

US EPA ARCHIVE DOCUMENT



UniFirst Corporation
68 Jonspin Road
Wilmington, MA 01887
Phone: 978-658-8888

Via FedEx

May 2, 2014

Joseph LeMay, Remedial Project Manager
USEPA, Office of Site Remediation and Restoration
5 Post Office Square, Suite 100
Boston, MA 02109-3912

**Re: Soil Vapor Extraction System Design Report, UniFirst Property
Wells G&H Superfund Site, Woburn, Massachusetts**

Dear Joe:

The Johnson Company, Inc., on behalf of UniFirst Corporation, has prepared the attached *Soil Vapor Extraction System Design Report* utilizing data collected during the 2012 vapor extraction pilot test at the UniFirst Property in Woburn, Massachusetts.

Please contact me if you have any questions regarding the attached report.

Sincerely,

A handwritten signature in blue ink, appearing to read "Timothy Cosgrave".

Timothy Cosgrave
Senior Manager, EHS
UniFirst Project Coordinator

Attachment – Soil Vapor Extraction System Design Report

cc:
Cindy Lewis, USEPA
Dave Sullivan, TRC
Joseph Coyne, MassDEP
Greg Bibler, Goodwin Procter
Bernie Kueper, B. Kueper & Associates
Bettina Longino, The Johnson Company

SOIL VAPOR EXTRACTION SYSTEM DESIGN REPORT

**UniFirst Property
Wells G&H Superfund Site
Woburn, Massachusetts**

May 2014

Submitted To:

**United States Environmental Protection Agency
Region 1**

5 Post Office Square, Suite 100
Boston, Massachusetts 02109-3912

Prepared for:

UniFirst Corporation

68 Jonspin Road
Wilmington, Massachusetts 01887

Prepared by:

The Johnson Company, Inc.

100 State Street Suite 600
Montpelier, VT 05602



ENVIRONMENTAL SCIENCE AND
ENGINEERING SOLUTIONS

PARTNERS FOR SMART THINKING
AND CREATIVE STRATEGIES

TABLE OF CONTENTS

1.0 INTRODUCTION	1
2.0 PILOT TEST SUMMARY AND BASIS OF DESIGN	1
2.1. PILOT TEST PROGRAM SUMMARY	2
2.2. BASIS OF DESIGN	4
3.0 FULL-SCALE DESIGN OVERVIEW	6
3.1. SOIL VAPOR EXTRACTION POINTS AND CONVEYANCE PIPING	6
3.2. PNEUMATIC ANALYSIS	7
3.3. PASSIVE AIR INJECTION WELL	7
3.4. SOIL VAPOR MONITORING POINTS	8
3.5. SVE BLOWER AND APPURTENANCES	9
3.6. TREATMENT OF AIR EMISSIONS	9
4.0 SVE SYSTEM OPERATION AND MONITORING	11
4.1. CONDENSATE MANAGEMENT	11
4.2. SVE SYSTEM MONITORING	12
4.2.1. VOC Monitoring	12
4.2.2. Applied Vacuum and Velocity	13
4.2.3. Activated Carbon Treatment System	13
4.2.4. Vacuum Response	14
4.2.5. SVE Blower System	14
4.3. SYSTEM CONTROLS AND AUTOMATED MONITORING	15
4.4. SVE SYSTEM OPTIMIZATION AND SHUTDOWN	15
5.0 REFERENCES	17

TABLES

Table 4-1 System Instruments, Equipment, and Sample Points

FIGURES

Figure 1-1 Property Location Map

Figure 4-1 Process Flow, Instrumentation, and Controls Diagram

DESIGN DRAWINGS

Sheet 1 Cover Sheet

Sheet 2 Site Plan

Sheet 3 Construction Details

Sheet 4 Construction Details

APPENDICES

- Appendix 1 Design Calculations
- Appendix 2 Manufacturers' Cut Sheets for SVE Equipment
- Appendix 3 Construction Specifications
- Appendix 4 Draft Operation, Maintenance and Monitoring Plan

1.0 INTRODUCTION

This *Soil Vapor Extraction Design Report* (Design Report) has been prepared on behalf of UniFirst Corporation (UniFirst) by The Johnson Company, Inc. (The Johnson Company) for submittal to the United States Environmental Protection Agency (USEPA). This Design Report contains a summary of the engineering design of the planned soil vapor extraction (SVE) system to be installed in and near the eastern portion of the existing building at the UniFirst Property, located at 15 Olympia Avenue in Woburn, Massachusetts (the Property). The Property location is shown on Figure 1-1. The design layout and details for the SVE system are shown on the design drawings provided with this report.

The planned SVE system includes new and existing SVE points, a passive air injection point, new and existing soil vapor monitoring (SVM) points, a blower to provide vacuum to the SVE points, and exhaust air treatment prior to emission to the atmosphere. This Design Report describes the individual elements of the SVE system, the basis of design, and the system operation and maintenance requirements. Design calculations, manufacturer's equipment cut sheets, construction specifications, and a draft Operation, Maintenance, and Monitoring Plan (OMMP) are included as appendices to this report.

2.0 PILOT TEST SUMMARY AND BASIS OF DESIGN

An SVE pilot test program was conducted at the UniFirst Property between October 9, 2012 and November 18, 2012 by The Johnson Company and B. Kueper & Associates, Ltd. (B. Kueper & Associates). USEPA's contractor, TRC, observed the work. The program consisted of the following components: pre-testing activities, SVE and SVM point installation, step and constant rate testing, and extracted vapor treatment and monitoring. The results of the pilot test were presented to USEPA in the February 2013 *Vapor Extraction Pilot Test Summary Report* (Pilot Test Report) (The Johnson Company and B. Kueper & Associates, 2013).

USEPA provided comments on the Pilot Test Report in an August 23, 2013 letter to UniFirst (USEPA, 2013). UniFirst and USEPA met on November 22, 2013 to discuss UniFirst Source Area Property topics, including the Pilot Test Report recommendations and USEPA's

August 2013 comments. At that meeting, USEPA and UniFirst aligned on the key elements of this Design Report (UniFirst, 2013).

2.1. PILOT TEST PROGRAM SUMMARY

The pilot test program demonstrated that SVE is a viable technology for reducing volatile organic compound (VOC) mass in unsaturated unconsolidated deposits at the Property. Based on pilot test observations, the full-scale SVE system will target unconsolidated deposits beneath and east/northeast of the eastern portion of the on-Property building.

A total of 52 soil samples for laboratory VOC analysis and 24 soil samples for field hydrophobic dye testing were collected during the pilot test point installation program to provide information on VOC-impacted unconsolidated deposits at the Property. Tetrachloroethene (PCE) was the VOC detected at the highest concentrations and in the most samples. PCE was detected at the highest concentrations in samples collected in the SVE-2 test area, where the loading dock historically had been located. Positive hydrophobic dye tests for NAPL also were recorded for three soil samples collected in the SVE-2 test area. TCE concentrations in soil exceeded the project criterion in samples collected in the SVE-1 and SVE-2 test areas and south of the former loading dock (planned SVE-5 area). The single 1,1,1-TCA detection was in the planned SVE-5 area.

Extracted vapor flow rates, vacuum response at observation locations, and demonstrated VOC mass removal at each SVE point during pilot testing demonstrated the viability of SVE to reduce VOC mass in unsaturated unconsolidated deposits in the impacted area. The extent of the observed radius of influence (ROI) varied between pilot test SVE points, but the ROIs overlapped, demonstrating the ability of SVE to influence unsaturated unconsolidated deposits throughout the area of VOC-impacted soils beneath the eastern portion of the building and the former loading dock area. The variation of the extent of ROI was likely due to differences in subsurface lithology, unconsolidated deposits thickness, moisture content, and ground surface cover. Based on observed vacuum response at shallow penetrations through the building slab during pilot testing, a full-scale SVE system is expected to provide the dual benefit of mitigating

potential vapor intrusion into the building and reducing contaminant mass in unsaturated unconsolidated deposits.

Step testing of the SVE points indicated that, although variable between SVE points, the ROI did not significantly increase with higher applied vacuums above a certain point. Constant rate testing indicated that the ROIs were relatively quickly established and did not measurably propagate over the duration of the test, especially under the building.

Vapor-phase granular activated carbon (GAC) effectively removed VOCs present in the extracted vapor stream during the pilot test. No photoionization detector (PID) screening readings or analytical results for treated vapor effluent samples exceeded 1 part per million by volume (ppmV) during testing, and no breakthrough of a primary canister (each of which contained approximately 175 pounds of GAC) occurred.

These general conclusions were considered in the following recommendations and conceptual design parameters presented in the Pilot Test Report:

- Pilot SVE points SVE-1 through SVE-4 will constitute the majority of the extraction points in the full-scale SVE system, with additional extraction points for the full-scale system added in the vicinity of the SVE-1 area northeast of the building and in the planned location of SVE-5.
- Shallow sub-slab vapor extraction points will not be necessary.
- A subset of the existing observation points at the Property will constitute the majority of the performance monitoring points for the full-scale SVE system, with additional observation points for the full-scale system added in the vicinity of the SVE-1 area northeast of the building and in the planned location of SVE-5.
- Vacuum coverage of the target treatment area can be achieved by applying vacuums of 20 to 30 inches of water (in. H₂O) at the six extraction points.
- To allow for point-by-point adjustment of applied vacuum and extracted vapor flow rate, each extraction point will be piped independently to a manifold at the extraction blower.
- Vapor-phase GAC can effectively remove VOCs present in the extracted vapor stream.
- The full-scale system would be operated until cumulative mass removal reaches asymptotic conditions and mitigation of potential influx of VOC-impacted soil vapor into the building is unnecessary.
- As VOC concentrations in the combined extracted vapor stream and the resultant mass removal rate become asymptotic, consideration would be given to pulsed operation of the system.

These recommendations and conceptual design parameters have been incorporated in the full-scale SVE design. The full-scale design also incorporates the following key elements discussed at the November 2013 meeting between USEPA and UniFirst:

- A scope for additional points in the SVE-1, SVE-5, and SVM-30 areas;
- A scope for soil sampling and hydrophobic dye testing at new installation locations;
- A passive air injection (PI) point;
- An operation and maintenance plan;
- Design specifications;
- Performance monitoring, including vacuum monitoring at existing SVM points and VOC monitoring at SVE points;
- System operation until cumulative mass removal approaches asymptotic conditions for each SVE point; and
- Shut down and rebound testing to determine whether to restart the system.

2.2. BASIS OF DESIGN

The full-scale design includes six SVE points with applied vacuums of approximately 16 to 27 in. H₂O and a nominal composite extracted soil vapor flow rate of 290 standard cubic feet per minute (SCFM). The planned applied vacuum levels provide manageable soil vapor flow rates and emissions treatment, and are not expected to result in groundwater mounding. Subsurface vacuum levels will be monitored to evaluate the zone of influence achieved by the SVE system.

The nominal flow rate and applied vacuum levels were developed using a pneumatic model of the SVE system in which pilot step test data were used to predict flow rates from extraction points under variable applied vacuum. The model results were used to refine the conceptual flow rate and applied vacuum parameters presented in the Pilot Test Report. The model also allowed predictions of the flow rate and applied vacuums produced by the planned piping configuration and blower. Based on the overlapping ROI observed during the pilot test, the actual flow rate is expected to be less than that predicted by the model. This will allow higher vacuum to be applied to the SVE points if necessary as determined by system monitoring. Where new SVE points are proposed (see below), their response to applied vacuum is assumed

to be similar to nearby existing SVE points and will be verified upon system start-up. See Appendix 1 for pneumatic model calculations.

The six SVE points for the final system include three new interior SVE points (SVE-2A, SVE-3A, and SVE-4A) to replace existing SVE points used during the pilot test (SVE-2, SVE-3, and SVE-4), the existing exterior pilot test point SVE-1, and two new exterior SVE points: SVE-6 (northwest of SVE-1) and SVE-5 (south of the former loading dock). The locations of the existing and proposed SVE points are shown on Sheet 2 of the attached design drawings.

The new interior replacement SVE point locations will improve extraction piping efficiency (fewer elbows, no sub-slab horizontal piping), thereby increasing the available vacuum of the system. The replacement SVE point locations will also reduce disruption to the operating business that occupies the building (no need for cutting and removal of the floor slab for pipe trenches), reduce potential indoor air impacts during system installation (e.g., dust), and eliminate the need for additional seams in the floor slab.

New borings will be advanced to further characterize soils in the area of SVE-5 and to the northwest of SVE-1. These borings will be completed as SVM points for monitoring ROI of the associated SVE points. Points SVM-101 and SVM-102 will be installed northwest of SVE-1 (and east of SVE-6). Points SVM-103 and SVM-104 will be installed south of SVE-5, and point SVM-105 will be installed east of SVE-5. Additionally, a shallow sub-slab vapor monitoring point will be installed near uncompleted monitoring point SVM-30. This point will be used to evaluate sub-slab depressurization in the southeast portion of the building. Locations of the new SVM points are shown on Sheet 2 of the attached design drawings and construction details are shown on Sheet 3.

Analytical results from soil vapor samples collected during the SVE pilot constant rate tests were used to develop a conservative estimate of VOC concentrations expected in the composite extracted soil vapor. Treatment of the extracted soil vapor will be provided by GAC prior to discharge to the atmosphere. Given the relatively low VOC concentrations expected in the extracted soil vapor, and the adsorptive capacity of GAC for those VOCs, GAC is the most

efficient and cost-effective treatment technology. See Appendix 1 for influent concentration estimate and carbon usage calculations.

3.0 FULL-SCALE DESIGN OVERVIEW

3.1. SOIL VAPOR EXTRACTION POINTS AND CONVEYANCE PIPING

As described above in Section 2.2, the full-scale SVE point network includes new SVE points installed adjacent to the existing interior points used for the pilot test (see Sheet 2 of the attached design drawings for SVE point locations). The interior pilot test SVE points were installed in the aisles of the on-Property building because of impediments to access to occupied storage lockers. For the full-scale system, UniFirst will permanently acquire and utilize the storage locker space necessary to locate the new SVE points outside of publicly-accessible aisles, for the reasons described in Section 2.2. Soil vapor conveyance piping from each interior SVE point will rise vertically to a point where it can run horizontally overhead. A pipe chase will be constructed in each associated storage locker to isolate the vertical piping. A lockable access door in the pipe chase, opening to the aisle, will be installed for system monitoring activities. See Sheet 3 of the attached design drawings for SVE point and piping details.

Vapor conveyance piping will be constructed of Schedule 40 PVC with cemented fittings. Where interior piping runs are vertical, the pipe will be braced from an adjacent wall where possible. Where interior piping runs are horizontal overhead, the pipe will be hung from the roof trusses or other support members. Horizontal pipe will be installed with a slight slope to facilitate drainage of condensate that collects inside the piping, if any, back to the SVE point. Conveyance piping from exterior SVE points will be buried up to the exterior building wall. Exterior SVE points will be protected by a cast-iron cover capable of supporting H-20 loading. At the building edge, the exterior buried piping will extend up to the ground surface and into a protective pipe chase to a point where it will penetrate the exterior wall, and continue up the inside wall to the horizontal overhead run. The overhead conveyance piping will run to a common point in the existing groundwater treatment system room (treatment room), as shown on Sheet 2 of the attached design drawings. Once in the treatment room, the individual overhead conveyance pipes will drop vertically and connect to a common manifold. Ahead of the common manifold, a vacuum gauge and flow velocity measurement port will be installed on

each branch upstream of a gate valve that can be used to adjust the vacuum applied to each individual SVE point. A single vacuum gauge installed in the common manifold will provide measurement of the vacuum applied to the downstream side of the valves. See Sheet 3 of the attached design drawings for a detail of the manifold.

3.2. PNEUMATIC ANALYSIS

A pneumatic model was developed to size and select an appropriate blower for the SVE system. Blower size is determined by the pressure differential required between the inlet and outlet of the blower to provide design vacuum levels at the SVE points. The pneumatic model considers the SVE system from a point at the ground surface near the SVE points to the outlet of the exhaust stack. The pneumatic model also supports the selection of pipe sizes based on air velocity and associated estimated friction losses. The model and its results are described in Appendix 1.

3.3. PASSIVE AIR INJECTION WELL

During the SVE pilot constant rate tests, VOC concentrations in the soil vapor extracted from SVE-2 were considerably less than those from other SVE points despite elevated VOC concentrations in soil just south of SVE-2 (e.g., SVM-12, SVM-13, and SVM-14). The easternmost portion of the building, in which SVE-2 is located, was formerly an exterior loading dock. The loading dock area was modified several times over the life of the building and finally enclosed to create the current interior loading dock. Several layers of bituminous concrete pavement in this area were abandoned in place and filled over with coarse sands and gravels. The resulting anisotropy of vacuum propagation below the building slab in this area is likely the cause of the low VOC concentrations observed at SVE-2 during the pilot test.

The majority of the screened section of SVE-2 is located below an asphalt layer within both a layer of high permeability gravel and cobbles, and a lower permeability ablation till layer. VOC concentrations are highest within the till layer; however, it is likely that the gravel layer produces the majority of the vapor flow. Additionally, the asphalt layer appears to act as a partial confining layer, as evidenced by atypically higher vacuum response in monitoring points screened below the asphalt layer than in shallow monitoring points similarly distant from SVE-2.

A passive air injection (PI) point will be installed to target vacuum influence and facilitate better vapor flow and VOC removal in the ablation till layer in the vicinity of SVE-2A. The planned PI point (shown as PI-1 on Sheet 2 of the design drawings, with a construction detail on Sheet 3 of the design drawings) will be installed southeast of SVE-2, outside the building, and screened only in the till layer. To further target the ablation till layer in this area, new SVE point SVE-2A will be screened only in the till layer. The PI point in conjunction with new point SVE-2A is expected to promote vapor flow through the till layer in the vicinity of SVM-12, the boring location where the highest VOC concentrations in soil were reported during pilot testing.

3.4. SOIL VAPOR MONITORING POINTS

As described in Section 2.2, several new SVM points and one new sub-slab vapor monitoring point will be installed as part of the full-scale SVE system. SVM points will be installed following the procedure described in the *Revised Vapor Extraction Pilot Test Work Plan* (The Johnson Company and B. Kueper & Associates, 2012) and associated *Quality Assurance Project Plan*. Soil core will be collected, logged, and screened for the presence of VOCs using a field PID equipped with a lamp with an ionization potential of 11.7-electron volts (eV). Soil samples for laboratory analysis of select VOCs and hydrophobic dye testing will be collected from the core obtained during installation of the new SVM points. At each location, one sample of fill/reworked materials and one sample of till, if present, will be submitted for laboratory analysis. Samples will be collected from a stained interval (if visible impact is observed) or from the interval with the highest PID reading (if visible impact is not observed). If PID readings along the soil core do not exceed background, the soil samples for laboratory analysis will be collected from the middle of the least permeable lithologic unit. For exterior points where shallow refusal was encountered during the pilot test program (e.g., near SVE-5), a sonic drilling rig will be used to advance the borings. Height limitations preclude the use of sonic drilling equipment inside the building.

