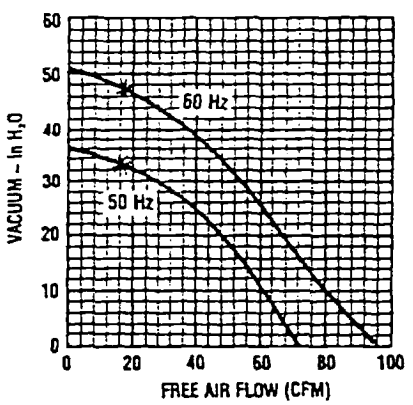
Model Number	Hz	Motor Specs	HP	RPM	Max Vac "H₂O	Max Vac mbar	Max Flow cfm	Max Flow m³h	Net Wt. lbs.	Net Wt. kg
R4110N-50	50	110/220-240-50-1	0.6	2850	35	924	72	122	60	28
	60	115/208-230-60-1	1.0	3450	48	895	88	150		
R4310P-50	50	220/380-50-3*	0.6	2850	35	924	72	122	58	27
	60	208-230/460-60-3*	1.0	3450	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.

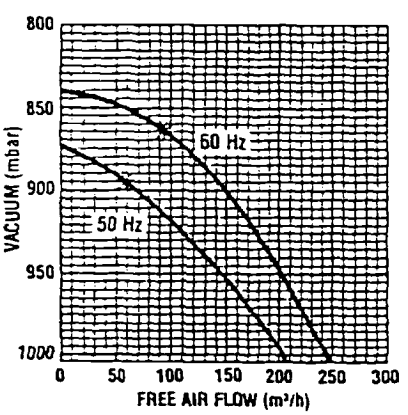
Product Performance (Metric U.S. Imperial)

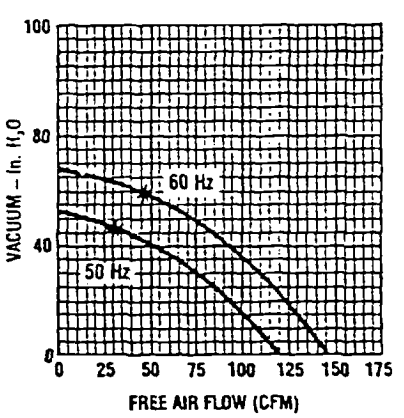
Model R4 Series



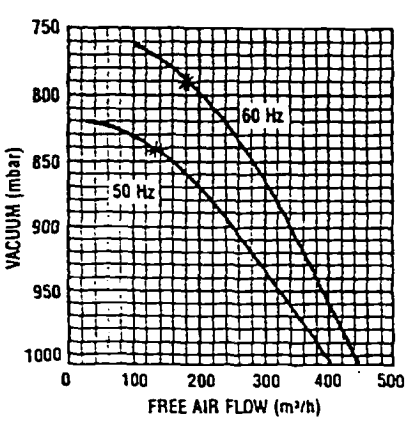


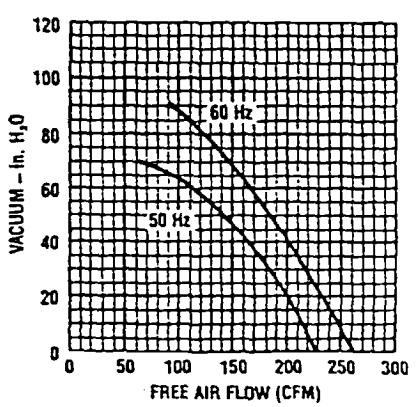
Model R5 Series





Model R6P Series

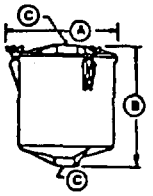




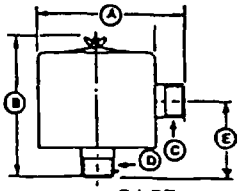
*Minimum flow permissible through the unit for trouble-free, continuous operation.

REGENAIR ACCESSORIES

Inline Filters (for vacuum)



R1-R3

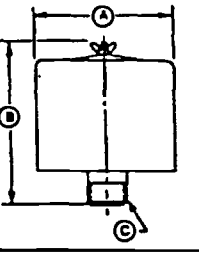


R4-R7

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

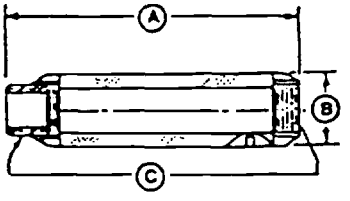
Inlet Filters (for pressure units only)



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

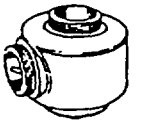
Vacuum Gauge, Part # #AJ497, 2 5/8" Diameter, 1/4" NPT, 0-60 inches H2O and 0-150 mbar

Vacuum Gauge, Part #AE134, 2 5/8", Diameter, 1/4" NPT, 0-160 inches H20 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

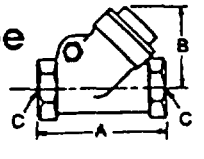
Relief Valve



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

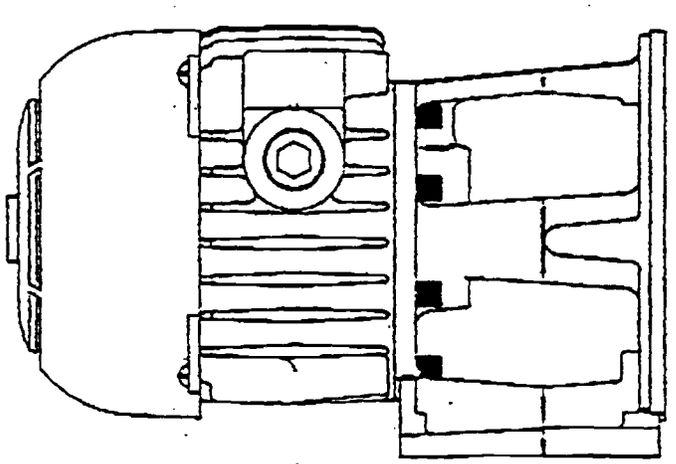
APPENDIX B
ROTARY-VANE BLOWER INFORMATION