The sub-slab vapor monitoring point will be installed in the fill sand and gravel immediately below the slab, near the uncompleted SVM-30 point in the southeast corner of the

building. The purpose of this point is to confirm that the planned SVE system achieves sufficient vacuum levels for sub-slab depressurization in this area of the building. The locations of the new monitoring points (SVM and sub-slab) are shown on Sheet 2 of the attached design drawings and construction details can be found on Sheet 3.

3.5. SVE BLOWER AND APPURTENANCES

The blower selected for the full-scale design is an 8.5 horsepower regenerative blower (see Appendix 2 for additional information on the selected SVE equipment). The skid mounted blower system includes an in-line particulate filter, a vacuum release valve, and an exhaust silencer. Also integral to the skid is a 40 gallon air/water separator (knockout tank). The knockout tank is fitted with a sight tube and automatic one horsepower centrifugal condensate transfer pump. The transfer pump can be run either in “hand” (manual) mode or in “auto” mode (where the pump is controlled by on/off liquid level switches located in the knockout tank). The knockout tank also has a high liquid level alarm switch that interrupts blower power when activated. A dilution air pipe and associated control valve will be installed and connected to the blower inlet. The dilution air inlet pipe will terminate outside the building. It is not expected that full-scale system operation will require ongoing dilution air; however, the ability to provide dilution air will allow flexibility in the use of the blower if conditions change in the future. It will also allow the blower and controls to be tested without having to extract soil vapor.

3.6. TREATMENT OF AIR EMISSIONS

During the SVE pilot constant rate tests, samples of extracted soil vapor were collected for VOC analyses at the beginning, midpoint, and end of each test. As expected, a reduction in VOC concentrations was noted in the end-of-test results relative to initial concentrations. The end-of-test VOC concentrations were used to design the GAC treatment system for extracted soil vapor (see Appendix 1). The carbon treatment system design is considered conservative because VOC concentrations are expected to decline during full-scale operation of the SVE system.

An estimate of carbon usage for treatment of the extracted soil vapor was calculated using vapor-phase isotherms for the individual VOC constituents (see Appendix 1). The vast majority (approximately 99%) of the calculated VOC mass in the extracted soil vapor is expected

to be PCE. Of those VOC constituents expected to be present in the extracted soil vapor, PCE is the most efficiently adsorbed by GAC.

Two parallel trains of two carbon drums in series (4 drums total) will provide treatment of the extracted soil vapor prior to emission. Treated soil vapor will be discharged to the atmosphere through a four-inch Schedule 40 PVC pipe, which will penetrate the exterior wall at the bottom of the roof joists and terminate two feet above the building. See Sheet 4 of the design drawings for a detail of the treatment system. Each drum will contain 175 pounds of GAC for a total of 350 pounds in the primary drums and 350 pounds in the secondary drums. Based on the carbon use estimate (see Appendix 1), approximately 2.7 pounds of GAC would be saturated with VOCs per day. It would, therefore, take 129 days to saturate the 350 pounds of GAC in the primary drums. However, complete saturation is not typically achieved before breakthrough of VOCs from a GAC vessel. Given the calculated time to primary drum saturation, the system is currently projected to operate on the order of a month before breakthrough occurs (defined as greater than 1 ppmV total VOCs, measured between primary and secondary GAC drums using a PID).

System operator visits, which will include PID screening of the treatment train to monitor for breakthrough, will initially be conducted weekly. In addition to weekly PID screening, influent and effluent vapor samples will be collected from the carbon treatment system after SVE system start up on Day 1, 7, 14, and 28 and will be compared for consistency with PID readings. Six-liter Summa[®] canisters will be used to collect the samples. Samples will be submitted to Alpha Analytical, Inc. of Mansfield, Massachusetts (Alpha), a National Environmental Laboratory Accreditation Conference (NELAC) (E87814) certified laboratory, for laboratory analysis of VOCs by Modified EPA Method TO-15. The laboratory analytical and subsequent PID screening data will be used to confirm 95 per cent or greater reduction in contaminant mass in the vapor stream prior to discharge, consistent with Title 310 of the Code of Massachusetts Regulations (CMR) Section 40.0049 - Remedial Air Emissions (310 CMR 40.0049).

As discussed above, influent soil vapor concentrations are expected to decline during system operation. When operations monitoring demonstrates this declining trend in extracted VOC concentrations, system operator visits and monitoring frequency will be reduced appropriately (e.g., monthly).

4.0 SVE SYSTEM OPERATION AND MONITORING

4.1. CONDENSATE MANAGEMENT

Based on the pilot test results, vacuum-induced groundwater mounding and introduction into the SVE system through the SVE points is not expected. Only one SVE pilot constant rate test (point SVE-3 at an applied vacuum of 64 in. H₂O) resulted in accumulation of water in the air/water separator. Step testing of the same point at 30 in. H₂O (the planned applied vacuum at SVE-3A) did not induce groundwater mounding. Nonetheless, the air/water separator will be equipped with float switches that control a transfer pump for any accumulated water. The transfer pump discharge will be piped to the existing backwash settling tank of the groundwater treatment system. When the water volume in the backwash settling tank is sufficient (e.g., after backwashing of carbon vessels associated with the existing groundwater treatment system), collected water will be pumped to the groundwater treatment system for treatment and discharge.

The water collected in the air/water separator during the SVE-3 constant rate test was sampled and analyzed for VOCs, and two compounds were reported above the laboratory detection limits: PCE at 150 micrograms per liter (µg/L) and trichloroethene (TCE) at 0.48 µg/L (estimated). These compounds are present in higher concentrations in the groundwater influent stream to the existing groundwater treatment system. Thus, the groundwater treatment system is capable of adequately treating any water that may collect in the air/water separator during full-scale SVE system operation.

It is expected that the transfer pump will initially be operated in “hand” (i.e., manual) mode. The sight tube installed on the air/water separator will allow observation of any accumulated water. During routine operator site visits, the pump will be used to transfer any accumulated water to the backwash settling tank. The air/water separator is equipped with a high level alarm that will shut down the SVE system blower if activated. If more water accumulates

than expected, the pump may be subsequently operated in the “auto” mode, where its operation will be controlled by the high/low level switches in the separator. The SVE system control panel will include an hour meter that tracks transfer pump run time.

4.2. SVE SYSTEM MONITORING

The performance of the SVE system will be monitored during routine site visits by the contracted system operator. Initially, the operator will visit the site on a weekly basis. Routine visit frequency may be reduced once operating parameters (including time to breakthrough for the GAC drums) are established. The operator will collect and record PID screening readings, vacuum and flow velocity measurements, and other operational parameters as described below. System monitoring information will be used to evaluate system operation and make decisions regarding system optimization. See Section 4.3 for system optimization procedures.

4.2.1. *VOC Monitoring*

A PID will be used to screen extracted soil vapor from individual SVE points for VOCs. These results will be considered when optimizing SVE operation. A sample port consisting of a brass valve and hose barb fitting will be installed in the conveyance piping from each SVE point upstream of the manifold (see detail on Sheet 3 of the design drawings). An isolation valve will be installed on the conveyance pipe downstream of the sample port. To screen the soil vapor with the PID, the isolation valve will be closed to eliminate the vacuum applied by the blower and allow the PID sampling pump to draw soil vapor from inside the conveyance pipe. The PID will be connected to the sample port and the sample valve opened. The maximum stable PID reading will be recorded. Following screening, the sample valve will be closed and the isolation valve re-opened.

A sample of the combined influent to the carbon treatment system will be collected no more frequently than bimonthly (every other month) during system operation. The sample will be collected in a 6-liter Summa® canister and analyzed for VOCs by USEPA Method TO-15.

A sample port will be installed in the conveyance piping near each SVE point for collection of Summa[®] canisters during shutdown testing (see Section 4.4). An isolation valve will be installed on the conveyance pipe downstream of this sample port.

4.2.2. *Applied Vacuum and Velocity*

Individual vacuum gauges at the manifold will be used to measure the vacuum applied to each SVE point. Friction loss in the conveyance piping is expected to be minimal (between 1 and 3 in. H₂O); the vacuum measured at the manifold will be representative of the vacuum at the SVE point. The applied vacuum at the SVE points will be confirmed with a digital manometer connected to the sample port proximal to each SVE point. Each conveyance pipe will also contain a valved sample port at the manifold that will allow the insertion of a portable thermal mass flow meter to measure the temperature and velocity of vapor extracted from the SVE point.

4.2.3. *Activated Carbon Treatment System*

A PID will be used to monitor carbon treatment system performance and to determine breakthrough of the primary carbon drums. The PID will be connected directly to sample ports to screen the system at the exhaust, between the primary and secondary carbon drums, and at the influent to the treatment system. VOC monitoring of the carbon treatment system will be performed sequentially beginning with the treated air, followed by the sample ports between each of the primary and secondary carbon drums, and ending with the sample port upstream of the carbon treatment system (see Figure 4-1 for schematic system layout and sample port locations). Under normal operational conditions a stabilized PID reading should be achievable at each location and that value will be recorded.

When a stabilized reading greater than 1 ppmV between the carbon drums is measured with the PID, the SVE blower will be shut down and the carbon change-out process initiated. A minimum of two spare drums will be kept on-Property to facilitate change-outs. The two primary drums will be removed from service, labelled, sealed (with bung caps), and stored for off-Property disposal or regeneration. The two secondary drums will be moved into the primary positions and two new drums will be installed in the secondary positions.

Given the serial configuration of activated carbon treatment, and the monitoring for breakthrough of VOCs between GAC vessels, it is not expected that VOCs will be present in the vapor exhaust. Should PID monitoring indicate the presence of VOCs in the exhaust, the blower will be shut down and the system will be evaluated to determine the cause of reduced treatment efficiency.

4.2.4. *Vacuum Response*

Sub-slab/subsurface vacuum will be measured at the new and existing monitoring points using a digital manometer or magnehelic gauge to determine response to applied vacuums. The sub-slab/subsurface vacuum response will be measured at start-up and following any system operational modifications that may result in a change in response (e.g., a change in applied vacuum to one or more SVE points). Based on pilot test observations, the sub-slab/subsurface vacuum is expected to establish relatively quickly and not change significantly over time. Periodic measurement of sub-slab/subsurface vacuum at the new and existing monitoring points during routine operations is therefore unnecessary.

4.2.5. *SVE Blower System*

Vacuum and pressure gauges will be installed to allow monitoring of the SVE blower inlet vacuum and discharge pressure. Vacuum gauges, installed upstream and downstream of the particulate filter on the blower inlet, will be used to determine the vacuum differential across the filter. An increase in vacuum differential across the filter would indicate particulate loading of the filter. When vacuum loss through the filter begins to affect SVE system performance (greater than 6 in. H₂O), the filter element will be replaced.

Other blower operational parameters that will be monitored and recorded include the blower discharge air temperature, depth of accumulated water in the air/water separator, and the blower and transfer pump run hours.

If dilution air is being used, the temperature and velocity of the dilution air stream will be measured using a portable thermal mass flow meter through a sample port in the inlet pipe and recorded. The vacuum in the pipe will also be measured and recorded.

4.3. SYSTEM CONTROLS AND AUTOMATED MONITORING

In addition to the manual monitoring performed by the system operator during routine site visits (see Section 4.2), the SVE system will be equipped with a programmable logic controller (PLC)-based automatic control system and remote telemetry. This will enable remote monitoring of the system by the operator, and automatic shutdown of the system in the case of process upsets that may damage the system.

Blower vacuum and discharge pressure will be monitored on an ongoing basis with pressure transducers installed on the suction and discharge piping, respectively. A pitot tube and differential pressure transmitter will be installed to monitor the air velocity in the four-inch diameter discharge stack. The PLC will continuously monitor the signals from the transducers and the differential pressure transmitter and compare them to specified operating ranges for blower vacuum, discharge pressure, and discharge air velocity (and resultant flow rate) as appropriate for the specific signal. If the PLC records a reading outside the specified operating range, an upset condition may exist; the power to the blower will be automatically interrupted, and a notification of system shutdown will be automatically sent to the operator. The PLC will also record data during routine operation for periodic download and review. Operating data and upset conditions monitored by the PLC will be available remotely to the operator through a cellular-based remote telemetry system.

The process flow, instrumentation and control diagram (Figure 4-1) provides a schematic overview of the full-scale system design. A summary listing of system instruments, equipment and sample points is provided in Table 4-1.

4.4. SVE SYSTEM OPTIMIZATION AND SHUTDOWN

To maximize the mass of VOCs removed by the SVE system, optimization of the SVE system will be performed at system startup, and again when significant changes in extracted VOC concentrations are observed.

The vacuum on any individual SVE point may be adjusted using control valves on the conveyance piping at the manifold. Total mass removal by the system will be optimized by adjusting the vacuum applied to the individual SVE points.

Optimal system performance will be based on PID screening results from the individual SVE points. The control valve will be adjusted to increase the vacuum (and resultant flow) at points that have higher PID readings and reduce (or eliminate) flow from points with low (or zero) readings. Periodic shutdown and rebound tests also will be performed to determine whether individual SVE points should be reactivated. After system optimization, the new and existing monitoring points will be used to monitor the area of influence of the system.

The full-scale system will be operated until cumulative VOC mass removal approaches asymptotic conditions for each SVE point. At that time, a one-month shutdown test will be conducted to assess whether pulsed operation of the system or final shutdown should be initiated. Prior to shut down and upon re-start, six-liter Summa[®] canisters will be used to collect a sample from each SVE point for analysis of VOCs by EPA Method TO-15. VOC concentrations in the re-start samples will be compared to concentrations in samples collected prior to shut down to assess rebound. The results of this evaluation will be presented to USEPA.

5.0 REFERENCES

The Johnson Company, Inc. and B. Kueper & Associates, Ltd., 2012. Revised Vapor Extraction Pilot Test Work Plan, UniFirst Property, Wells G&H Superfund Site, Woburn, Massachusetts. July 31.

The Johnson Company, Inc. and B. Kueper & Associates, Ltd., 2013. Vapor Extraction Pilot Test Summary Report, UniFirst Property, Wells G&H Superfund Site, Woburn, Massachusetts. February 22.

UniFirst Corporation (UniFirst), 2013. November 22 UniFirst EPA Meeting Summary. Email from Tim Cosgrave to Joseph LeMay. November 25.

United States Environmental Protection Agency (USEPA), 2013. EPA Review Comments, February 2013 Vapor Extraction Pilot Test Summary Report, UniFirst Property, Wells G&H Superfund Site, Woburn, Massachusetts. August 23.

TABLES

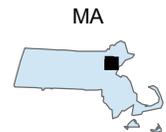
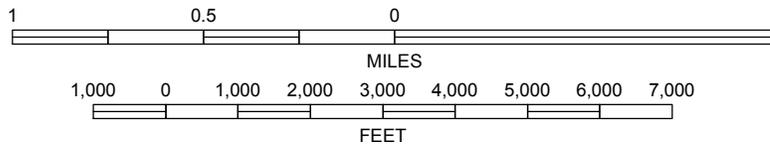
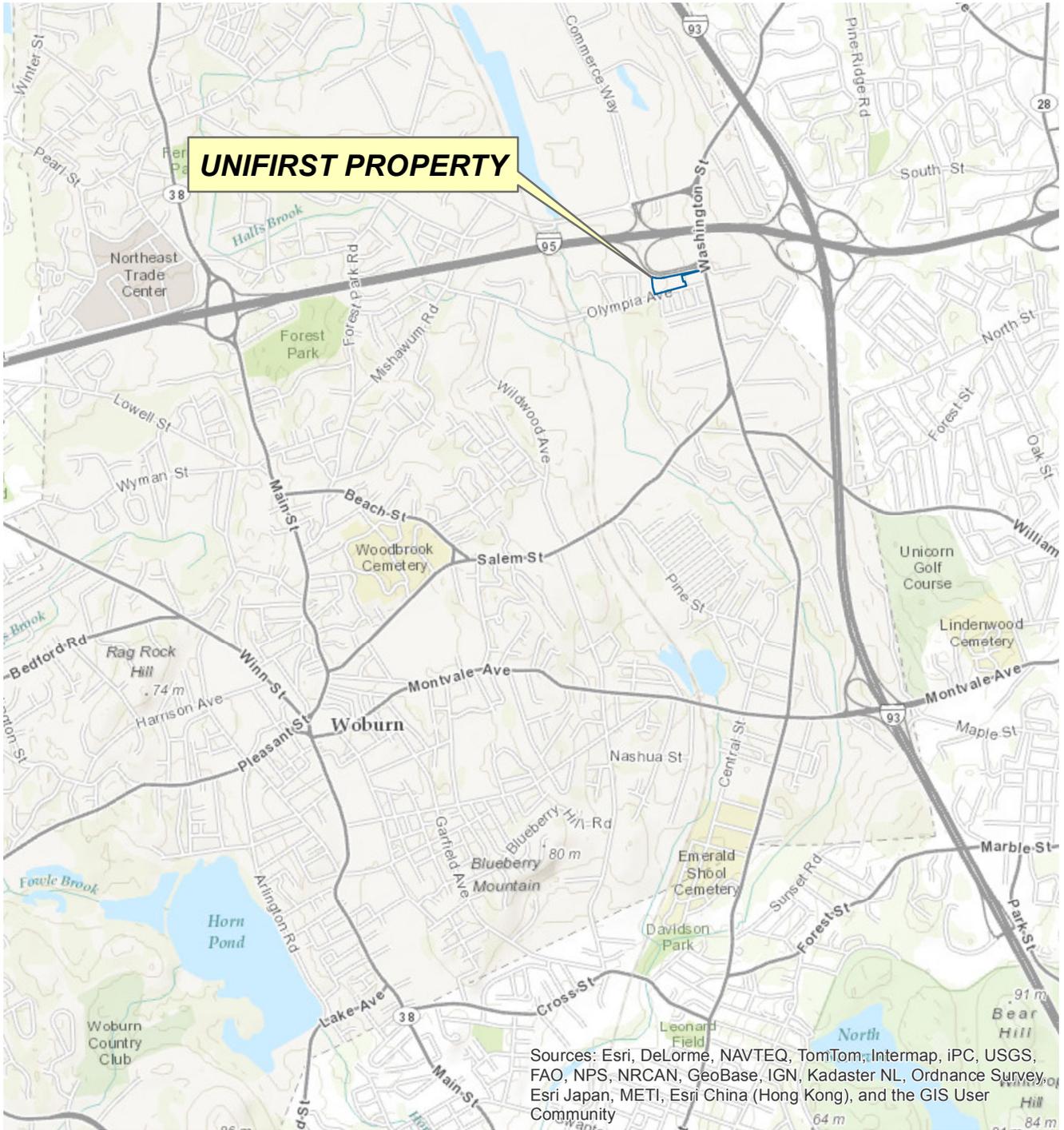
**Table 4-1: System Instruments, Equipment and Sample Points
Soil Vapor Extraction System**