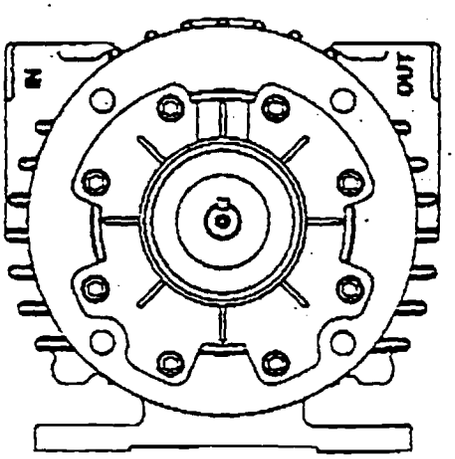
70-230
G360PL
153039

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

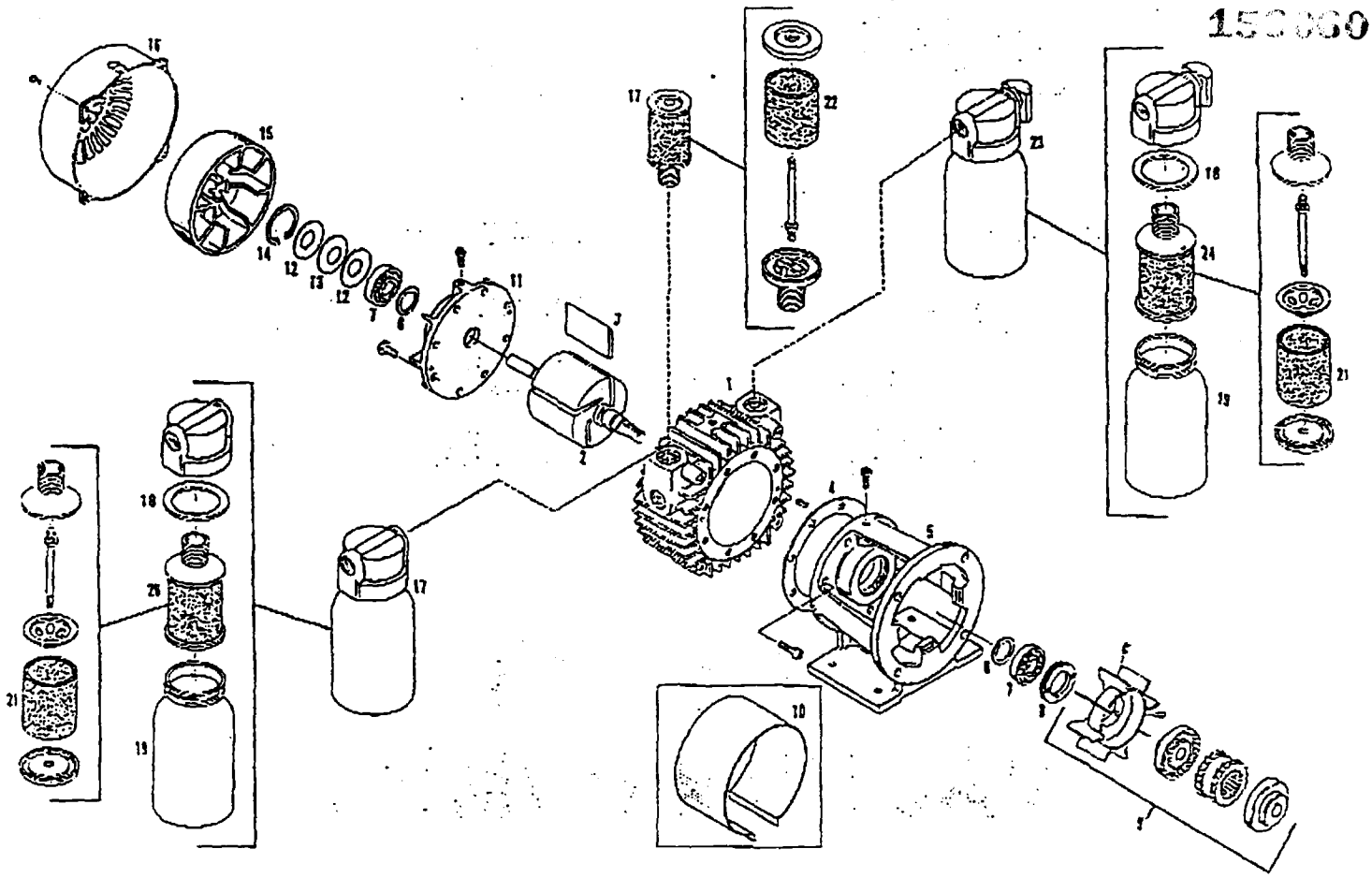
PARTS LIST and OPERATING INSTRUCTIONS
1067, 2067, and 2567

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—V103	1067—P102	2067-V103	2067-P102	2567-V103	2567-P107
1	Body	1	AH345	AH345	AH191	AH191	AH300	AH333
2	Rotor Assembly	1	AH428	AH428	AH192	AH192	AH192	AH192
* 3	Vane	4	AH430	AH430	AH195	AH195	AH195	AH195
* 4	Body Gasket	1	AH567	AH607	AH607	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	AA800C	AA905F	AA800D	AA905G	AA800D	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	AA800F		AA900F		AA900F	
24	Muffler Assembly	1	AC434-1		AC436-1		AC436-1	
	Service Kit		K306	K336	K350	K357	K300	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

Gast Manufacturing Co., Ltd.
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High Wycombe, Bucks HP12 3SN
England 23571
FAX 444-943-6588

Gast Manufacturing Corp.
2550 Meadowbrook Road
Benton Harbor MI 49022
616/926-6171
FAX 616-925-8288

Gast Manufacturing Corp.
505 Washington Ave.
Carlstadt NJ 07072
201/933-8484
FAX 201-933-5545

Brenner-Fiedler & Assoc.
13824 Bentley Place
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

CHECK VALVES—vacuum

	AE238	¼" NPT, male
	AJ550	¼" NPT, female
	AJ550A	⅜" NPT, female

CHECK VALVES—vacuum swing

	AH325A	¾" NPT
	AH325B	1" NPT

CORDS—ELECTRIC

	AA816	½" ⅓" ¾" hp, 115V without switch, 10 ft.
	AA818	½" ¾" hp, 230V without switch, 10 ft.
	AA696	⅛" ¼" ½" hp, 115 V with switch, 10 ft.

FILTERS—no jars

	AC432	⅜" female NPS, 10 m icron
	AC430	⅛" male NPS, 10 m icron
	AC435	¾" male NPS, 10 micron
	AA505E	⅜" female NPS, 50 micron
	AA505F	½" male NPS, 50 micron
	AA505G	¾" male NPS, 50 micron
	B300A	¼" male NPS, 50 micron
	B343B	½" male NPS, 50 micron
	AD750	1" male NPS, 50 micron

FILTERS—glass jar

	AA617G	½" NPS, 2 oz., 50 micron
	AA922H	¼" NPS, ¾" oz., 50 micron
	AD560	1" NPS, 2 qt., 50 micron
	AB599	⅜" NPS, 1 pt., 10 micron
	AB599D	⅜" NPS, 1 pt., 50 micron
	AB600	½" NPS, 1 pt., 50 micron
	AB600F	½" NPS, 1 pt., 10 micron
	AB601B	¾" NPS, 1 pt., 10 micron
	AB601C	¾" NPS, 1 pt., 50 micron
	AA600C	½" NPS, 1 qt., 10 micron
	AA600E	½" NPS, 1 qt., 50 micron
	AA900D	¾" NPS, 1 qt., 10 micron
	AA900J	¾" NPS, 1 qt., 50 micron
	V400G	¼" NPS, 8 oz., 50 micron
	V500D	⅜" NPS, 8 oz., 50 micron
	V400C	½" NPS, 8 oz., 50 micron

FILTERS—metal jar

	AB609D	¼" NPS, ½" pt., 10 micron
	AB612	½" NPS, ½" pt., 10 micron
	AB606B	¾" NPS, ½" pt., 10 micron
	AB609	¼" NPS, ½" pt., 50 micron
	AB608	⅜" NPS, ½" pt., 50 micron
	AB650C	¾" NPS, 1 qt., 10 micron
	AB650G	¾" NPS, 1 qt., 50 micron
	AB665	½" NPS, 1 qt., 50 micron
	AB665B	½" NPS, 1 qt., 10 micron

FILTERS—plastic jar

	AA922N	⅛" NPS, ¾" oz.
	V400M	¼" NPS, 8 oz.
	V500N	⅜" NPS, 8 oz.

FLUSHING SOLVENT

	AH255	1 qt.