Instrument¹	Description	Related Alarms / Interlocks
VI-1 – VI-6	Vacuum gauges at manifold – upstream of throttling valves	None – monitor vacuum upstream of throttling valves applied to individual wells
VI-7	Vacuum gauge at manifold – downstream of throttling valves	None – monitor vacuum upstream of knock-out tank
VI-8	Vacuum gauge upstream of particulate filter F-1	None – monitor pre-filter vacuum
VI-9	Vacuum gauge downstream of particulate filter F-1	None – monitor post-filter vacuum
PI-1	Pressure gauge on B-1 discharge	None – monitor blower discharge pressure ahead of carbon treatment
PI-2	Pressure gauge on P-1 discharge	None – monitor pump discharge pressure
LSL-1	Low water level switch in the knockout tank	Turn off P-1
LSH-1	High water level switch in the knockout tank	Turn on P-1
LSHH-1	High high water level switch in the knockout tank	LAHH-1/system shutdown and call-out if high level
VT-1	Pressure transducer installed on suction side of B-1, measures operating vacuum of soil vapor extraction	PLC records data from VT-1; system shutdown and call-out if vacuum drops below or exceeds set-points
PT-1	Pressure transducer installed on discharge side of B-1, measures operating pressure upstream of carbon treatment	PLC records data from PT-1; system shutdown and call-out if pressure drops below or exceeds set-points
TI-1	Temperature indicator on B-1 exhaust pipe	None – monitor blower discharge air temperature
FIT-1	Flow element in discharge stack	PLC records data from FIT-1; system shutdown and call-out if flow drops below set-point
Equipment¹		
B-1	Extraction blower operates continuously at a fixed motor speed.	
P-1	Condensate transfer pump, hand or cyclical operations based on LSL-1 and LSH-1 at a fixed motor speed.	
TK-1	40 gallon air/water separator (knock-out tank) - separates water (condensation) from the soil gas stream ahead of blower B-1	
F-1	Particulate filter on blower suction - filters any particulates from the soil gas stream ahead of blower B-1	
GAC A1-B2	Soil gas treatment provided by 2 parallel trains of 2 drums in series, minimum 175 pounds carbon/drum	
Sample Points²		
SP-1 – SP-6	Sample ports for individual soil vapor streams from corresponding SVE point	
SP-7	Sample port for combined soil vapor stream from all active SVE points	
SP-8	Sample port for dilution air stream	
SP-9	Sample port for soil vapor stream at blower discharge (includes dilution air if active)/influent to carbon treatment	
SP-10A	Sample port between carbon treatment drums GAC-A1 and GAC-A2.	
SP-10B	Sample port between carbon treatment drums GAC-B1 and GAC-B2.	
SP-11	Sample port on discharge stack	
SP-12	Sample port on condensate pump discharge	
FP-1 – FP-6	Docking ports for flow rate measurement with a thermal mass flow meter for the corresponding SVE point	
FP-7	Docking port for flow rate measurement with a thermal mass flow meter for the combined vapor stream from all active SVE points	
FP-8	Docking port for flow rate measurement with a thermal mass flow meter for the dilution air stream	
FP-9	Docking port for flow rate measurement with a thermal mass flow meter for the blower discharge	

¹ Refer to Process Flow, Instrumentation and Controls Diagram for nomenclature

² Sample points SP-1 – SP-11 allow for the collection of soil vapor samples and/or measurement of the vapor pressure/vacuum

FIGURES



MAP LOCATION

BASE MAP: ESRI World Topographic Map

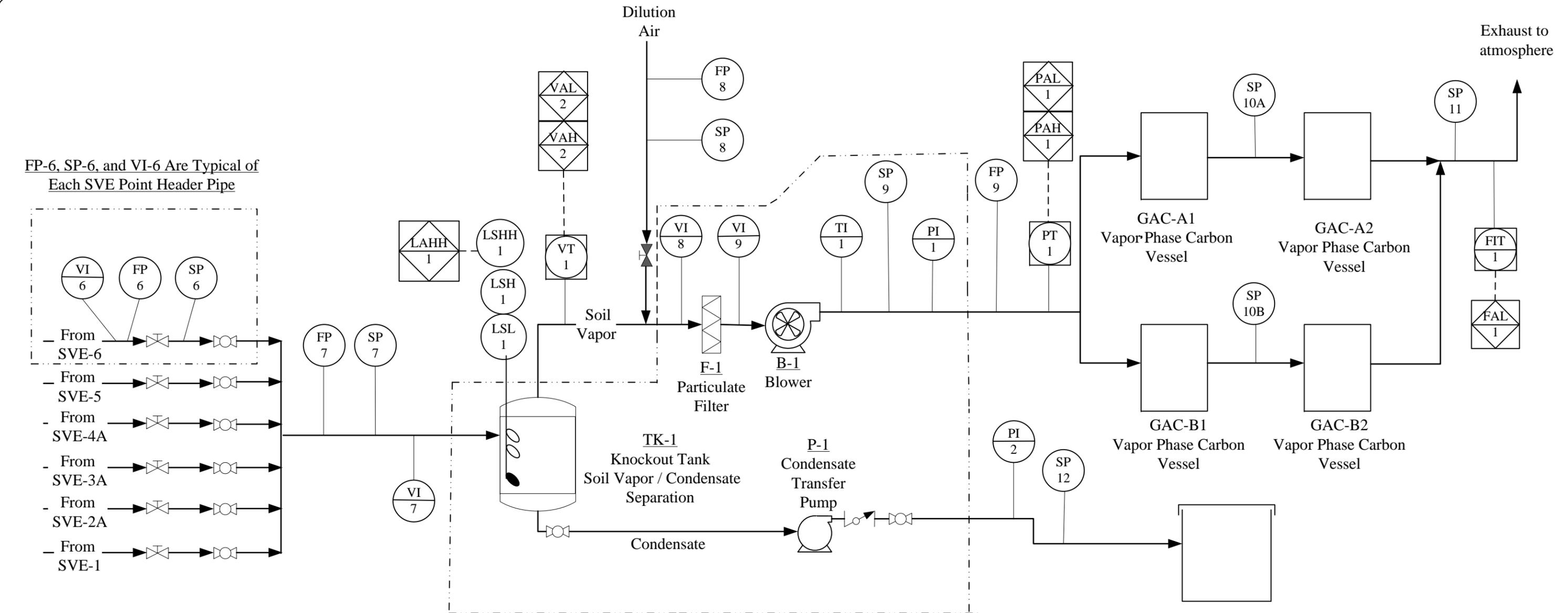
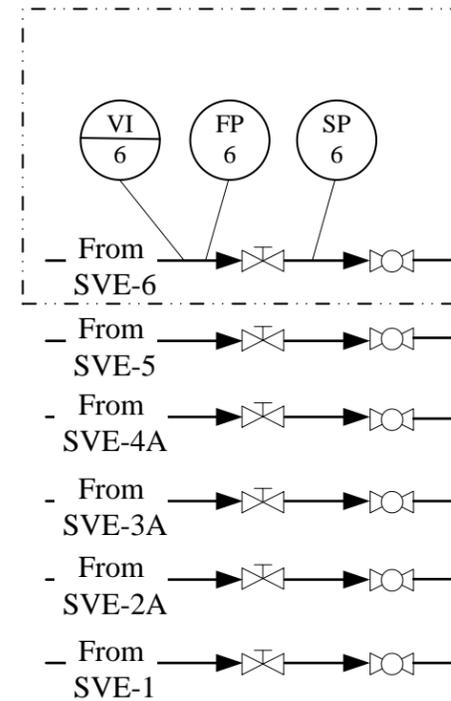
**FIGURE 1-1: PROPERTY LOCATION MAP
UNIFIRST PROPERTY
WOBURN, MASSACHUSETTS**



100 State Street, Suite 600
Montpelier, VT 05602

Drawn by: DPB	Date: 01/14/13
Chk'd by: BLL	Date: 02/08/13
App'd by: BLL	Date: 02/08/13
Scale: 1" = 1/2 mile	Project: 1-2114-2

FP-6, SP-6, and VI-6 Are Typical of Each SVE Point Header Pipe



LEGEND

Symbology for Instruments and Alarms:

First Letter:

- F = flow
- L = level
- P = pressure
- S = sample
- T = temperature
- V = vacuum

Second Letter:

- A = alarm
- I = indicator
- P = port
- S = switch
- T = transmitter

Third and Fourth Letters:

- H = high
- L = low
- T = transmitter



Process instrument or sample port



Process instrument with local display



Instrument with Data Connection



Programmed Alarm Function

Other Symbology

--- Data connection

→ Process piping and flow direction

Level Switches

○ white = high level switch,

● black = low level switch

↗ Ball check valve

○ Normally open ball valve

⊗ Normally closed gate Valve

⊘ Normally open gate Valve

Equipment Included in Blower Skid Assembly

PROCESS ALARMS

ID	Description	Interlocks
LAHH-1	High condensate level alarm in the knockout tank (TK-1)	Turn off B-1, prevent operation of P-1
VAL-1	Low vacuum alarm	Turn off B-1
VAH-1	High vacuum alarm	Turn off B-1
PAL-1	Low pressure alarm	Turn off B-1
PAH-1	High pressure alarm	Turn off B-1
FAL-1	Low flow rate alarm	Turn off B-1

FIGURE 4-1
SOIL VAPOR EXTRACTION SYSTEM
PROCESS FLOW, INSTRUMENTATION, AND CONTROLS DIAGRAM
WELLS G&H SUPERFUND SITE
UNIFIRST PROPERTY WOBURN, MA



100 State Street
 Montpelier, VT 06502
 (802) 229-4600
 Drawn by: PCS
 Check'd by: BMLK
 Date: 05/1/14
 Scale: None
 Project: 1-2114-2

DESIGN DRAWINGS

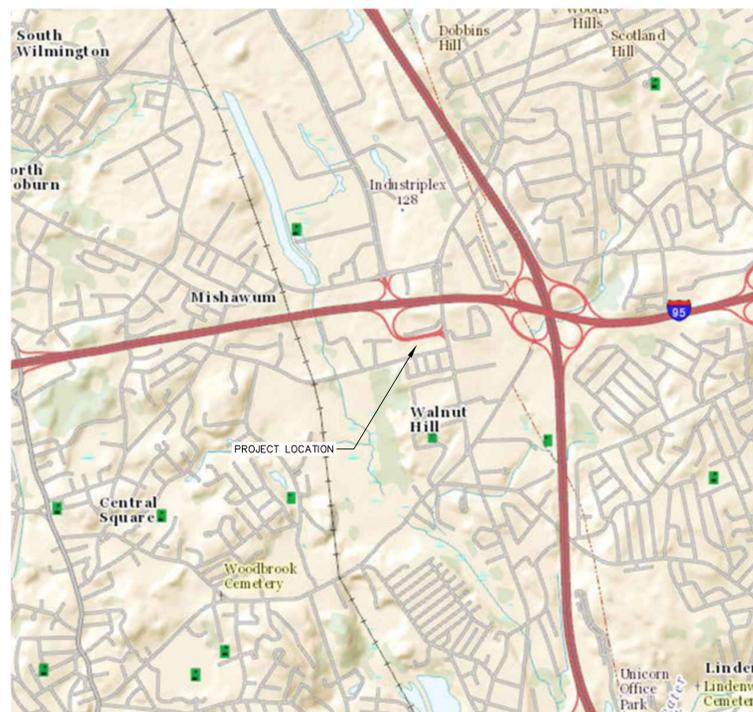
DESIGN DRAWINGS

SOIL VAPOR EXTRACTION SYSTEM

WELLS G&H SUPERFUND SITE, UNIFIRST PROPERTY

WOBURN, MASSACHUSETTS

MAY 2014



SITE LOCUS MAP
SCALE: N/A

SHEET	TITLE
1	COVER SHEET WITH SITE LOCUS MAP
2	SITE PLAN
3	CONSTRUCTION DETAILS
4	CONSTRUCTION DETAILS

#	Date	Drwn	Chk'd	App'd	Description

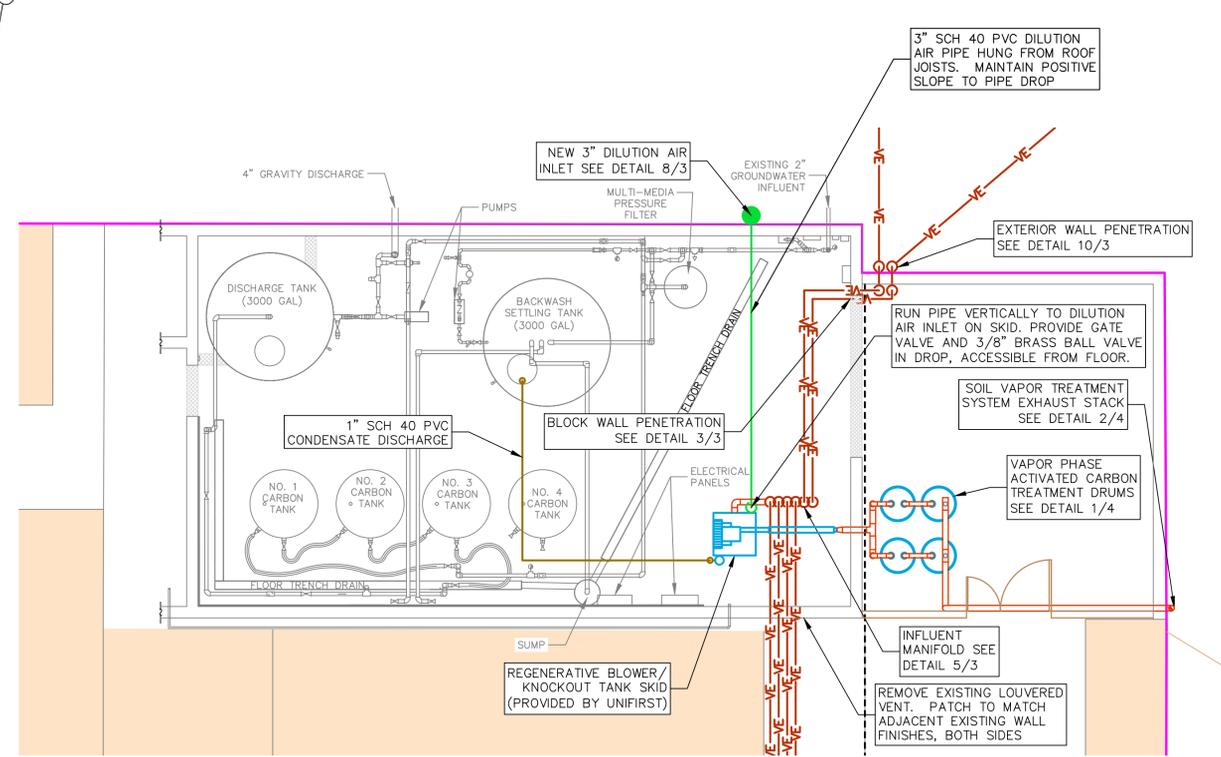
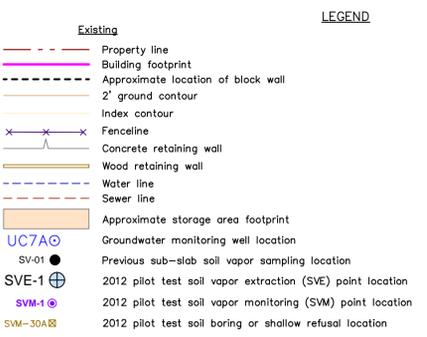
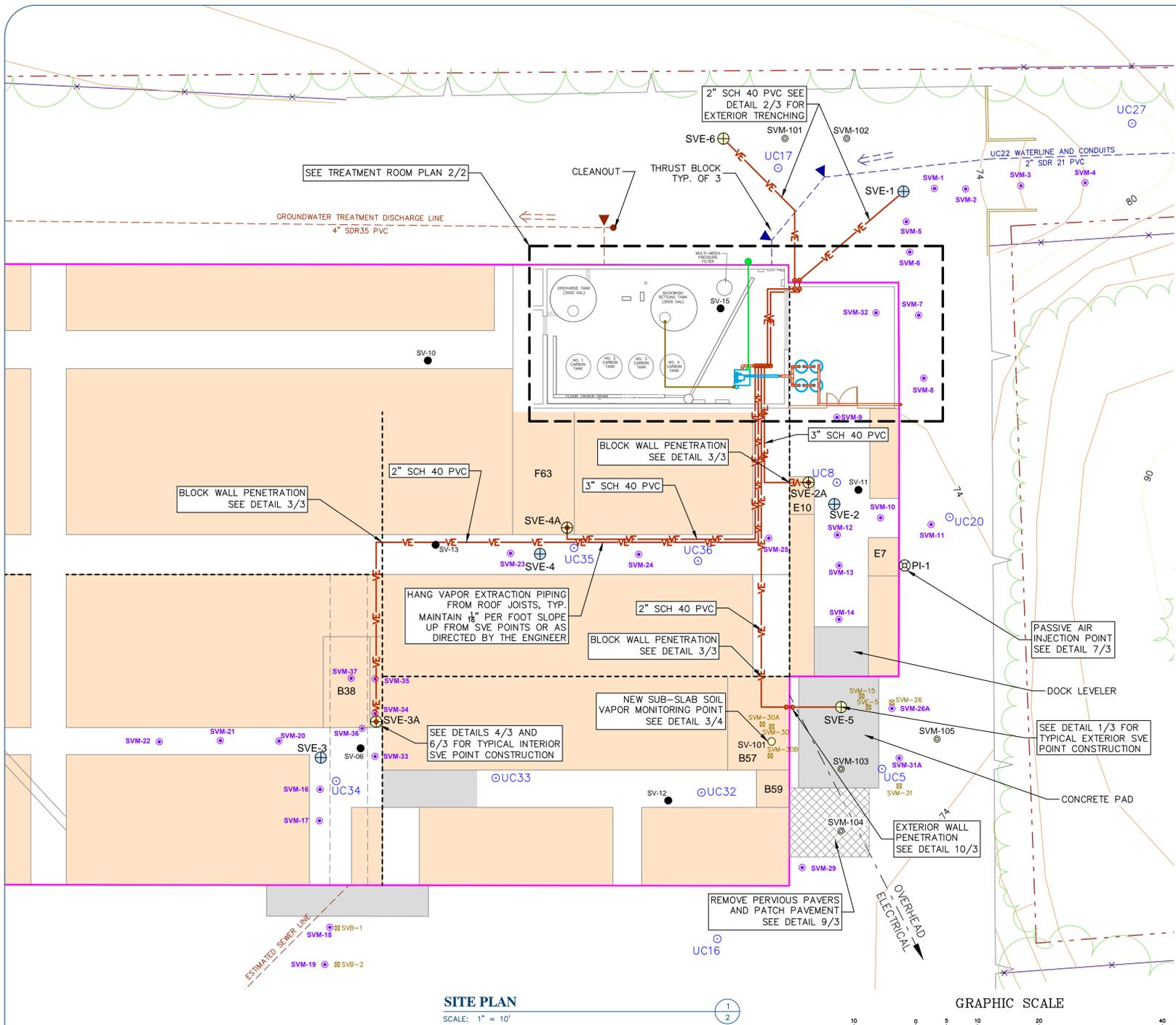
PREPARED FOR
UNIFIRST CORPORATION
68 JONSPIN ROAD
WILMINGTON, MA 01887
Job#: 1-0145-05

PREPARED BY

The Johnson Company
ENVIRONMENTAL SCIENCE AND ENGINEERING SOLUTIONS
100 State Street, Suite 600
Montpelier, Vermont 05602
(802) 229-4600 phone
(802) 229-5876 fax
www.johnsonco.com

DRAWING
Scale: As Shown
Drawn On: 05/02/14
Drawn By: BMLK
Checked On: 05/02/14
Checked By: CMC
Print Date:

TITLE
COVER SHEET
SOIL VAPOR EXTRACTION SYSTEM
WELLS G&H SUPERFUND SITE, UNIFIRST PROPERTY
WOBURN, MASSACHUSETTS



- Notes:**
1. Base map prepared by Col-East, Inc. of North Adams, MA. at a scale of 1 inch = 100 feet from April 1990 aerial photographs modified after Martingage Engineering Associates, Inc. Nov.2, 1992. All property lines are approximate. Well locations from a survey by BSC Group of Boston, MA.
 2. Interior building information from an undated Layout Drawing of the Extra Space Storage Operation provided to UniFirst Corp.
 3. Pilot Test point locations based on a field survey by The Johnson Company in October 2012.
 4. All locations are approximate.

#	Date	Drwn	Chk'd	App'd	Description

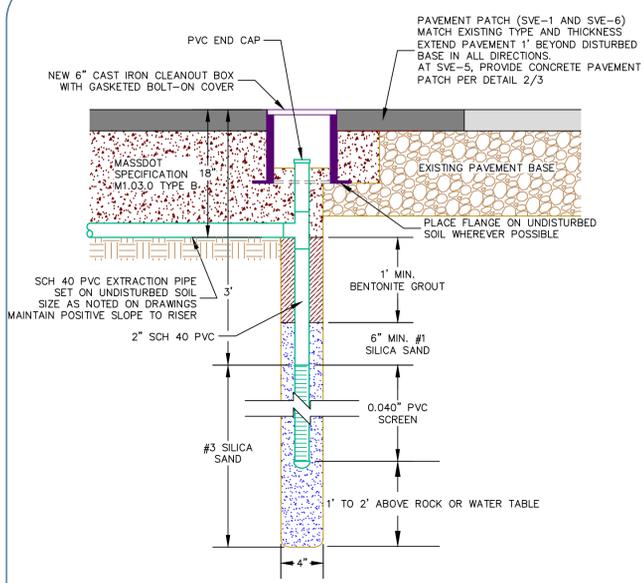
UNIFIRST CORPORATION
68 JONSPIN ROAD
WILMINGTON, MA 01887

PREPARED BY
The Johnson Company
ENVIRONMENTAL SCIENCE AND ENGINEERING SOLUTIONS

100 State Street, Suite 600
Montpelier, Vermont 05602
(802) 229-4600 phone
(802) 229-5876 fax
www.johnsonco.com

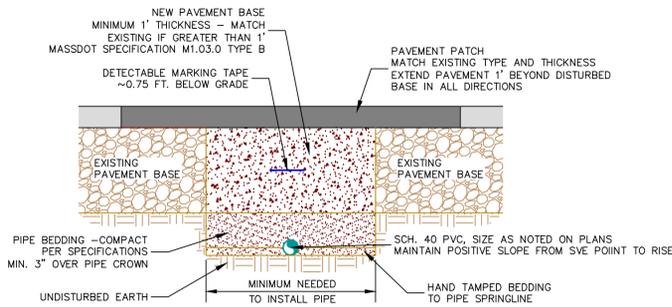
Scale: AS NOTED
Drawn On: 05/02/14
Drawn By: BMLK
Checked On: 05/02/14
Checked By: CMC
Print Date:

SITE PLAN
SOIL VAPOR EXTRACTION SYSTEM
WELLS G&H SUPERFUND SITE, UNIFIRST PROPERTY
WOBURN, MASSACHUSETTS



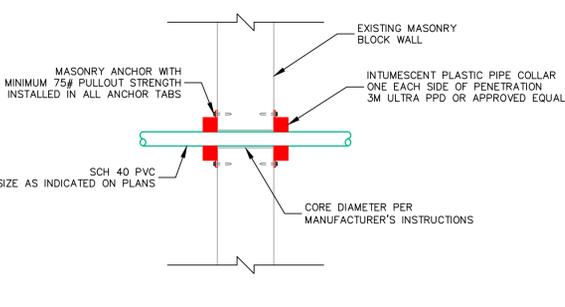
DETAIL 1 EXTERIOR SOIL VAPOR EXTRACTION POINT
SCALE: N.T.S.

NOTE:
AT EXISTING WELL SVE-1, REMOVE CONCRETE FILL AT WELL HEAD AND CUT EXISTING SCH 40 PVC CASING TO ALLOW FOR INSTALLATION OF TEE.

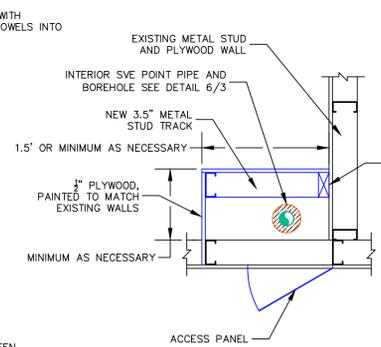


DETAIL 2 EXTERIOR EXTRACTION PIPE TRENCH
SCALE: NONE

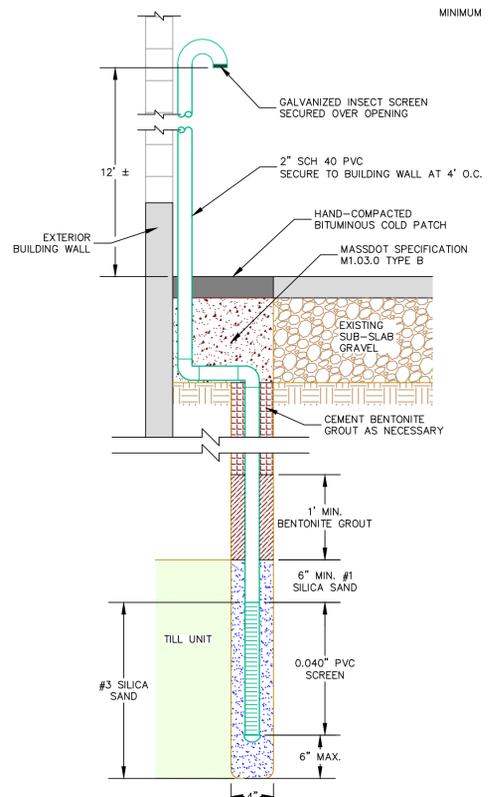
NOTE:
1. AT SVE-5, PROVIDE PORTLAND CEMENT CONCRETE PATCH WITH THICKNESS TO MATCH EXISTING SLAB. EPOXY #4 REBAR DOWELS INTO EXISTING SLAB AT 18" O.C. ALTERNATING SIDES.



DETAIL 3 INTERIOR BLOCK WALL PENETRATION
SCALE: N.T.S.

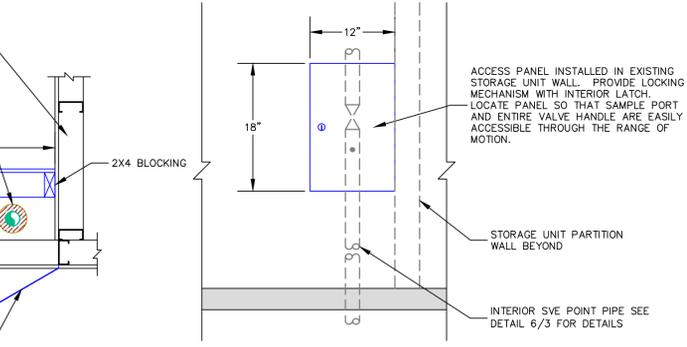


DETAIL 4 SVE POINT VALVE ACCESS PANEL
SCALE: N.T.S.



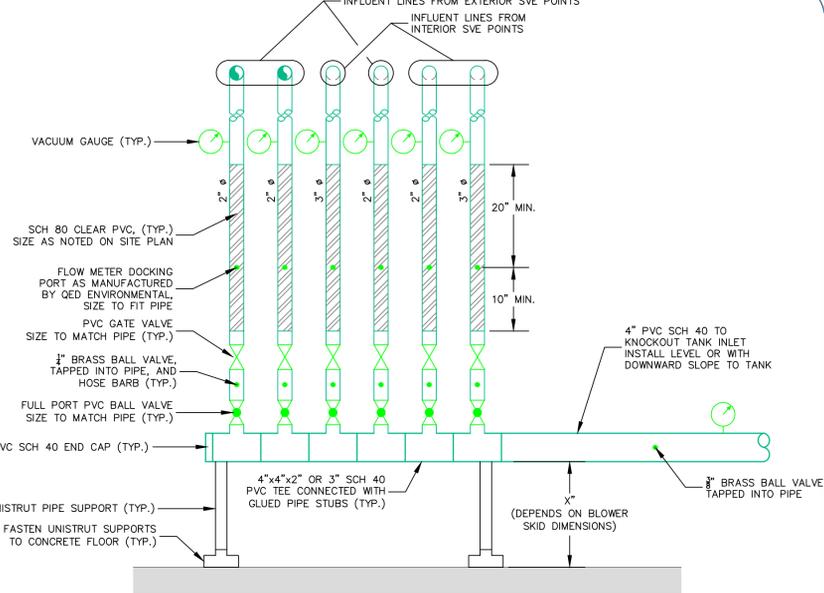
DETAIL 5 PASSIVE AIR INJECTION WELL
SCALE: N.T.S.

NOTE:
1. SCREENED INTERVAL TO BE FIELD DETERMINED BY A QUALIFIED GEOLOGIST

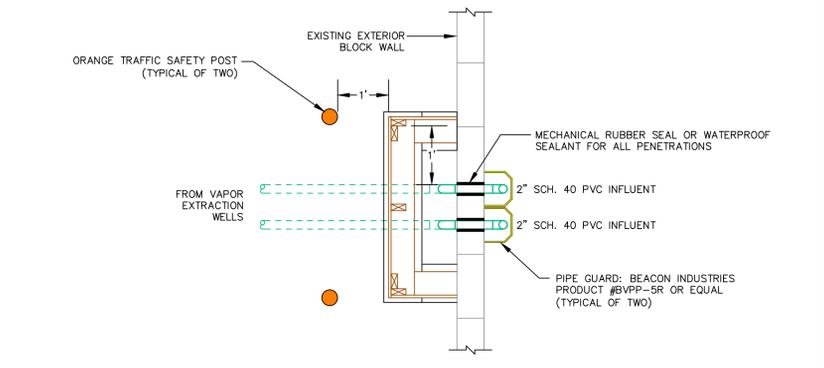


DETAIL 6 INTERIOR SOIL VAPOR EXTRACTION POINT
SCALE: N.T.S.

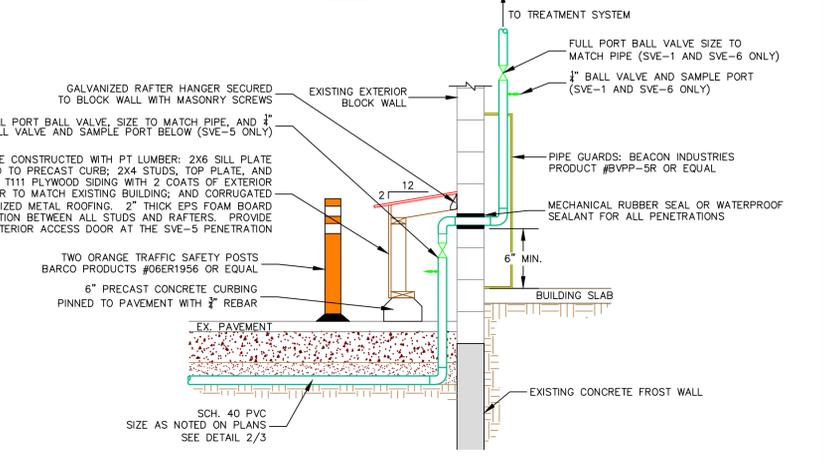
NOTE:
1. WELL SVE-2A SHALL BE SCREENED IN THE TILL UNIT ONLY. SCREENED INTERVAL TO BE FIELD DETERMINED BY A QUALIFIED GEOLOGIST.
2. CONSTRUCT PIPE CHASE ON INTERIOR OF STORAGE UNIT TO HOUSE SVE PIPE RISER. PROVIDE ACCESS PANEL IN STORAGE LOCKER WALL FOR SAMPLE PORT AND BALL VALVE. SEE DETAIL 4/3.



DETAIL 7 INFLUENT MANIFOLD
SCALE: N.T.S.



DETAIL 8 EXTERIOR AIR INLET
SCALE: N.T.S.



DETAIL 9 PERMEABLE PAVEMENT REPLACEMENT
SCALE: N.T.S.

DETAIL 10 PENETRATION THROUGH EXTERIOR BUILDING WALL
SCALE: N.T.S.

NOTE:
1. ADJUST ENCLOSURE WIDTH AS NECESSARY TO ACCOMMODATE VARYING NUMBERS OF PIPE PENETRATIONS.
2. PROVIDE ISOLATION VALVE AND SAMPLE PORT ON THE INTERIOR OF THE BUILDING AT THE SVE-1 AND SVE-6 PENETRATIONS AND ON THE EXTERIOR OF THE BUILDING AT THE SVE-5 PENETRATION.

#	Date	Drwn	Chk'd	App'd	Description

K:\1-2114-2\CAD\SVE FINAL DESIGN\FINAL DESIGN BASE DRAWING.DWG

UNIFIRST CORPORATION
68 JONSPIN ROAD
WILMINGTON, MA 01887

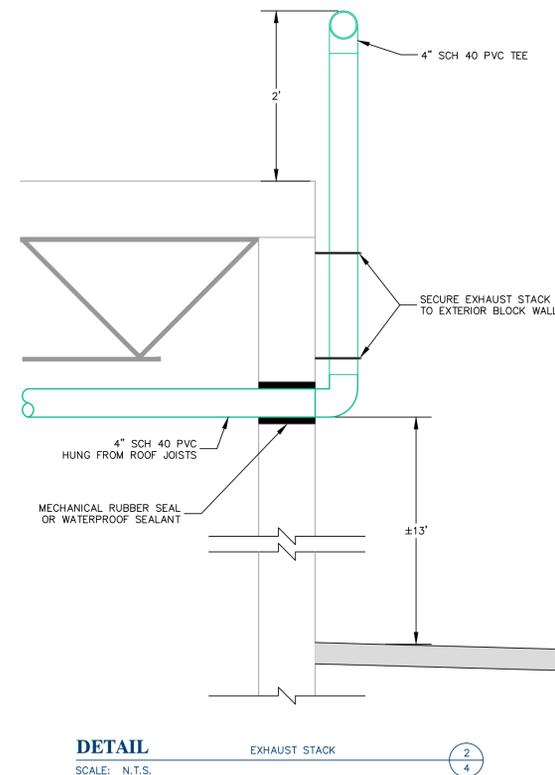
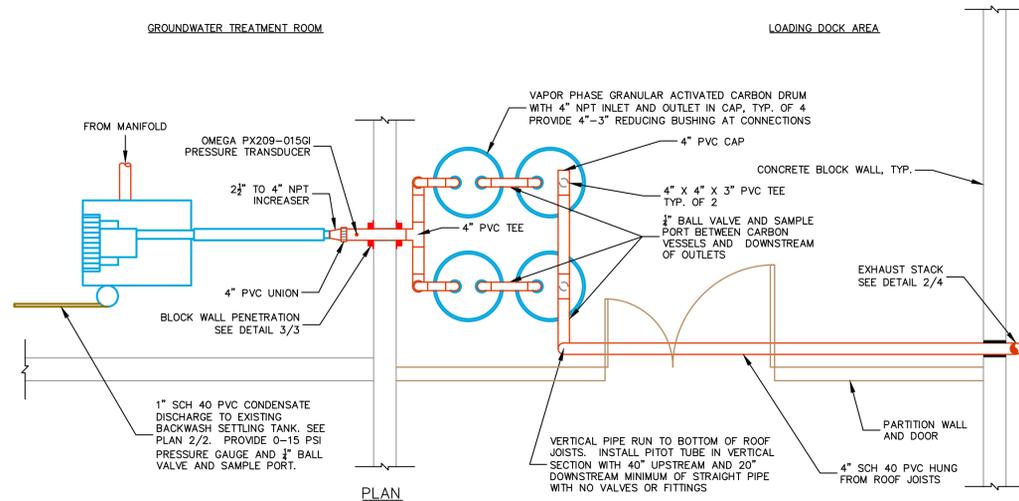
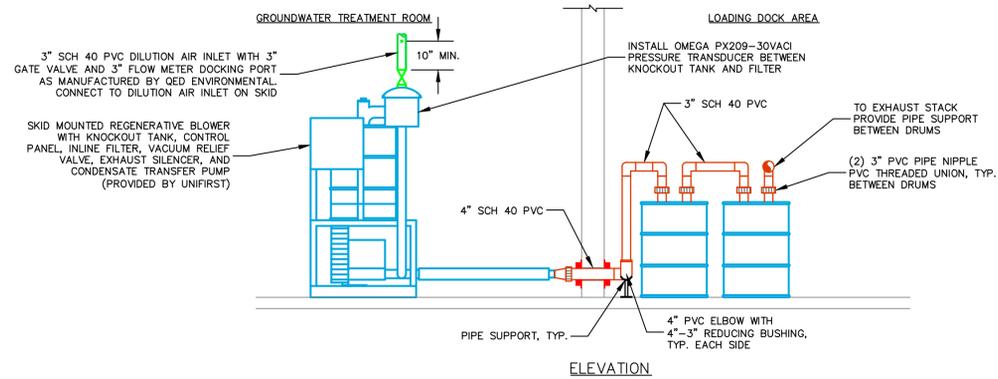
Job#: 1-2114-02

PREPARED BY
The Johnson Company
ENVIRONMENTAL SCIENCE AND ENGINEERING SOLUTIONS

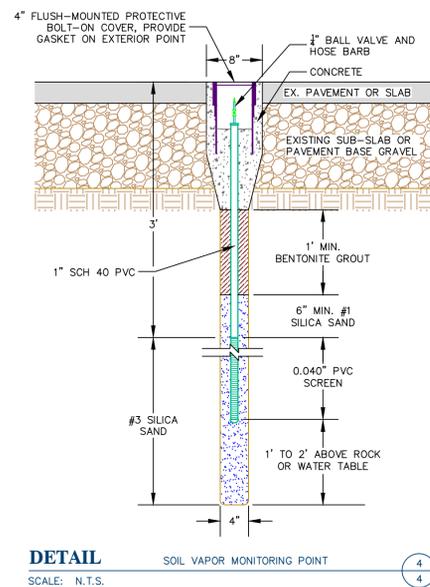
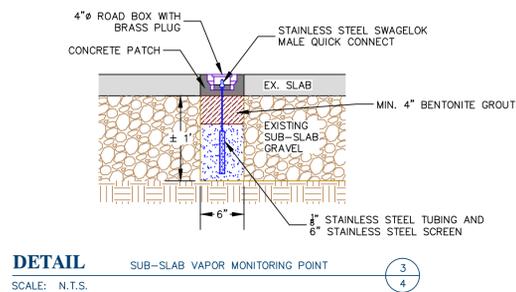
100 State Street, Suite 600
Montpelier, Vermont 05602
(802) 229-4600 phone
(802) 229-5876 fax
www.johnsonco.com

Scale: AS NOTED
Drawn On: 05/02/14
Drawn By: BMLK
Checked On: 05/02/14
Checked By: CMC
Print Date:

CONSTRUCTION DETAILS
SOIL VAPOR EXTRACTION SYSTEM
WELLS G&H SUPERFUND SITE, UNIFIRST PROPERTY
WOBURN, MASSACHUSETTS



DETAIL VAPOR PHASE ACTIVATED CARBON TREATMENT SYSTEM 1/4
SCALE: 1" = 2.5'



DETAIL SUB-SLAB VAPOR MONITORING POINT 3/4
SCALE: N.T.S.