FOOT SUPPORT ASSEMBLIES

	AC136	0211, 0322, 0522
	AE240	⅛"-¾" hp piston pumps
	AE241	½"-⅔" piston pumps
	AE245	⅛" hp piston pumps

GAUGES—pressure

	AA842	⅛" NPS, 0-30 psi
	AA542B	¼" NPS, 0-30 psi 0-2K/cm²
	AA806	¼" NPS, 0-160 psi (back mount)
	AA807	¼" NPS, 0-160 psi (back mount)
	AP563	¼" NPS, 0-100 psi, heavy duty (bottom mount)

GAUGES—vacuum

	AA540	¼" NPS, 0-30" Hg, 0-760 m/m Hg
	AA541	¼" NPS, 0-30" Hg

HANDLES—carrying

	AP333	for ½" and ¾" hp units

MUFFLERS—glass jar

	AB599B	⅜" NPS, 1 pt., 10 micron, for oil-less pumps
	AB600C	½" NPS, 1 pt., 50 micron, for oil-less pumps
	AB600J	½" NPS, 1 pt., 30 micron, for oil-less pumps
	AD560	1" NPS, 2 qt., 50 micron
	AB5608	1" NPS, 2 qt., 50 micron, with fining for quieter operation
	AA900F	¾" NPS, 1 qt., 10 micron, for oil-less pumps
	AA900G	¾" NPS, 1 qt., 50 micron, for oil-less pumps
	AA922B	¼" NPS, ¾" oz., 50 micron, for oil-less pumps
	AA922G	same as AA922 but with silencing tube
	AA617F	½" NPS, 2 oz., 50 micron, for oil-less pumps

MUFFLERS—metal jar

	AB612A	½" NPS, ½" pt., 10 micron
	AB609B	¼" NPS, ½" pt., 10 micron
	AB606A	⅜" 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.
	VS25G	⅜ 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
	AA205	¼" NPS, flow below 2 cfm
	AA500	⅜" NPS, flow below 10 cfm
	AA307	¾" NPS, flow above 10 cfm
	AP570S	¼" NPS, 0-100 psi
	AP730	¼" NPT, 0-100 psi
	AE960	1" NPT, 0-100 psi

RELIEF VALVES—vacuum

	AA204	⅛" NPS, flow below 2 cfm
	AA207	¼" NPS, flow below 2 cfm
	AA540A	⅜" NPS, flow from 2-15 cfm
	AA308	¾" NPS, flow above 10 cfm
	AE961	1" NPS, for 4565, 5565

SWITCH—vacuum

	AE265	¼" NPS

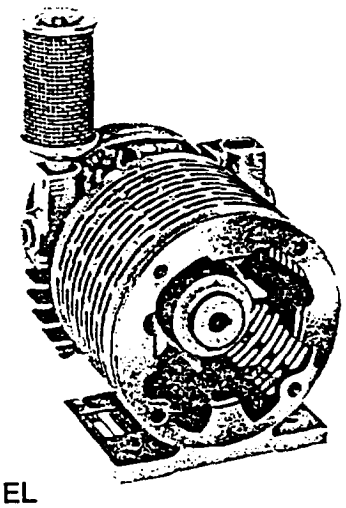
TRAPS—vacuum

	AA673	⅛" NPS, 8 oz.
	AA675B	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	

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)

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

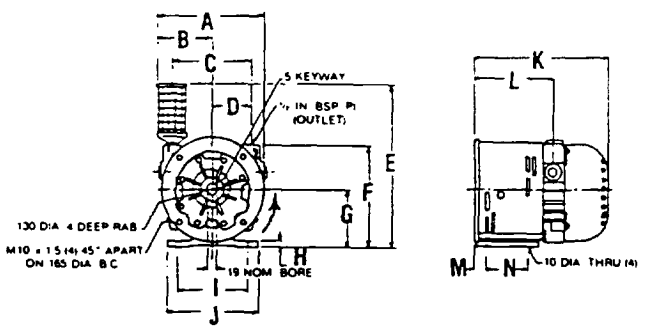
Dimensions for reference only.

Important Notice:

Pictorial and dimensional data is subject to change without notice.

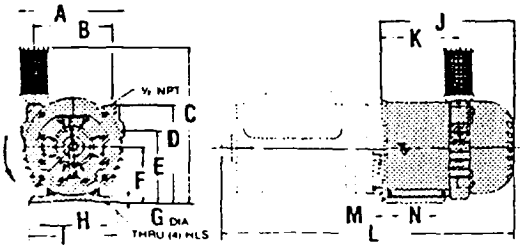
METRIC MODEL

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

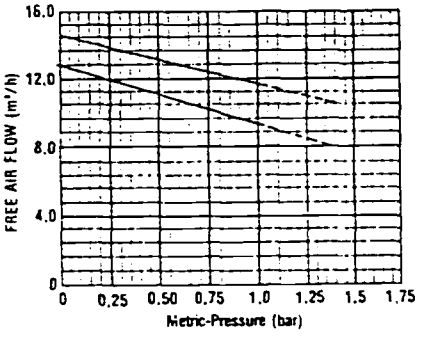
Model Number	Motor	RPM		HP	kW	Net Wt.	
		60 cycle	50 cycle			lbs.	kg
1067-P102	Not included	1725	1425	1	0,75	34	15,40
1067-P104 (metric)	Not included	1725	1425	1	0,75	34	15,40
†1067-P106-G561X (like 1067-P102 plus motor)	110/220-240; 115/208-230; 50/60-1	1725	–	1	0,75	65	29,5
2067-P102	Not included	1725	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

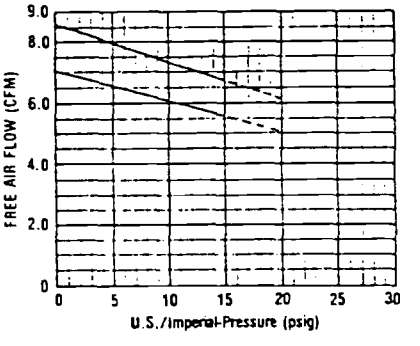
†Motor includes Thermotector.

Product Performance (Metric U.S. Imperial)

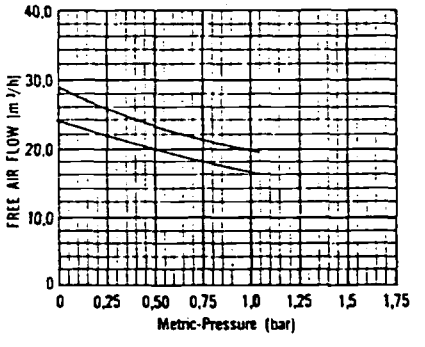
Black line on curve is for 60 cycle performance.
Blue line on curve is for 50 cycle performance.