DETAIL SOIL VAPOR MONITORING POINT 4/4
SCALE: N.T.S.

#	Date	Drwn	Chk'd	App'd	Description

UNIFIRST CORPORATION
68 JONSPIN ROAD
WILMINGTON, MA 01887

PREPARED FOR
Job#: 1-2114-02

PREPARED BY
The Johnson Company
ENVIRONMENTAL SCIENCE AND ENGINEERING SOLUTIONS

100 State Street, Suite 600
Montpelier, Vermont 05602
(802) 229-4600 phone
(802) 229-5876 fax
www.johnsonco.com

Scale: AS NOTED
Drawn On: 05/02/14
Drawn By: BMLK
Checked On: 05/02/14
Checked By: CMC
Print Date:

CONSTRUCTION DETAILS
SOIL VAPOR EXTRACTION SYSTEM
WELLS G&H SUPERFUND SITE, UNIFIRST PROPERTY
WOBURN, MASSACHUSETTS

APPENDIX 1
DESIGN CALCULATIONS

APPENDIX 1

SOIL VAPOR EXTRACTION SYSTEM DESIGN CALCULATIONS

1. PNEUMATIC MODEL AND BLOWER SELECTION

A pneumatic model of the system was developed in order to size and select an appropriate blower for the SVE system. The blower size is determined by the pressure differential required between the inlet and outlet of the blower in order to provide design vacuum levels at the SVE points. The pneumatic model considers the system from a point at the ground surface near the SVE points to the outlet of the exhaust stack.

Friction loss between the ground surface and the SVE point (i.e. applied SVE point vacuum) was modeled using step test data from the pilot test. Applied vacuum at each pilot test SVE point was plotted against the soil vapor flow rate produced by the point. Regressions were applied to each data set to obtain a mathematical relationship between vacuum and flow rate for each point (see Figures A1-1 through A1-4). This empirical relationship accounts for friction loss through the soil at varying system flow rates. Proposed SVE point locations were assumed to be similar to nearby pilot test wells. For the two locations where a pilot test SVE point is not immediately adjacent to proposed SVE points, SVE-6 was assumed to be similar to SVE-1 and SVE-5 was assumed to be similar to SVE-3.

Friction losses in each piping run between SVE points and the blower inlet manifold were modeled using the Darcy-Weisbach equation (Equation 1 below). The airflow is assumed to behave as an incompressible fluid due to the low velocity in the system. Friction losses due to valves and fittings were modeled using the equivalent length method.

$$h_f = f \frac{L V^2}{D 2g}$$

Equation 1. – Darcy-Weisbach Equation

Backpressure on the blower outlet must also be included in the blower sizing and selection. The backpressure is equal to the friction losses between the blower outlet and the stack outlet. The pipe, valve, and fitting losses were modeled as described in the preceding paragraph. Losses through the vapor phase GAC treatment were modeled using available manufacturer's data.

In a parallel pipe system, pressures at the inlet (atmospheric pressure in this case) and outlet (at the blower inlet manifold) are the same for all branches. Pressure drop (resulting from friction losses) in each branch must, therefore, be equal. In order to develop a system curve, various flow rates were entered into the model and the resulting system pressure drop was calculated. Since flow rate controls both mechanical friction losses (pipes, valves, and fittings) and friction losses through soil, flow rate in each piping run was adjusted iteratively until the pressure drop through each branch was equal. Thus, total system pressure drop and applied vacuum at each SVE point are calculated for a given total flow rate.

In order to provide flexibility in balancing the system for optimal contaminant removal, control valves will be provided in each influent pipeline. The pilot test indicates that optimal contaminant removal will be obtained by applying a vacuum of approximately 20 inches of water (in. H₂O) on points SVE-2A and SVE-4A and 30 in. H₂O on the remaining SVE points. In order to model the response of the blower at this predicted optimal extraction scenario, friction losses from the control valves were included in the model. A pressure drop of 10 inches of water was modeled across the control valves on the piping runs from points SVE-2A and SVE-4A when developing the system curve. This simulates the use of control valves to achieve lower applied vacuums at SVE-2A and SVE-4A.

Once the total system pressure drop is calculated, it is added to the blower outlet backpressure at the given flow rate. This sum is plotted against the system flow rate to form one point on the system curve. Various flow rates are input into the system model and plotted to form the complete system curve. The resulting system curve is then compared to blower vacuum curves provided by the manufacturers. The intersection of the system and blower vacuum curves is the theoretical operating point of a particular blower (i.e. the flow rate that can be expected to be produced by the blower when connected to the system). See Table A1-1 for an example pneumatic model calculation sheet.

An HRB 800 regenerative blower, manufactured by Republic Blower Systems, has been selected for the SVE system. The theoretical operating point of this blower is 290 cubic feet per minute at standard conditions (SCFM) at a vacuum of 54 inches of water (see Figure A1-5). The pneumatic model predicts that this blower will create vacuums at the SVE points of 16 in. H₂O at points SVE-2A and SVE-4A, and 25-27 in. H₂O at the remaining points.

Due to observed overlap in the areas of influence of the SVE points during the pilot test, it is expected that the actual flow rate at a given amount of applied vacuum will be lower than predicted by the model. The overlapping areas of influence will reduce the volume of air available to be extracted from each point. At a reduced flow rate, the blower is capable of producing a higher vacuum (i.e., the operating point moves up the blower curve). Therefore, the specified blower should be able to achieve the design applied vacuum at each well. The existing and proposed soil vapor monitoring wells will be used to monitor the SVE system area of influence (see Final Design Report section 4.2.4).

2. ESTIMATED INFLUENT SOIL GAS CONCENTRATION

Influent soil gas samples were collected from each of the SVE points during the constant-rate portion of the pilot test; at the beginning, midpoint, and end of the 24- or 48-hour test. The samples were analyzed for VOCs by EPA Method TO-15. The end-of-test results are considered a conservative representation of expected concentrations during the early operation of the full-scale system. As expected, a decline in VOC concentrations over the constant rate test durations was noted; therefore, VOC concentrations are expected to decline over time during full-scale operation of the SVE system as well. The end-of-test analytical results are provided in Table A1-2.

As described in the *Vapor Extraction Pilot Test Summary Report* (The Johnson Company and B. Kueper & Associates, 2013), the detections of carbon disulfide are not considered representative of soil vapor conditions at the Property and have therefore been ignored. Carbon disulfide was also reported in the two laboratory duplicate samples (samples which were not collected at the UniFirst Property) at concentrations of 3.83 and 7.01 $\mu\text{g}/\text{m}^3$.

The influent concentration estimate was calculated by weighting the individual SVE point concentrations by the percentage of the composite flow produced by SVE 2 and SVE 4 at 20 in. H_2O and SVE 1 and SVE 3 at 30 in. H_2O vacuum (design applied vacuums under full-scale operation). The method detection limit was used for compounds that were reported by the laboratory as non-detect. Table A1-3 provides the individual flow rates and their percentage of the composite flow. Table A1-4 provides the estimated influent concentrations.

3. ESTIMATED VAPOR PHASE CARBON USAGE

An estimate of contaminant mass flow rate was derived using the calculated influent concentration and the nominal flow rate predicted by the pneumatic model for full-scale operation, 290 SCFM. The vast majority (99%) of the calculated VOC mass in the extracted soil vapor is expected to be tetrachloroethene (PCE). Of those VOC constituents expected to be present in the extracted soil vapor, PCE is the most efficiently adsorbed by GAC. The mass flow rate calculations are provided in Table A1-5.

The calculated mass flow rate was used to determine expected carbon use and replacement frequency. Vapor phase carbon adsorption isotherms, developed by an activated carbon manufacturer (available online at www.pacco-intl.com/isotherms.asp), were used to evaluate adsorptive capacity of the individual compounds at their estimated influent concentration. Isotherm graphs used in the development of carbon usage estimates are provided as Figures A1-6 through A1-9.

The soil gas treatment will consist of two parallel trains of two carbon drums in series (as employed during the pilot testing). Each drum contains 175 pounds of granular activated carbon (GAC) for a total of 350 pounds in the primary drums and 350 pounds in the secondary drums. The carbon use estimate calculation yields a saturation loading of approximately 2.7 pounds per day (see Table A1-5). It would, therefore, take 129 days to saturate the 350 pounds of GAC contained in the primary drums. However, complete saturation is not typically achieved before breakthrough of VOCs from a GAC vessel. Given the calculated time to primary drum saturation, the system is expected to operate for at least two weeks before breakthrough occurs. Breakthrough is defined as greater than 1 ppmV total VOC, measured between primary and secondary drums by a PID with an 11.7 eV lamp. This estimate is consistent with the pilot test when during approximately 2 days of step testing and 7 days of constant rate testing, no reproducible positive PID readings were obtained from samples collected between the primary and secondary drums.

TABLES

**TABLE A1-1
SOIL VAPOR EXTRACTION SYSTEM PNEUMATIC MODEL
WELLS G&H SUPERFUND SITE, UNIFIRST PROPERTY
WOBURN, MASSACHUSETTS**

Constants

Density of air	0.00238	slugs/ft ³ (59° F and 1 atm)
Gravity	32.2	ft/s ²
μ	0.000000374	lb*s/ft ² (59° F and 1 atm)
Flow at blower	290	SCFM

SVE Points and Piping

Parameter	SVE-1	SVE-2A	SVE-3A	SVE-4A	SVE-5	SVE-6	Blower Inlet
Flow (SCFM)	13.6	111.5	33	85	33.3	13.6	290
Nom. Size (in.)	2	3	2	3	2	2	4
Inside Dia. (in.)	2.067	3.068	2.067	3.068	2.067	2.067	4.026
Pipe Area (ft ²)	0.023	0.051	0.023	0.051	0.023	0.023	0.088
Velocity (ft/s)	9.7	36.2	23.6	27.6	23.8	9.7	54.7
Re	1.07E+04	5.89E+04	2.59E+04	4.49E+04	2.61E+04	1.07E+04	1.17E+05
ε/d	2.903E-05	1.956E-05	2.903E-05	1.956E-05	2.903E-05	2.903E-05	1.490E-05
f	0.0304	0.0203	0.0245	0.0216	0.0244	0.0304	0.0176
L (ft.)	64.2	50	139.7	88.1	103	70.5	3
Regular 90° Bend	7	3	4	4	6	6	0
45° Bend	0	0	0	0	0	1	0
Tee - Branch Flow	2	1	1	1	2	2	0
Ball Valve (open)	1	1	1	1	1	1	0
Equivalent Length (ft.)	65.4	42	36.3	49.9	59.7	62.3	0
Friction Loss (ft. air)	33.6	148.9	216.4	137.7	203.3	34.4	7.3
Friction Loss (psi)	0.02	0.08	0.12	0.07	0.11	0.02	0.00
Friction Loss (in. H ₂ O)	0.5	2	3	2	3	1	2
Soil Losses (in. H ₂ O)	27	16	25	16	25	27	0
Induced Control Valve Losses (in. H ₂ O)	0	10	0	10	0	0	0
Total Losses (in. H ₂ O)	28	28	28	28	28	28	2

Vacuum at Blower Inlet (in. H₂O)	30
--	-----------

TABLE A1-1 (continued)
SOIL VAPOR EXTRACTION SYSTEM PNEUMATIC MODEL
WELLS G&H SUPERFUND SITE, UNIFIRST PROPERTY
WOBURN, MASSACHUSETTS

Pressure Drop Through Vapor Treatment and Exhaust

Parameter	PVC to Tee	Through Drums	Carbon Drum ¹	Stack
Flow (SCFM)	290	145	145	290
Nom. Size (in.)	4	3	n/a	4
Inside Dia. (in.)	4.026	3.068	n/a	4.026
Pipe Area (ft ²)	0.088	0.051	n/a	0.088
Velocity (ft/s)	54.7	47.1	n/a	54.7
Re	1.17E+05	7.66E+04	n/a	1.17E+05
ε/d	1.5E-05	2.0E-05	n/a	1.5E-05
f	0.0176	0.0192	n/a	0.0176
L (ft.)	1.6	9.2	n/a	30
Regular 90°	0	5	n/a	3
45° Fitting	0	0	n/a	0
Tee - Branch Flow	1	1	n/a	0
Ball Valve (open)	0	0	n/a	0
Increaser	0	0	n/a	0
Equivalent Length (ft.)	22.0	55.9	n/a	34.2
Friction Loss (ft. air)	57.6	168.6	610.5	156.6
Friction Loss (psi)	0.03	0.09	0.32	0.08
Friction Loss (in. H ₂ O)	0.8	2.5	9	2.3

<u>Back Pressure at Blower Outlet (in H₂O)</u>	23.6
--	-------------

System Curve Point

Δ P (in. H ₂ O)	53.8
Air Flow (SCFM)	290

TABLE A1-2
SELECTED CONSTANT RATE TEST SAMPLE RESULTS FROM 2012 PILOT TEST
WELLS G&H SUPERFUND SITE, UNIFIRST PROPERTY
WOBURN, MASSACHUSETTS

Location	SVE-1	SVE-2	SVE-3	SVE-4
Sample	End of Test	End of Test	End of Test	End of Test
Date	10/27/2012	11/18/2012	11/09/2012	11/15/2012
Time	7:42	7:17	7:43	7:18
1,1,1-Trichloroethane	ND < 35.6	ND < 10.9	49.0	38.5
Carbon disulfide	ND < 20.3	ND < 6.23	6.29	10.8
cis-1,2-Dichloroethene	100	17.9	ND < 7.93	35.0
Tetrachloroethene	63,300	6,360	40,300	22,800
Trichloroethene	586	44.3	67.7	88.7

Notes

1. All results reported as $\mu\text{g}/\text{m}^3$

**TABLE A1-3
PROPORTIONAL VAPOR EXTRACTION FLOW RATES
WELLS G&H SUPERFUND SITE, UNIFIRST PROPERTY
WOBURN, MASSACHUSETTS**

Extraction Well	Applied Vacuum (in. H₂O)	Flow Rate (SCFM)	Percent of Total
SVE-1	30	15	5.3%
SVE-2	20	130	46.1%
SVE-3	30	38	13.5%
SVE-4	20	99	35.1%
Total		282	100.0%

TABLE A1-4
ESTIMATED INFLUENT CONCENTRATIONS
WELLS G&H SUPERFUND SITE, UNIFIRST PROPERTY
WOBURN, MASSACHUSETTS

Compound (Extraction Well)	Concentration $\mu\text{g}/\text{m}^3$	Percentage of Composite Flow %	Weighted Concentration $\mu\text{g}/\text{m}^3$
Tetrachloroethene			
SVE-1	63,300	0.05	3,367
SVE-2	6,360	0.46	2,932
SVE-3	40,300	0.13	5,430
SVE-4	22,800	0.35	8,004
PCE			19,734
cis-1,2-Dichloroethene			
SVE-1	100	0.05	5
SVE-2	17.9	0.46	8
SVE-3	7.9	0.13	1
SVE-4	35.0	0.35	12
cis-1,2 DCE			27
Trichloroethene			
SVE-1	586	0.05	31
SVE-2	44.3	0.46	20
SVE-3	67.7	0.13	9
SVE-4	88.7	0.35	31
TCE			92
1,1,1-Trichloroethane			
SVE-1	35.6	0.05	2
SVE-2	10.9	0.46	5
SVE-3	49.0	0.13	7
SVE-4	38.5	0.35	14
1,1,1 TCA			27

**TABLE A1-5
ESTIMATE OF VAPOR PHASE GRANULAR ACTIVATED CARBON USE
WELLS G&H SUPERFUND SITE, UNIFIRST PROPERTY
WOBURN, MASS**

Constants:	Q_{air} cfm, 20°C	Q_{air} m ³ /min									
	290	8.21									
Compound	Expected Concentration		Constituent Mass Flow Rate					Carbon Saturation Rate			
	$\mu\text{g}/\text{m}^3$	ppm	g/min	lb/min	lb/hr	lb/day	lb/month	%W/W ²	lb/hr	lb/day	lb/month
Tetrachloroethene	19,734	2.87	0.1621	3.57E-04	0.0214	0.514	15.43	23	0.09	2.24	67
1,1,1-Trichloroethane	27	0.005	0.0002	4.89E-07	2.9E-05	0.001	0.02	2.3	0.00	0.03	1
Trichloroethene	92	0.02	0.0008	1.67E-06	0.0001	0.002	0.07	3	0.00	0.08	2
<i>cis</i> -1,2-Dichloroethene	27	0.01	0.0002	4.89E-07	0.0000	0.001	0.02	0.5	0.01	0.14	4
			Total (lb./day)		0.518						
			% of total	PCE	99.3%						
				1,1,1 TCA	0.14%						
				TCE	0.46%						
				<i>cis</i> -1,2 DCE	0.14%						
						Mass of carbon, primary drums (lb.)		350			
						Carbon saturated per day (lb.)		2.5			
						Time to saturation (days)		141			

Notes:

1. See table A1-3 for calculation of expected concentrations
2. Carbon adsorption capacity as a percentage of carbon mass. See Figures A1-6 to A1-9.

FIGURES

FIGURE A1-1
APPLIED VACUUM VERSUS VAPOR FLOW RATE — SVE-1
WELLS G&H SUPERFUND SITE, UNIFIRST PROPERTY
WOBURN, MASSACHUSETTS

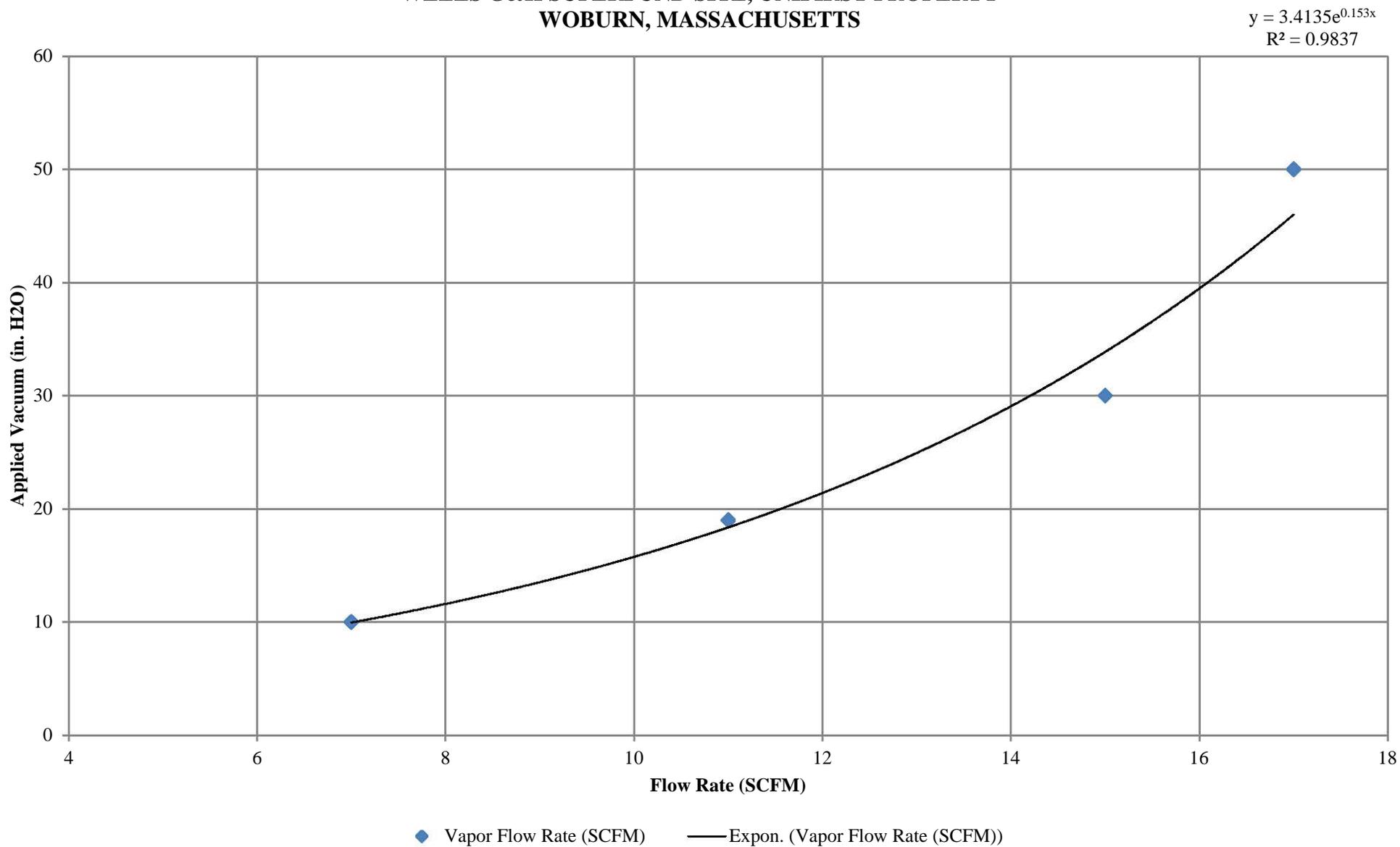


FIGURE A1-2
APPLIED VACUUM VERSUS VAPOR FLOW RATE — SVE-2
WELLS G&H SUPERFUND SITE, UNIFIRST PROPERTY
WOBURN, MASSACHUSETTS

$y = 0.001x^{2.0499}$
 $R^2 = 0.9914$

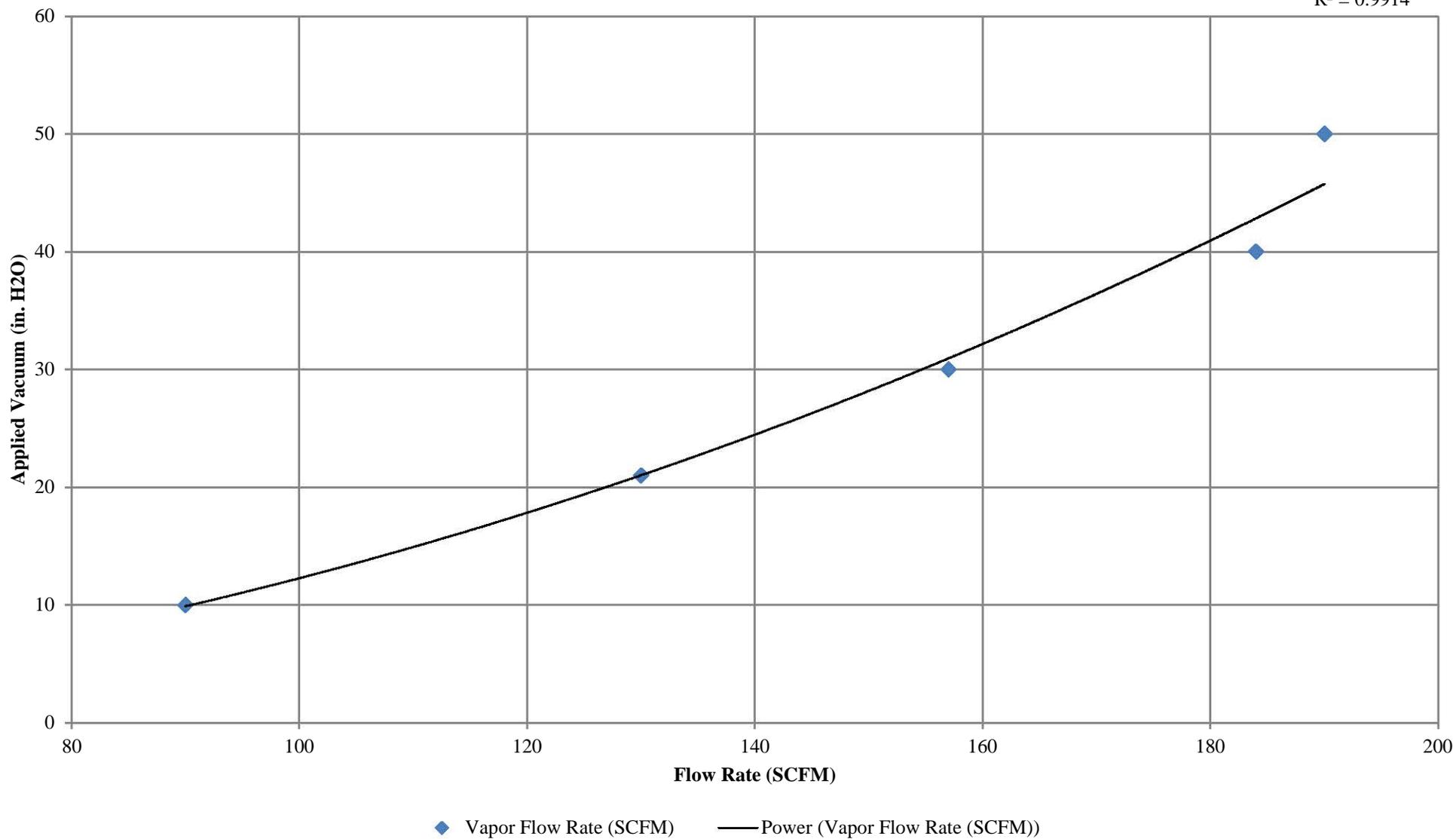
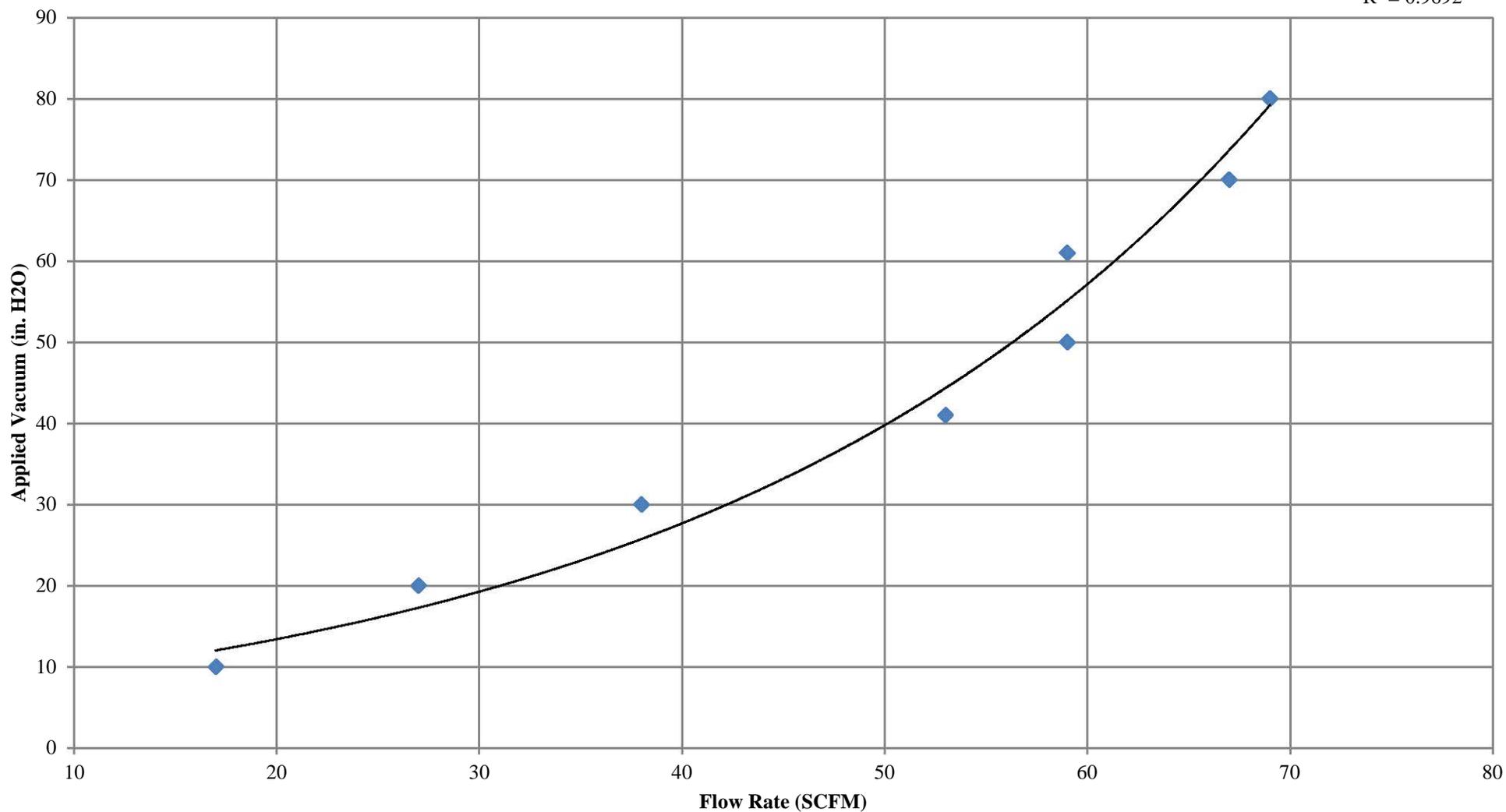


FIGURE A1-3
APPLIED VACUUM VERSUS VAPOR FLOW RATE — SVE-3
WELLS G&H SUPERFUND SITE, UNIFIRST PROPERTY
WOBURN, MASSACHUSETTS

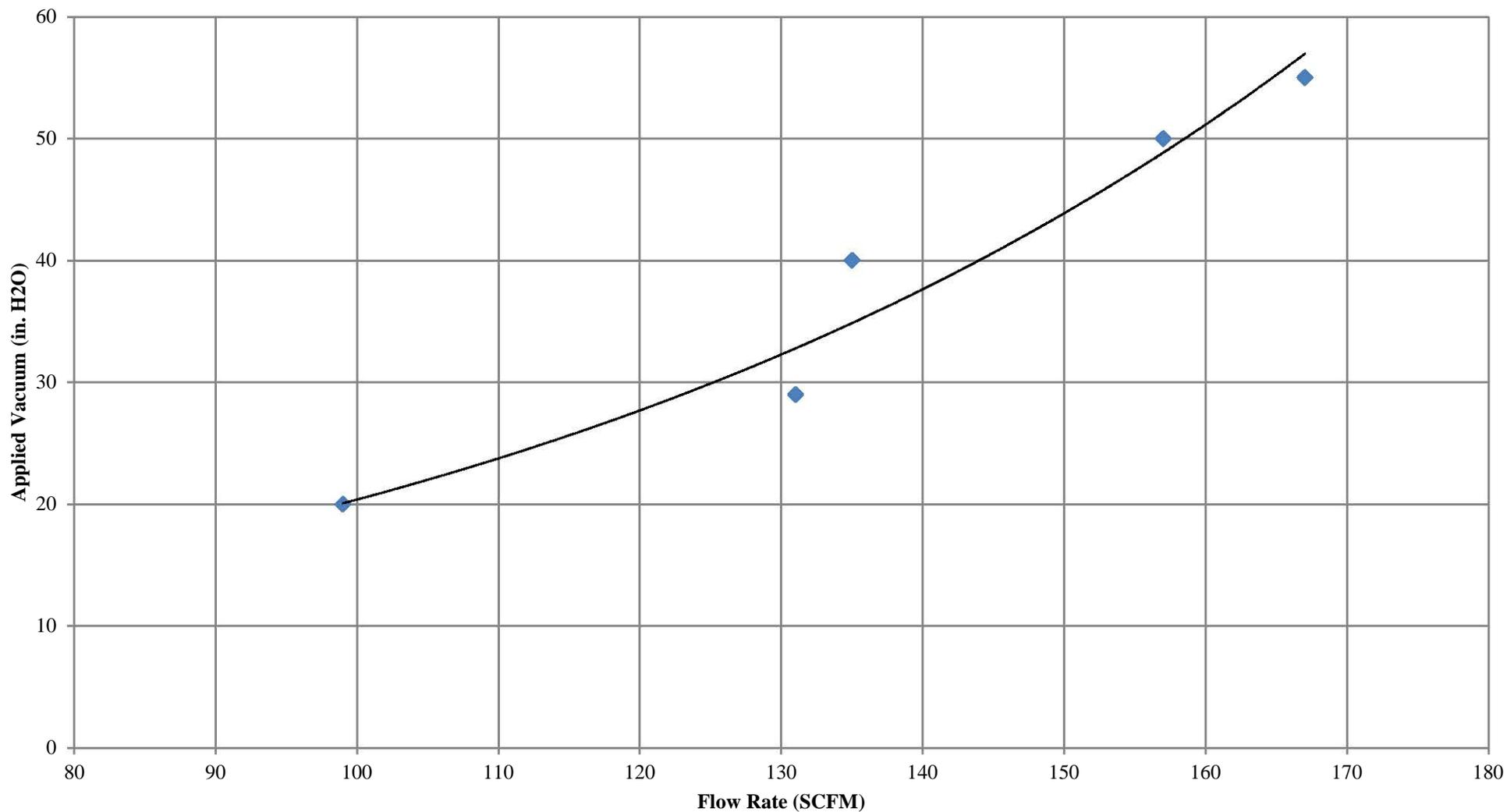
$y = 6.4914e^{0.0363x}$
 $R^2 = 0.9692$



◆ Vapor Flow Rate (SCFM) — Expon. (Vapor Flow Rate (SCFM))

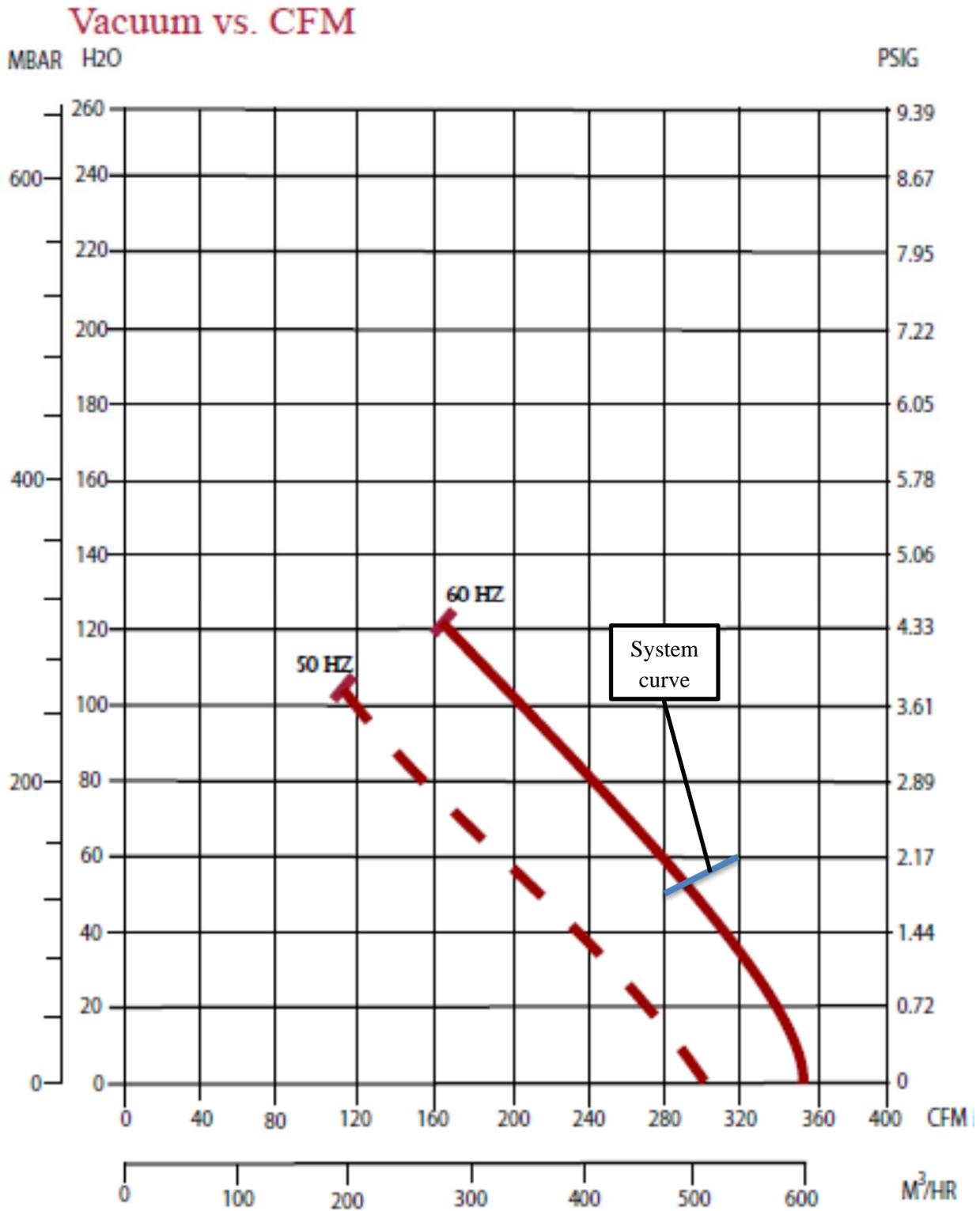
FIGURE A1-4
APPLIED VACUUM VERSUS VAPOR FLOW RATE — SVE-4
WELLS G&H SUPERFUND SITE, UNIFIRST PROPERTY
WOBURN, MASSACHUSETTS

$y = 4.3933e^{0.0153x}$
 $R^2 = 0.9482$



◆ Vapor Flow Rate (SCFM) — Expon. (Vapor Flow Rate (SCFM))

**FIGURE A1-5
 REPUBLIC HRB 800 BLOWER CURVE AND SYSTEM CURVE
 WELLS G&H SUPERFUND SITE, UNIFIRST PROPERTY
 WOBURN, MASSACHUSETTS**