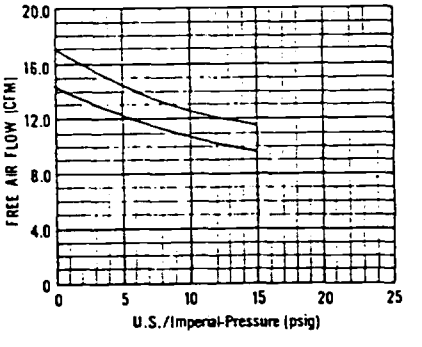
Model 1067



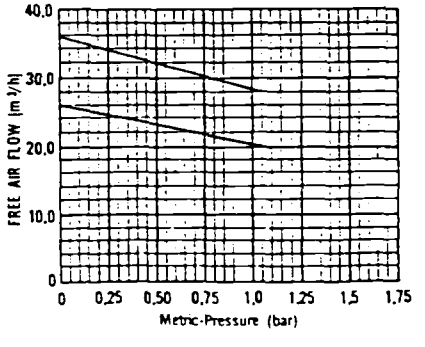


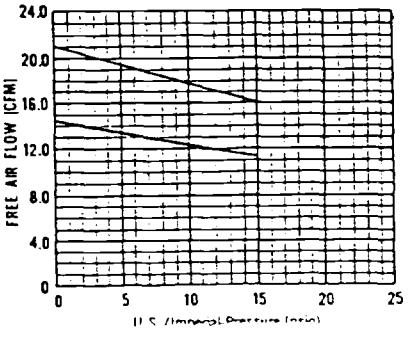
Model 2067





Model 2567





BLOWER EXTRACTION SYSTEM DATA COLLECTION SHEET

SITE:_____

DATE	TIME	INLET VACUUM 1 (IN. WATER) a/	INLET TEMP. (DEGREES F) a/	INLET VACUUM 2 (IN. WATER) b/	OUTLET TEMP. (DEGREES F) c/	FILTER CHANGED (Y or N)	BLOWER FUNCTIONING UPON ARRIVAL (Y or N)	COMMENTS	CHECKED BY

a/ Gauge is located between the well and the air filter.

b/ Gauge is located between the air filter and the blower unit.

c/ Gauge is located on the blower outlet piping.

BLOWER INJECTION SYSTEM DATA COLLECTION SHEET

SITE:_____

DATE	TIME	INLET VACUUM (IN. WATER)	OUTLET TEMP. (DEGREES F)	OUTLET PRESSURE (IN. WATER)	FILTER CHANGED (Y or N)	BLOWER FUNCTIONING UPON ARRIVAL (Y or N)	COMMENTS	CHECKED BY

SHEET OF

DRILL LOG

CLIENT Carswell AFB WELL OR BORING NUMBER VW1SB

PROJECT Bioventing LOCATION POL Fuel Loading

DRILLING FIRM Profile G.L. ELEVATION _____ LOGGER BRV

DRILLING RIG CME 75 HSA RIG OPERATOR Tom Placek

BEGINNING 5/25/93 AND END OF DRILLING AND CONSTRUCTION OPERATION 5/25/93

GROUNDWATER LEVEL FIRST ENCOUNTERED _____ AND FINAL _____

DATE: ( ) ( )

DEPTH IN FEET	SAMPLING INTERVAL	GRAPHIC LOG	LITHOLOGIC AMD CHARACTERISTIC DESCRIPTION	REMARKS LO. NO. OF SAMPLE TAKEN / RECOVERY (FEET) / OVA READING (PPM)
	0-2'	0-3½ split barrel sample - Full recovery	Fill No recovery Clay, dark brownish black some odors, damp, some small gravel.	split spoon, no recovery
	0-3½'		Fill/gravel No recovery	split spoon 4000 ppm clean hole
			Olive gray, clay, some fine sand damp, few gr small gravel.	Headspace @ 3' = > 5000 ppm
5	3½-8½	Full recovery		sample collected at 5-6' for BTEX & TPH 5
		sandy clay	light gray	Headspace @ 8½' = 5000 ppm
		3' recovery 8½-11½	Olive (mottled) damp clay, some nodules.	
10	8½-11½		No headspace sample collected due to hydrocarbons	sample collected at 10-11' for All analysis nutrients. 10
	11½-16½	5' recovery	@ 11' sandy clay (medium sand) moist. Light olive gray	
			11½' light olive gray medium to coarse sand with small gravel. saturated.	gravel 15½-16'
15				15
20				20
25				25

SHEET OF

DRILL LOG

CLIENT _____ WELL OR BORING NUMBER MPA 1 of 2

PROJECT Bioventing LOCATION POL Tank Farm, Fuel loading

DRILLING FIRM Profile G.L. ELEVATION _____ LOGGER BRV

DRILLING RIG CME 75 HSA RIG OPERATOR Tom Placek.

BEGINNING 5/25/93 AND END OF DRILLING AND CONSTRUCTION OPERATION 5/25/93

GROUNDWATER LEVEL FIRST ENCOUNTERED _____ AND FINAL _____

DATE: ( ) ( )

DEPTH IN FEET	SAMPLING INTERVAL	GRAPHIC LOG	LITHOLOGIC AMD CHARACTERISTIC DESCRIPTION	REMARKS LD. NO. OF SAMPLE TAKEN / RECOVERY (FEET) / OVA READING (PPM)
	0-2'	100% recovery	Olive black clay, light odors Few clay films. dry to damp	OVA scan = <50 ppm
	2-4'	100% recovery	olive gray clay, light odors some small nodules.	scan 50-200 ppm
5	3½-8½'	100% recovery	Black highly plastic clay large gravel (Fill) from 3½-5' damp.	OVA scan 5 50-250 ppm
			Light olive gray, dry to damp clay few small nodules. slight mottling	5000 ppm scan at 9½'
10	8½-13½'		light gray Fine sandy clay, moist odors	~~500-1000~~ ppm 10
			light olive gray to olive at 13½'. ~~clay~~ sandy clay and clay interbed damp	500-1000 4000 @ 13'
			clayey sand, light olivegray at 13'. TD 13.5'.	
15				15
20				20
25				25

SHEET OF

DRILL LOG

150071

CLIENT Carswell AFB — WELL OR BORING NUMBER MPB

PROJECT Biovent Test system — LOCATION POL Tank Farm, Fuel loading area

DRILLING FIRM Profile Field Services — G.L. ELEVATION _____ — LOGGER BRV

DRILLING RIG CME 75 HSA — RIG OPERATOR Tom Placek

BEGINNING 5/26/93 AND END OF DRILLING AND CONSTRUCTION OPERATION _____

GROUNDWATER LEVEL FIRST ENCOUNTERED 11.5' AND FINAL _____

DATE: ( ) ( )

DEPTH IN FEET	SAMPLING INTERVAL	GRAPHIC LOG	LITHOLOGIC AND CHARACTERISTIC DESCRIPTION	REMARKS: I.D. NO. OF SAMPLE TAKEN / RECOVERY (FEET) / OVA READING (PPM)
0	0-2'	No	Fill material, highly plastic black clay with large gravel Fill.	No recovery pushed shelby tube 1-3'.
5	3½-8½'		olive black, highly plastic clay w/ med to large gravel (fill), damp (oily)	odors, 5
			olive gray ~~sandy~~ clay with little fine sand, few nodules (small) damp, plastic.	increasing odors Headspace @ 7' = >5000 ppm
10	8½-11½'		light olive gray to olive sandy clay (fine sand) moist to wet at 11½'. plastic soils	Headspace @ 10' = >5000 ppm 10
15			TD ~~11.5'~~ BRV 11.2' TD tagged	15
20				20
25				25

SHEET OF

DRILL LOG

CLIENT Carswell AFB WELL OR BORING NUMBER MPC

PROJECT Bioventing system LOCATION Fuel loading area, POL

DRILLING FIRM Profile G.L. ELEVATION _____ LOGGER BRV

DRILLING RIG CME 75 HSA RIG OPERATOR Tom Placek

BEGINNING 5/26/93 AND END OF DRILLING AND CONSTRUCTION OPERATION _____

GROUNDWATER LEVEL FIRST ENCOUNTERED _____ AND FINAL _____

DATE: ( ) ( )