Blower curve provided by Republic Blower Systems

FIGURE A1-6
 TETRACHLOROETHENE VAPOR PHASE ISOTHERM
 WELLS G&H SUPERFUND SITE, UNIFIRST PROPERTY
 WOBURN, MASSACHUSETTS

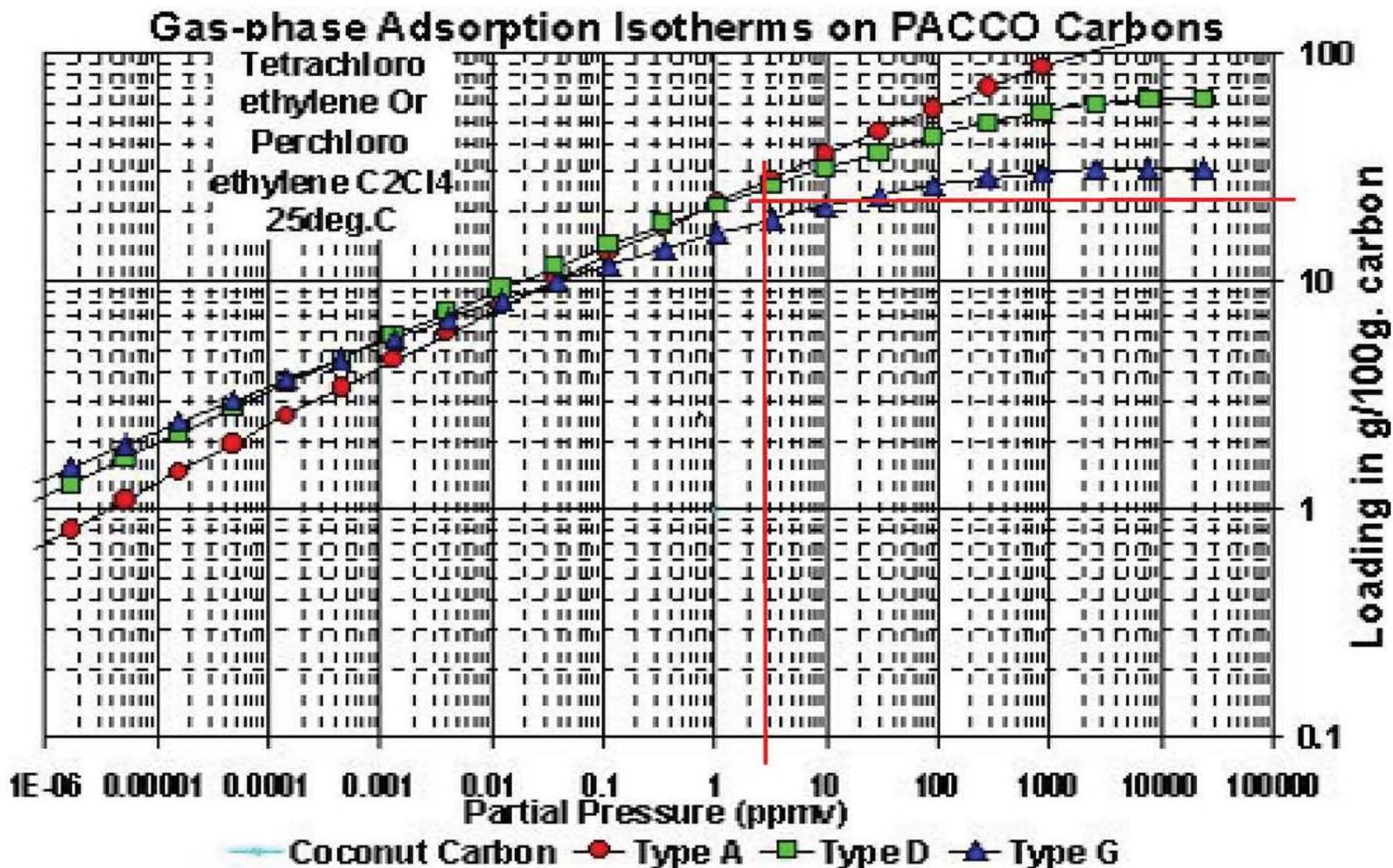


FIGURE A1-7
 1,1,1-TRICHLOROETHANE VAPOR PHASE ISOTHERM
 WELLS G&H SUPERFUND SITE, UNIFIRST PROPERTY
 WOBURN, MASSACHUSETTS

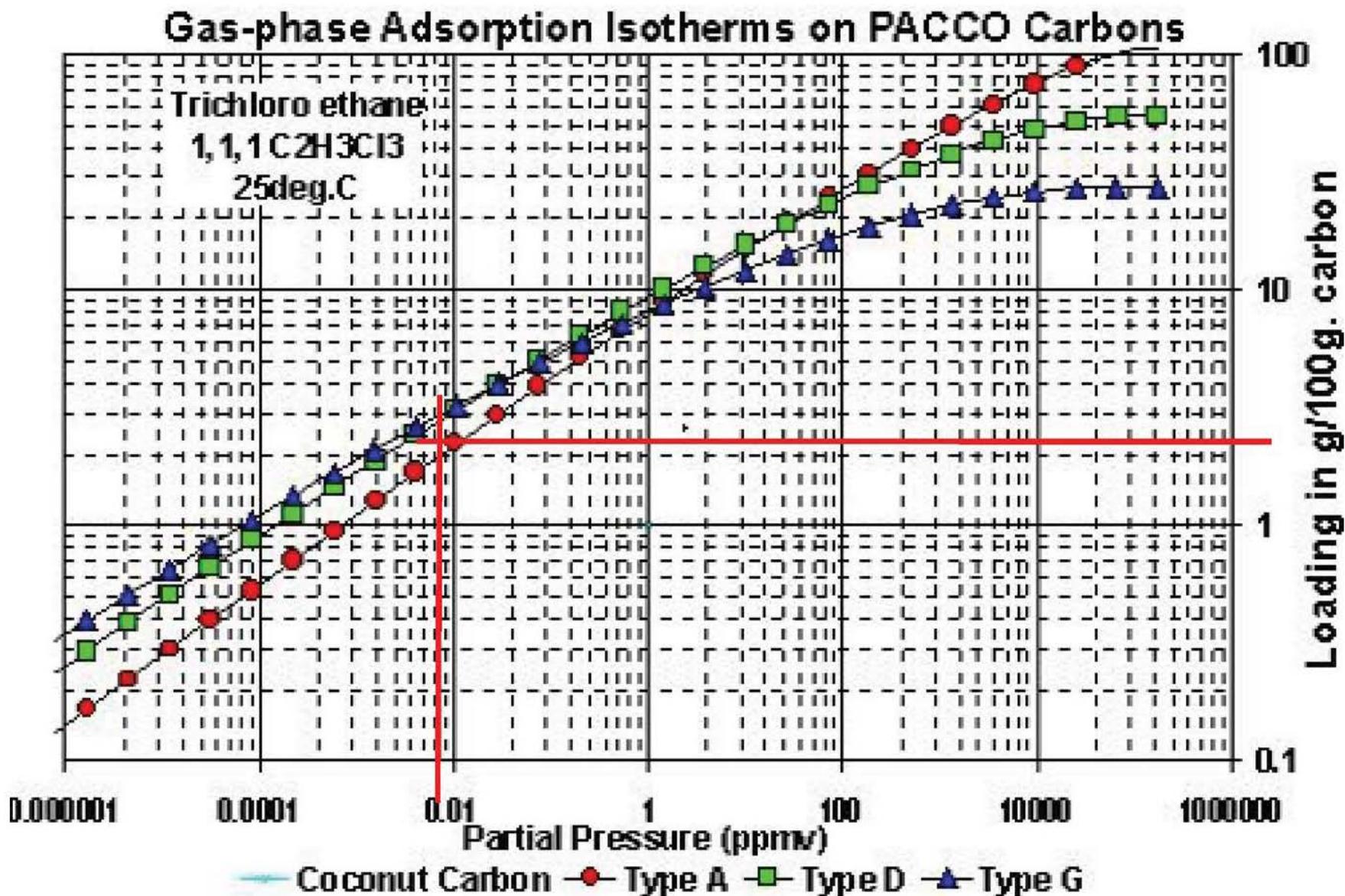


FIGURE A1-8
 TRICHLOROETHENE VAPOR PHASE ISOTHERM
 WELLS G&H SUPERFUND SITE, UNIFIRST PROPERTY
 WOBURN, MASSACHUSETTS

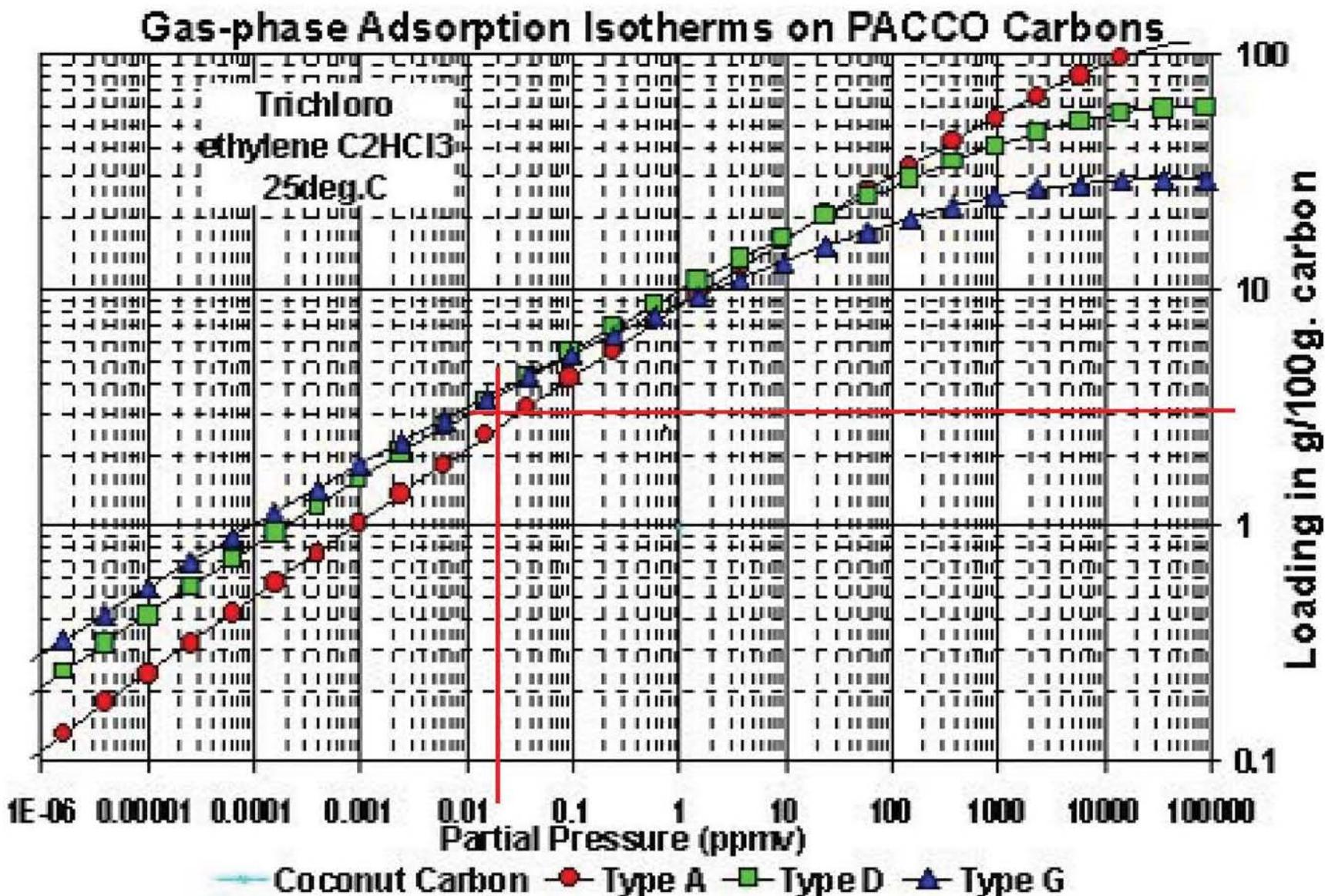
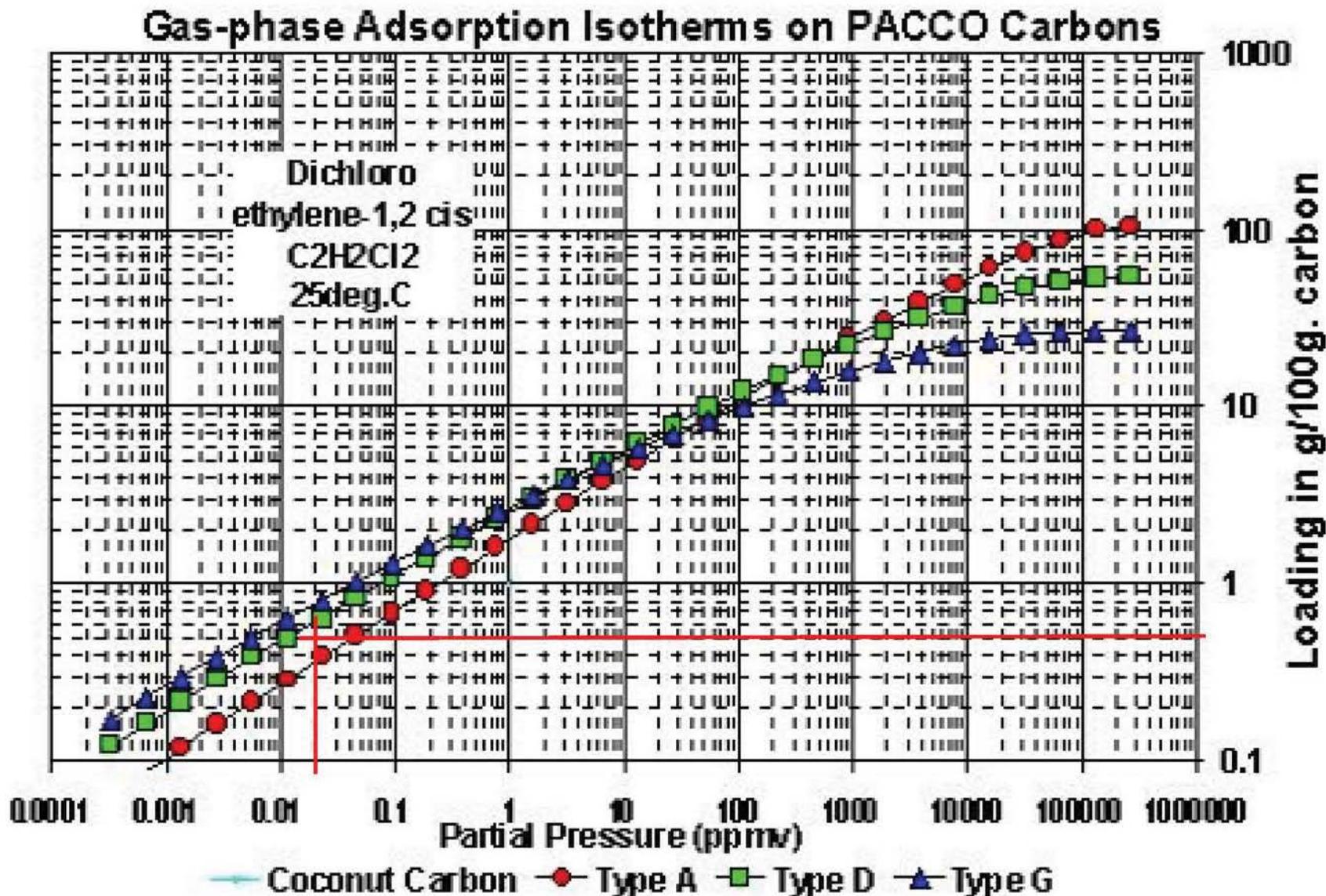


FIGURE A1-9
 cis-1,2-DICHLOROETHENE VAPOR PHASE ISOTHERM
 WELLS G&H SUPERFUND SITE, UNIFIRST PROPERTY
 WOBURN, MASSACHUSETTS



APPENDIX 2

**MANUFACTURERS' CUT SHEETS FOR SVE EQUIPMENT
(provided on CD only)**

Blower System

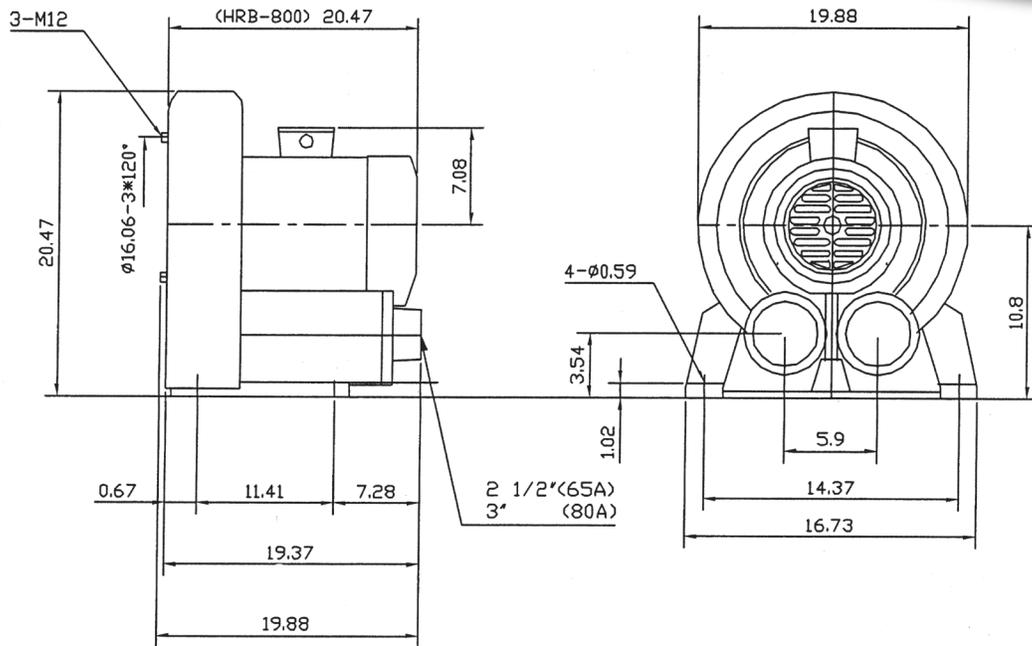


Republic Regenerative Blower HRB 800

REPUBLIC

Blower Systems®

Republic offers a complete line of regenerative blowers for high vacuum or compressed air applications in both horizontal and vertical mounted positions. TEFC motors are UL, cUL and CE certified. The impeller is directly connected to the motor shaft, providing powerful air force without undue friction. The bearings are outside the compression chamber, ensuring maximum operational reliability under high differential pressure. This low-maintenance, oil-free design provides continuous, dependable service to our customers.