DEPTH IN FEET	SAMPLING INTERVAL	GRAPHIC LOG	LITHOLOGIC AMD CHARACTERISTIC DESCRIPTION	REMARKS I.D. NO. OF SAMPLE TAKEN / RECOVERY (FEET) / OVA READING (PPM)
	0-2'	2' recovery	Brownish black clay with few small to medium gravel. damp	odors OVA Scan = 500 ppm
	2-4'	1½' recovery	olive gray silty clay, few small nodules, dry to damp. weak moderate structure	odors OVA Scan = 2000 ppm
5	3½-8½	4.2' recovery	olive black & olive gray clay very firm & plastic, damp. heavy odors. medium to large gravel from 3½ - 5'.	OVA scan = 2000 ppm
	8½- 12'	4' recovery	light olive gray silty clay,	OVA
10			light olive gray fine sandy clay/ somewhat mottled plasticity is high strong odors, damp to moist.	OVA = 3000 ppm
			light olive gray clayey fine sand, moist	heavy odors
			TD = 12.2'	
15				
20				
25				

SHEET 01

DRILL LOG (SB1)

CLIENT Carswell AFB — WELL OR BORING NUMBER MPBG1

PROJECT Bioventing Test system — LOCATION Fuel loading area (POL) — 15C073

DRILLING FIRM Parratt Field Services — G.L ELEVATION _____ — LOGGER BRW

DRILLING RIG CME 75 HSA — RIG OPERATOR Tom Placek

BEGINNING 5/28/93 AND END OF DRILLING AND CONSTRUCTION OPERATION _____

GROUNDWATER LEVEL FIRST ENCOUNTERED _____ AND FINAL _____

DATE: ( ) ( )

DEPTH IN FEET	SAMPLING INTERVAL	GRAPHIC LOG	LITHOLOGIC AMD CHARACTERISTIC DESCRIPTION	REMARKS I.D. NO. OF SAMPLE TAKEN / RECOVERY (FEET) / OVA READING (PPM)
	0-2'	1½' recovery	light brown silty clay with small to med gravel & nodules. dry to damp. no odors	
	2-4		olive black clay, few small nodules. damp. hydrocarbon odors.	Headspace @ 3' = 5000 ppm scan = 200 ppm
5	3½-8½	3' recovery	light brown & Black highly plastic clay with small to medium gravel. dry to damp	5
			light olive grey fine sandy clay with few small nodules and gravel. damp.	Headspace at 7' = 400-300 ppm scan odors.
10	8½-12½'	2½' recovery	Same as above	10
			light gray clayey sand (fine) moist to wet at bottom. strong odors	sample for BTEX TAH @ 10-11'. OVA scan = 4500 ppm
			H_2O at 12'.	
15				15
20				20
25				25

DRILL LOG

CLIENT Carswell AFB
WELL OR BORING NUMBER MP BG2
PROJECT ST14 Bioventing
LOCATION POL Farm, near warehouse
DRILLING FIRM Env Profile
G.L. ELEVATION
LOGGER BRV
DRILLING RIG CME 75 HSA
RIG OPERATOR Tom Placek
BEGINNING 6/15/93 AND END OF DRILLING AND CONSTRUCTION OPERATION 6/15/93
GROUNDWATER LEVEL FIRST ENCOUNTERED AND FINAL
DATE: ( ) ( )

DEPTH IN FEET	SAMPLING INTERVAL	GRAPHIC LOG	LITHOLOGIC AND CHARACTERISTIC DESCRIPTION	REMARKS: LO. NO. OF SAMPLE TAKEN / RECOVERY (FEET) / OVA READING (PPM)
	0-2	6" recovery	small gravel, loam, sand	
	2-4'	6" recovery	Silty clay with some small to medium, dark brown	OVA scan = 0 ppm
5	3½-8½	3.25' recovery	dark olive gray silty clay w/ small to med. gravel. very firm clayey.	headspace @ 6' = 0.5 ppm
			light olive gray fine sandy clay. clayey.	OVA scan = 0 ppm
10	8½-12	4.0' recovery	light olive gray fine sandy clay, highly plastic and moist. wet @ 12'. No odors.	OVA scan = 0 ppm 10 sample MPBG-2-12 collected from 10-12'. headspace @ 10' = 0.0 ppm
			12' TD.	
15				15
20				20
25				25

Engineering-Science Inc.
7800 Shoal Creek Blvd, Suite 222W
Austin, Texas 78757
512/467-6200 FAX 512/467-7044

CHAIN OF CUSTODY RECORD

Kjordahl

PROJECT NO.	PROJECT NAME	NO. OF CONTAINERS	Analysis Required									REMARKS
AU380.01	Carswell Bioventing System		TRPH (EPA 418.1)	BTEX (EPA 8020)	TPH (EPA 8015 Mod)	PAH (EPA 8310)	Pesticides (EPA 8080)	Herbicides (EPA 8150)	Priority Pollutant Metals			
SAMPLERS (Signatures) Brian Vandyke												

DATE	TIME	MATRIX	SAMPLE IDENTIFICATION										
5/26/93	1700	Soil	MPC 6-7		X	X							2 drums fuel odors
5/26/93	1700	Soil	MPC 10-11		X	X	X	X	X	X	X	X	3 drums fuel odors with diesel range smell

Relinquished by: (Signature)	Date	Time	Received by: (Signature)	Relinquished by: (Signature)	Date	Time	Received by: (Signature)
Brian Vandyke	5/26/93	1915					
Relinquished by: (Signature)	Date	Time	Received by: (Signature)	Relinquished by: (Signature)	Date	Time	Received by: (Signature)

White: laboratory returns with data, **yellow**: laboratory copy, **pink**: sampler copy

5 of 21

Engineering-Science Inc.
7800 Shoal Creek Blvd, Suite 222W
Austin, Texas 78757
512/467-6200 FAX 512/467-7044

CHAIN OF CUSTODY RECORD

PROJECT NO.: AU380.01

PROJECT NAME: Carswell Bioventing [illegible]

SAMPLERS (Signatures): Brian Vanderglas [signature]

DATE	TIME	MATRIX	SAMPLE IDENTIFICATION	NO. OF CONTAINERS	Analysis Required: [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	REMARKS
5/25/93	0910	Soil	[illegible] VW1 [illegible]	2	X	X									High organic vapor readings on OVA (rows 1–3)
5/25/93	1020	Soil	[illegible] VW1 [illegible] 11	2	X	X	X	X	X	X	X	X	X		
5/25/93	1440	Soil	MPA 9-10	2	X	X	X	X	X	X	X	X	X		
5/26/93	0910	Soil	MPB 9-10	2	X	X	X	X	X	X	X	X			High OVA readings, odors
5/26/93	~~09~~ 1410	Soil	MPBA1 [illegible] 11	2	X	X									High OVA Readings (odors)

Relinquished by: (Signature)	Date	Time	Received by: (Signature)	Relinquished by: (Signature)	Date	Time	Received by: (Signature)
Marc Harder	5/26/1993	1435	[illegible signature]				

White: laboratory returns with data, **yellow**: laboratory copy, **pink**: sampler copy

1500?7

CHAIN OF CUSTODY RECORD — NDRC LABORATORIES, INC. — 1000 East Collins Blvd., Richardson, TX 75... (214, ...-559

Submitted by	Bill to
Name: Engineering Science	Name: [illegible]
Address: 7800 Shoal Creek Blvd #202W, Austin TX 78757	Address:
Contact: Brian Vanderglas	Contact:
Phone: 512/467 6200	Phone:
Fax: 512/467-7014	Fax:
	PO/SO #: AU280.01

Lab use only
Due Date:

RCRA ☐
NPDES ☐
Section / Date

Proj. No.	Project Name
AU280.01	Carswell AFB Bioventing Pilot Study

Matrix[1]	Date	Time	Comp	Grab	Identifying Marks	No. of Containers[2] VOA	A/G 1 Lt.	250 ml	P/O	TRPH & Particle Size Analysis	BTEX (EPA 8020)	Soil Moisture	pH	Total Plate Count	Alkalinity	Nitrogen (TKN)	Phosphorous	Lab. Sample ID
Soil	6/15/93	1025		✓	MPE62: 10'				2	✓	✓	✓	✓	✓	✓	✓	✓	
Soil	6/15/93	1415		✓	VW2: 10-11				2	✓	✓	✓	✓	✓	✓	✓	✓	
Soil	6/16/93	0830		✓	VW3: 7-8				2	✓	✓	✓	✓	✓	✓	✓	✓	
Soil	6/16/93	0850		✓	VW3: 10-11				2	✓	✓							
Soil	6/16/93	1145		✓	VW4: 10-11				2	✓	✓	✓	✓	✓	✓	✓	✓	

Turn around time ☐ 100% ☐ 50% ☑ Standard Other: _____ Temperature °C: _____

Relinquished by: (Signature)	Date:	Time:	Received by: (Signature)	Date:	Time:
Brian Vanderglas	6/16/93	1:50	[illegible]		
Relinquished by: (Signature)	Date:	Time:	Received by: (Signature)	Date:	Time:
Relinquished by: (Signature)	Date:	Time:	Received by: (Signature)	Date:	Time:

Remarks: High organic vapor readings measured on all samples with OVA.

By submitting these samples, you agree to the terms and conditions contained in NDRC's Price Schedule.

[1] Matrix W - Water S - Soil SD - Solid L - Liquid A - Air Bag C - Charcoal tube SL - Sludge O - Oil
[2] Container VOA - 40 ml vial A/G - Amber / Or Glass 1 Liter 250 ml - Glass wide mouth P/O - Plastic or other _____

NDRC cannot accept verbal changes. Please Fax written changes to

Airbill # 32 814160 1974

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

Page 1 of 1

PROJECT # AU380.01 / 380 PO # Concord AFB Permit COLLECTED BY (Signature) Brian Vandeff

REMARKS Send results to Brian Vandeff, Radian Corporation, 8501 Shoal Creek Blvd, Ste 1220W Austin, TX 78757 (512) 467-1100 ext Engineering Services

FIELD SAMPLE I.D.#	SAMPLING MEDIA (Tenax, Canister etc.)	DATE/TIME	ANALYSIS	VAC./PRESSURE	LAB I.D. #
ST14 - VW	Canister # 12387	6/9/93 1445	TO-3		
ST14 - MPA 1	Canister # 12360	6/9/93 1500	TO-3		
ST14 MPC 7	Canister # 11442	6/9/93 1518	TO-3		

RELINQUISHED BY: DATE/TIME	RECEIVED BY: DATE/TIME	RELINQUISHED BY: DATE/TIME	RECEIVED BY: DATE/TIME
Brian Vandeff 6/10/93 1625	Federal Express		

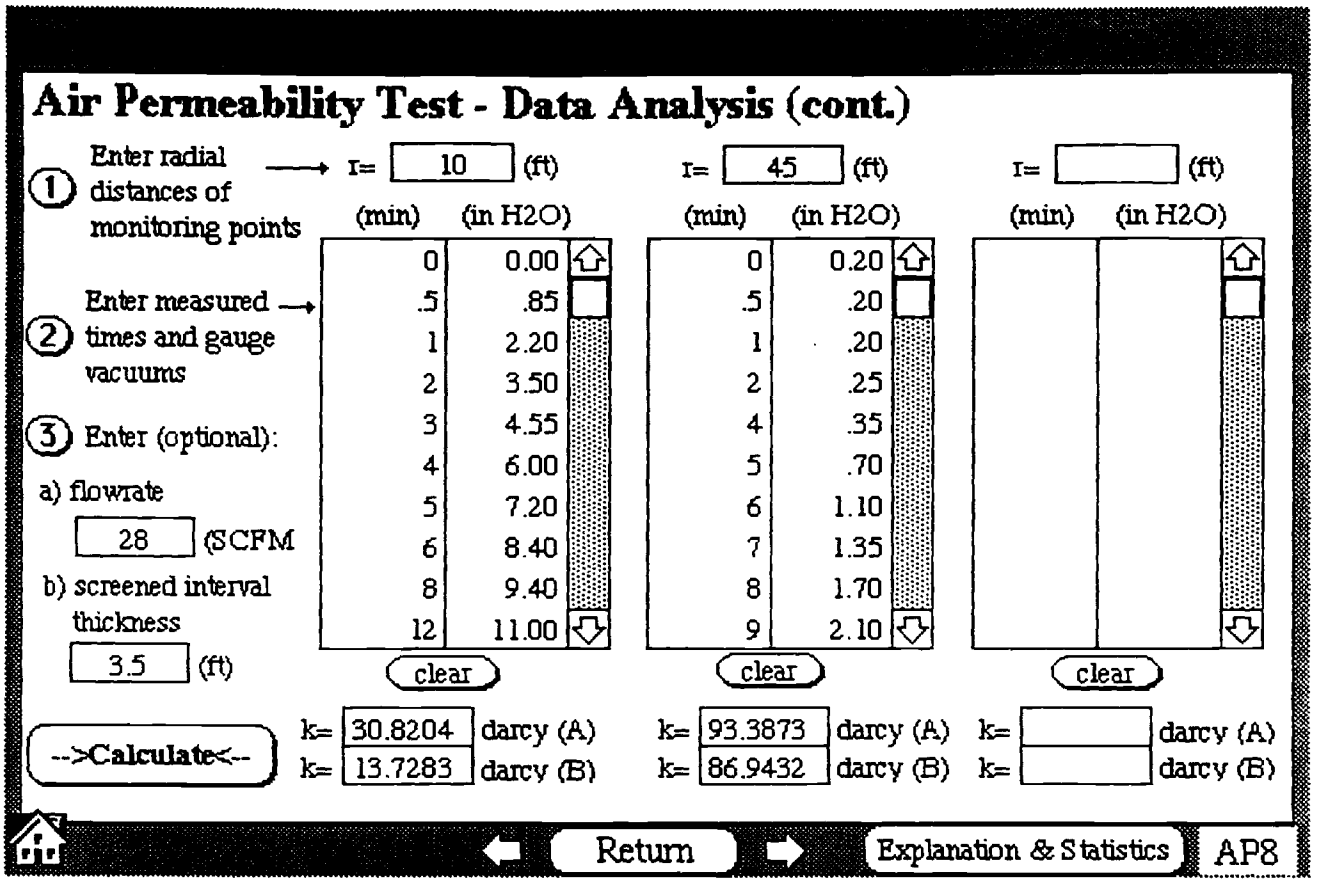
LAB USE ONLY

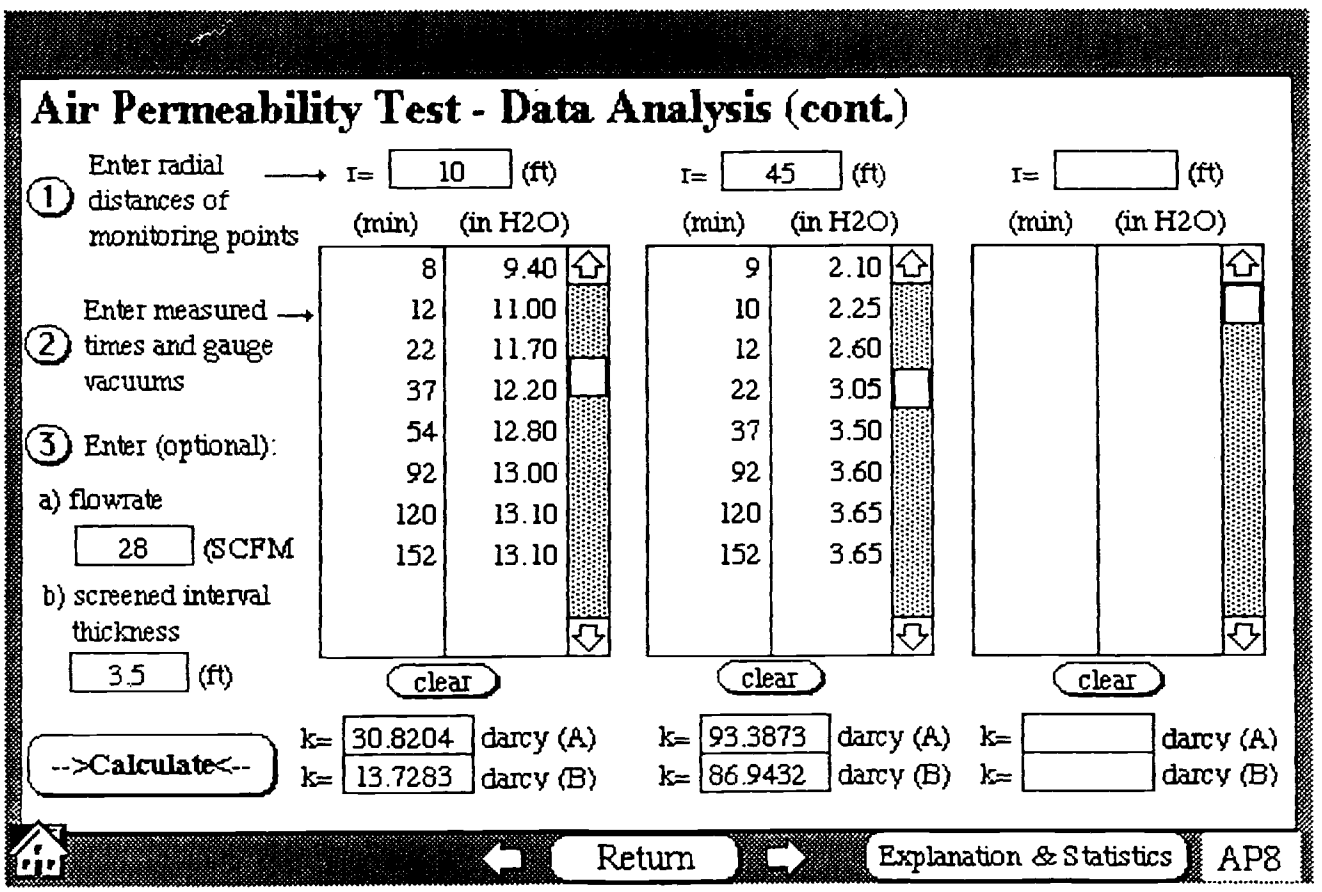
SHIPPER NAME	AIR BILL #	OPENED BY: DATE/TIME	TEMP(°C)	CONDITION

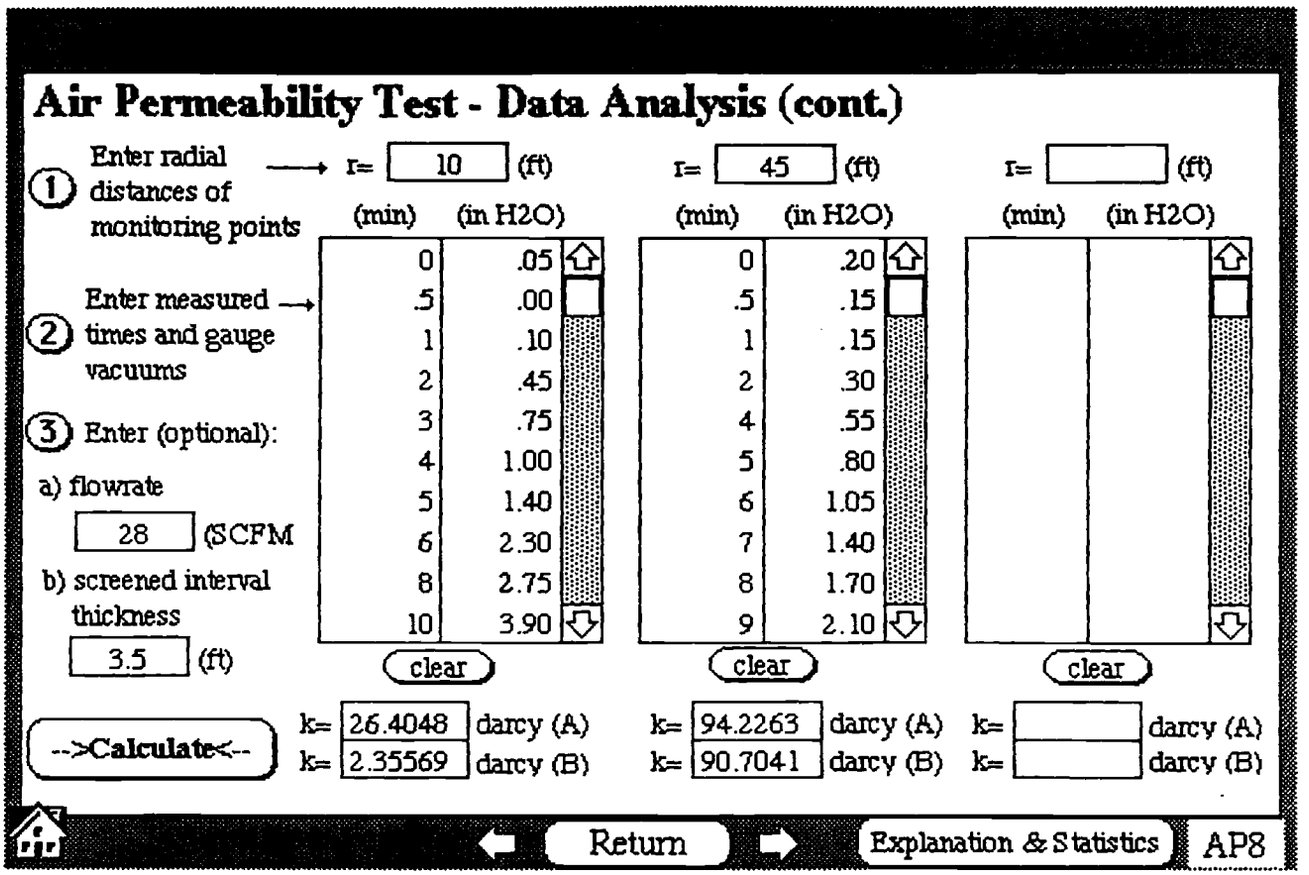
REMARKS

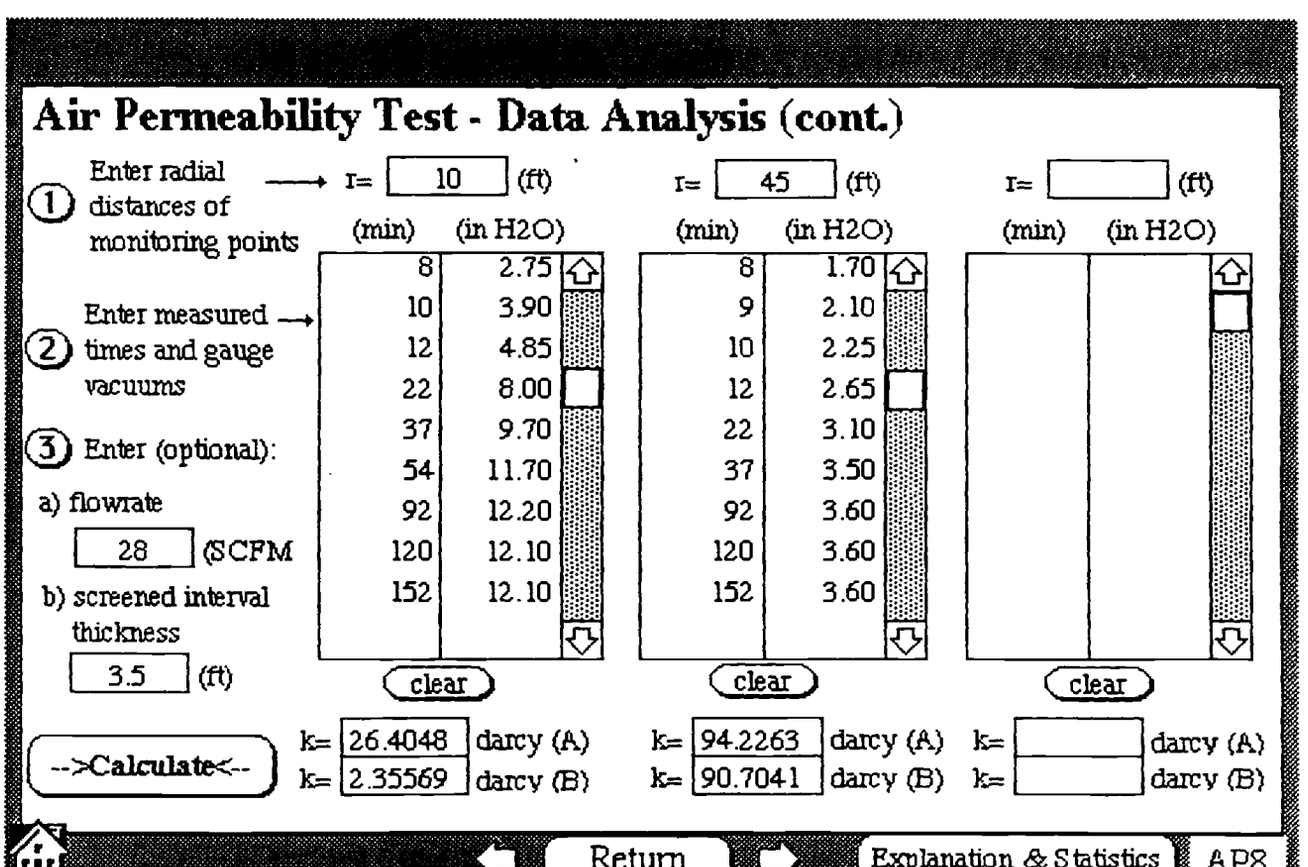
Appendix D

HyperVentilate® Air Permeability Calculation Cards


Air Permeability Test - Data Analysis (cont.)
1 Enter radial distances of monitoring points
r= 10 (ft)
r= 45 (ft)
r= (ft)
(min) (in H2O)
0 0.00
.5 .85
1 2.20
2 3.50
3 4.55
4 6.00
5 7.20
6 8.40
8 9.40
12 11.00
clear
(min) (in H2O)
0 0.20
.5 .20
1 .20
2 .25
4 .35
5 .70
6 1.10
7 1.35
8 1.70
9 2.10
clear
(min) (in H2O)
clear
2 Enter measured times and gauge vacuums
3 Enter (optional):
a) flowrate
28 (SCFM
b) screened interval thickness
3.5 (ft)
-->Calculate<--
k= 30.8204 darcy (A)
k= 13.7283 darcy (B)
k= 93.3873 darcy (A)
k= 86.9432 darcy (B)
k= darcy (A)
k= darcy (B)
Return
Explanation & Statistics
AP8


Air Permeability Test - Data Analysis (cont.)
1 Enter radial distances of monitoring points
r= 10 (ft)
r= 45 (ft)
r= (ft)
(min) (in H2O)
8 9.40
12 11.00
22 11.70
37 12.20
54 12.80
92 13.00
120 13.10
152 13.10
clear
(min) (in H2O)
9 2.10
10 2.25
12 2.60
22 3.05
37 3.50
92 3.60
120 3.65
152 3.65
clear
(min) (in H2O)
clear
2 Enter measured times and gauge vacuums
3 Enter (optional):
a) flowrate
28 (SCFM
b) screened interval thickness
3.5 (ft)
-->Calculate<--
k= 30.8204 darcy (A)
k= 13.7283 darcy (B)
k= 93.3873 darcy (A)
k= 86.9432 darcy (B)
k= darcy (A)
k= darcy (B)
Return
Explanation & Statistics
AP8


Air Permeability Test - Data Analysis (cont.)
1 Enter radial distances of monitoring points
r= 10 (ft)
r= 45 (ft)
r= (ft)
(min) (in H2O)
2 Enter measured times and gauge vacuums
3 Enter (optional):
a) flowrate
28 (SCFM
b) screened interval thickness
3.5 (ft)
0 .05
.5 .00
1 .10
2 .45
3 .75
4 1.00
5 1.40
6 2.30
8 2.75
10 3.90
0 .20
.5 .15
1 .15
2 .30
4 .55
5 .80
6 1.05
7 1.40
8 1.70
9 2.10
clear
clear
clear
-->Calculate<--
k= 26.4048 darcy (A)
k= 2.35569 darcy (B)
k= 94.2263 darcy (A)
k= 90.7041 darcy (B)
k= darcy (A)
k= darcy (B)
Return
Explanation & Statistics
AP8


Air Permeability Test - Data Analysis (cont.)
1 Enter radial distances of monitoring points
r= 10 (ft)
r= 45 (ft)
r= (ft)
(min) (in H2O)
2 Enter measured times and gauge vacuums
3 Enter (optional):
a) flowrate
28 (SCFM
b) screened interval thickness
3.5 (ft)
8 2.75
10 3.90
12 4.85
22 8.00
37 9.70
54 11.70
92 12.20
120 12.10
152 12.10
8 1.70
9 2.10
10 2.25
12 2.65
22 3.10
37 3.50
92 3.60
120 3.60
152 3.60
clear
clear
clear
-->Calculate<--
k= 26.4048 darcy (A)
k= 2.35569 darcy (B)
k= 94.2263 darcy (A)
k= 90.7041 darcy (B)
k= darcy (A)
k= darcy (B)
Return
Explanation & Statistics
AP8

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