Advantages

- ▲ Low noise 78dB
- ▲ Continuous, low-maintenance operation
- ▲ Saves space and electricity
- ▲ Trouble-free installation
- ▲ Easy replacement of parts
- ▲ Outboard bearings yielding longer life
- ▲ Dual voltage 220/440

Product Options

- ▲ 2-1/2" Relief Valve (recommended)
- ▲ Inlet Filter (recommended)
- ▲ Liquid filled gauge
- ▲ Check Valve
- ▲ Belt-driven bare shaft blowers are available
- ▲ Explosion proof motors available
(Class 2/GroupB/Division 1 Certified)

Phase	Motor (HP)	Current @ 50 Hz		Current @ 60 Hz		Sounds Level (dB)	Rated Pressure (in. H2O)		Rated Vacuum (in. H2O)		Air Flow (cfm)		Weight (lbs)
		190V	380V	220V	440V		60 Hz	50 Hz	60 Hz	50 Hz	60 Hz	50 Hz	
3	8.5	22.9	13.3	24.2	14.2	78	110	118	122	106	353	297	318

5131 Cash Road ▲ Dallas, TX 75247 ▲ P 214.631.8070 ▲ F 214.631.3673 ▲ 800.847.0380

www.republicsales.com

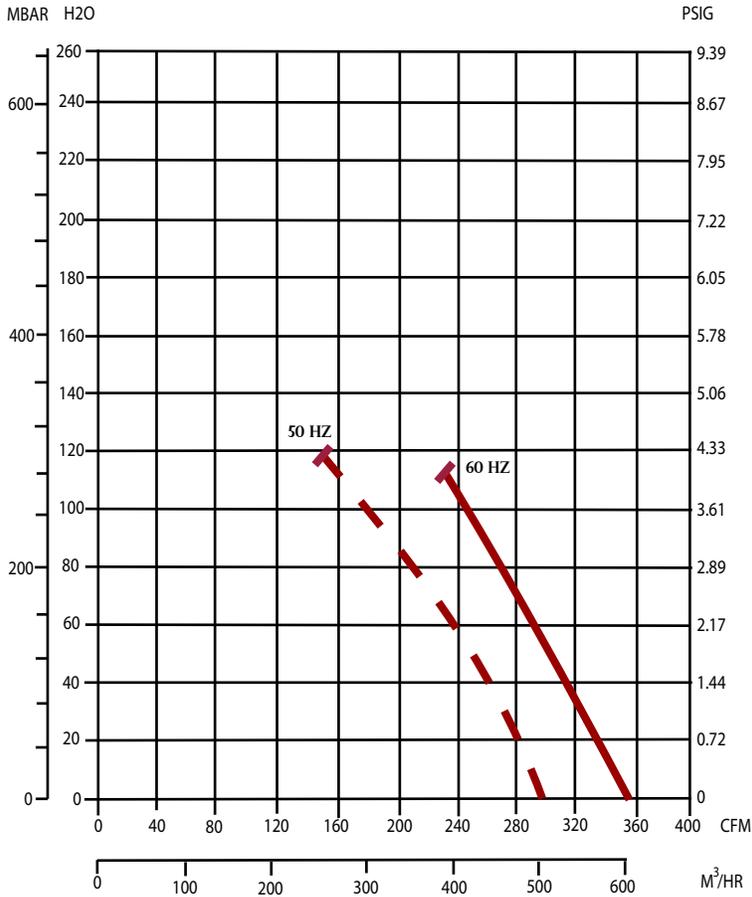
US EPA ARCHIVE DOCUMENT



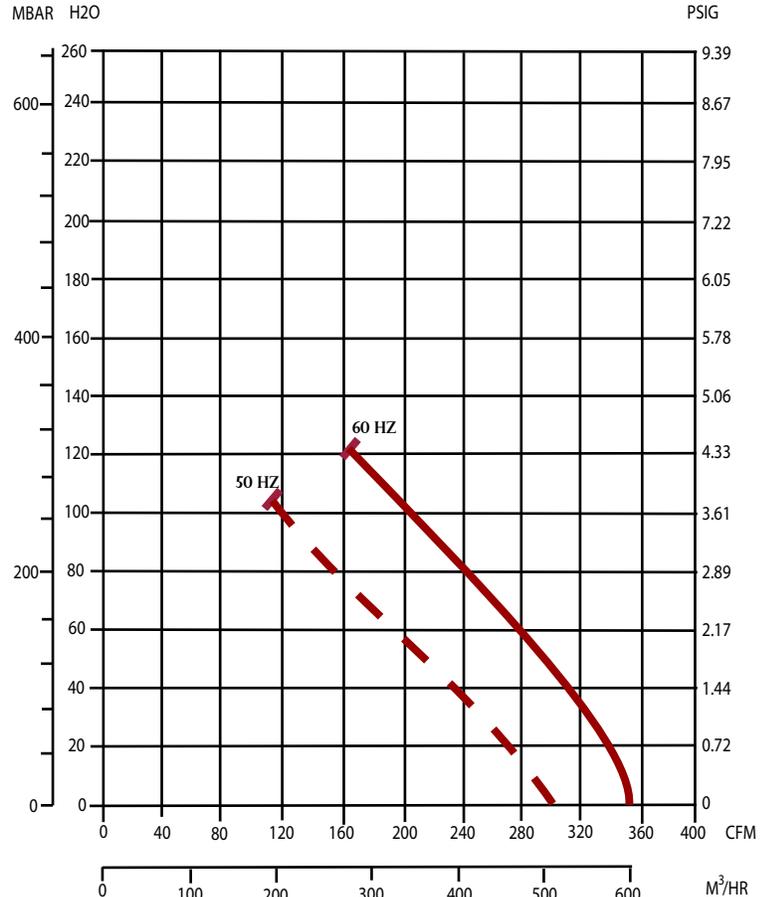
Republic Regenerative Blower HRB 800

REPUBLIC
Blower Systems®

Pressure vs. CFM

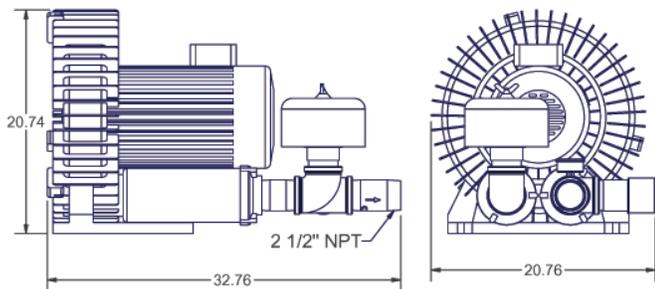


Vacuum vs. CFM



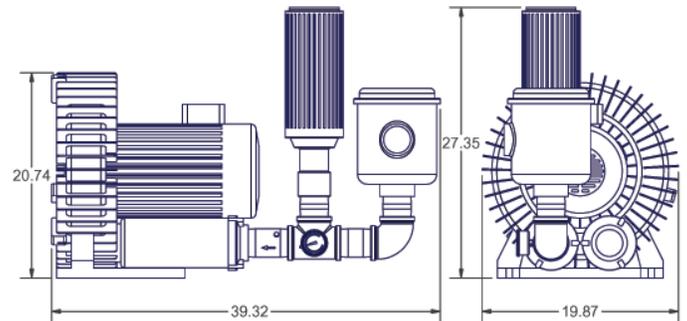
All Republic Regenerative Blowers are available in preassembled kits for either pressure or vacuum applications. These kits include an inlet filter and relief valve, and have been tested prior to shipment. Optional items for these kits include check valve and gauge.

KPHRB800 - Pressure Kit Drawing



Kit Pressure Pump 2 1/2" NPT KPHRB800

KVHRB800 - Vacuum Kit Drawing



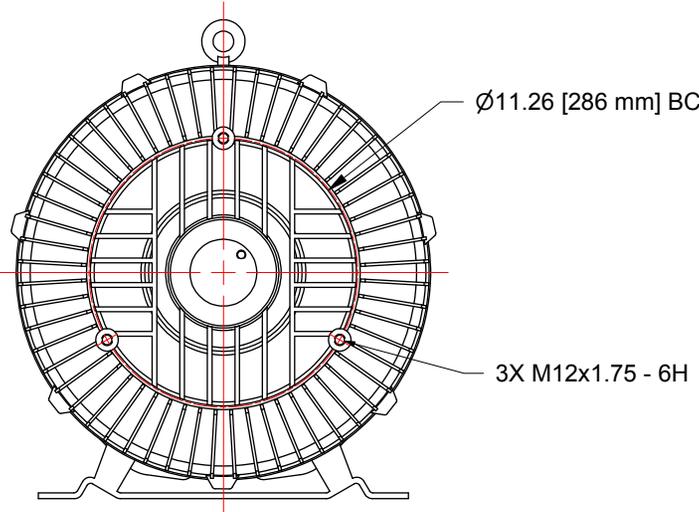
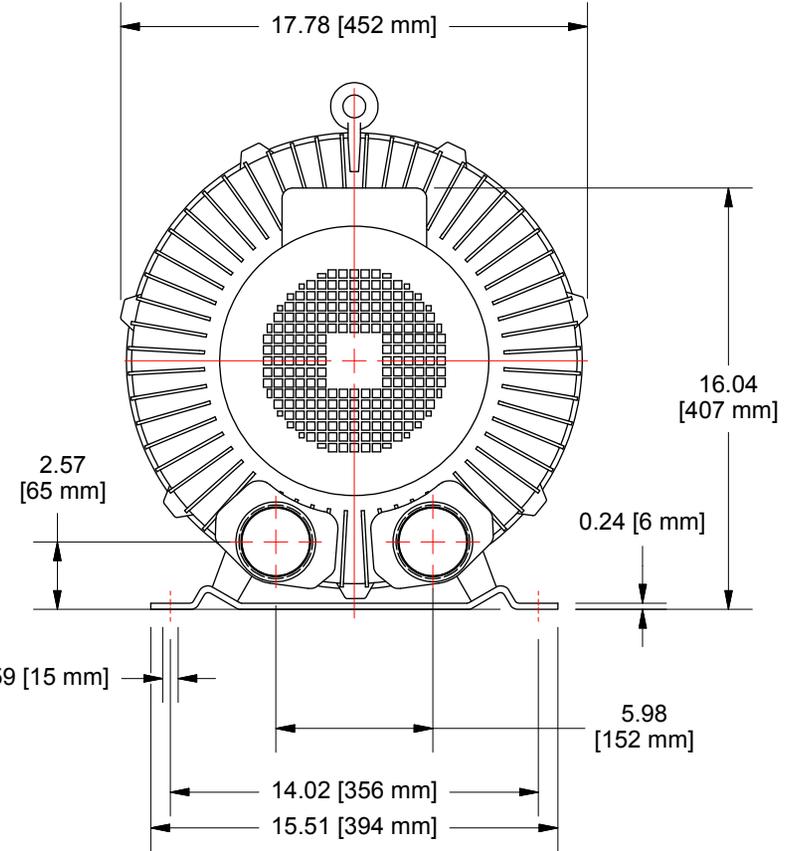
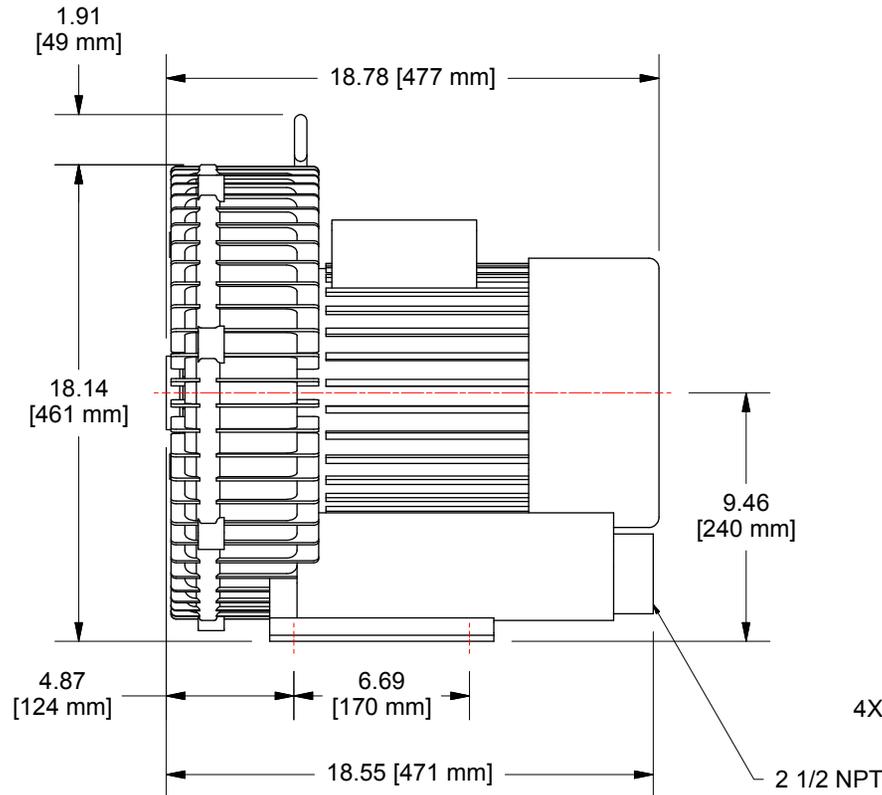
Kit Vacuum Pump 2 1/2" NPT KVHRB800

5131 Cash Road ▲ Dallas, TX 75247 ▲ P 214.631.8070 ▲ F 214.631.3673 ▲ 800.847.0380

www.republicsales.com

©Republic Blower Systems®
Modified 05.11

REVISIONS		DATE	REV BY	ZONE
ECR#	REV	DESCRIPTIONS		



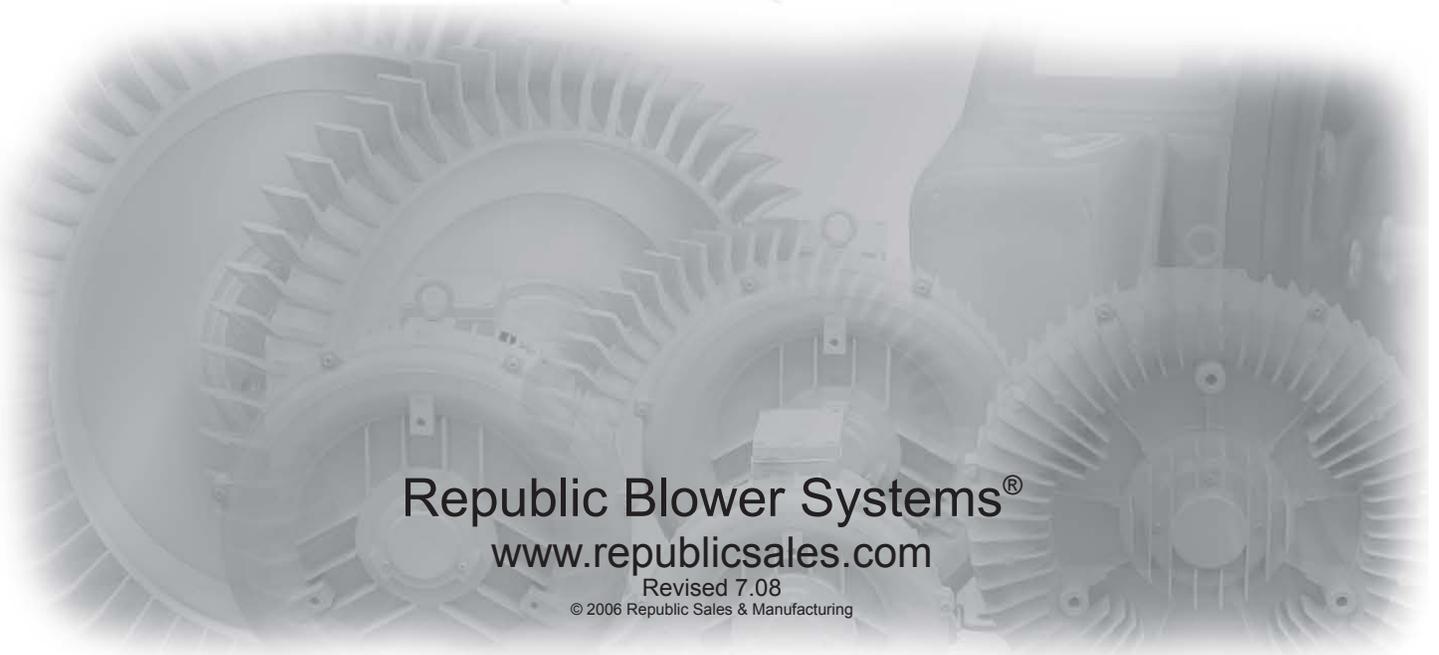
UNLESS OTHERWISE SPECIFIED ALL DIMENSIONS ARE IN INCHES DECIMALS: XXX ± .005 XX ± .010 FRACTIONS: ± 1/32 ANGLES: ± 0°-30" BREAK ALL SHARP EDGES MACHINE SURFACE FINISH IN RMS 12.5 NOTICE PROPRIETY RIGHTS INVOLVED THIS DOCUMENT AND ALL ACCOMPANYING INFORMATION AND DATA ARE AND REMAIN THE PROPERTY OF REPUBLIC SALES & MFG. AND ARE NOT TO BE COPIED, REPRODUCED, REPRODUCED, TRANSMITTED OR DISCLOSED TO OTHERS WITHOUT EXPRESS WRITTEN PERMISSION AND ARE TO BE RETURNED UPON REQUEST. THEREFORE, ALL RIGHTS IN PROPRIETY AND NOVEL FEATURES OF THE SUBJECT MATTER ARE EXPRESSLY RESERVED BY REPUBLIC SALES & MFG. RECEIPT'S AGREEMENT TO THE FOREGOING IS INDICATED BY ACCEPTANCE OF THIS DOCUMENT.	DRAWN R Tandy 3/3/2011	Republic Sales & Mfg. www.republicsales.com
	ROUTING	TITLE
	QA	Republic Sales Regen Blower
	MFG	SIZE DWG NO REV
APPROVED	C HRB800	SCALE SHEET 1 OF 1
MATERIAL		
FINISH		

Republic Blowers

Ring Blower • Side Channel Blower • Regenerative Blower
Owner's Manual



REPUBLIC
Blower Systems®



Republic Blower Systems®
www.republicsales.com

Revised 7.08
© 2006 Republic Sales & Manufacturing



Criteria Use Criteria

- ▲ Use only clean, dry air.
- ▲ Do not use flammable or explosive gases or atmosphere that contains such gases.
- ▲ Operate at 0°C – 40°C (32°F – 104°F).
- ▲ Protect unit from contaminants and moisture.
- ▲ Protect all surrounding items from exhausted air. This exhausted air can be very hot.
- ▲ Air particles, water vapor, oil based contaminants or other liquids must be filtered out.
- ▲ This blower must be installed with the proper sized inlet and inline filter, gauge and relief valve to protect the blower from contaminants and over-heating.
- ▲ When using the blower at a high altitude or high temperatures, please consult with Republic Blower Systems prior to use.

Safety Safety Notice

To insure safe operation, we have provided many important safety guidelines in this manual for the Republic Regenerative Blower. Please read this instruction manual carefully and pay particular attention to instructions with the following signs:



DANGER: Indicates an imminently hazardous situation which, if not avoided, will result in death or serious injury.



WARNING: Indicates a potentially hazardous situation, which, if not avoided, could result in death or serious injury.



Installation



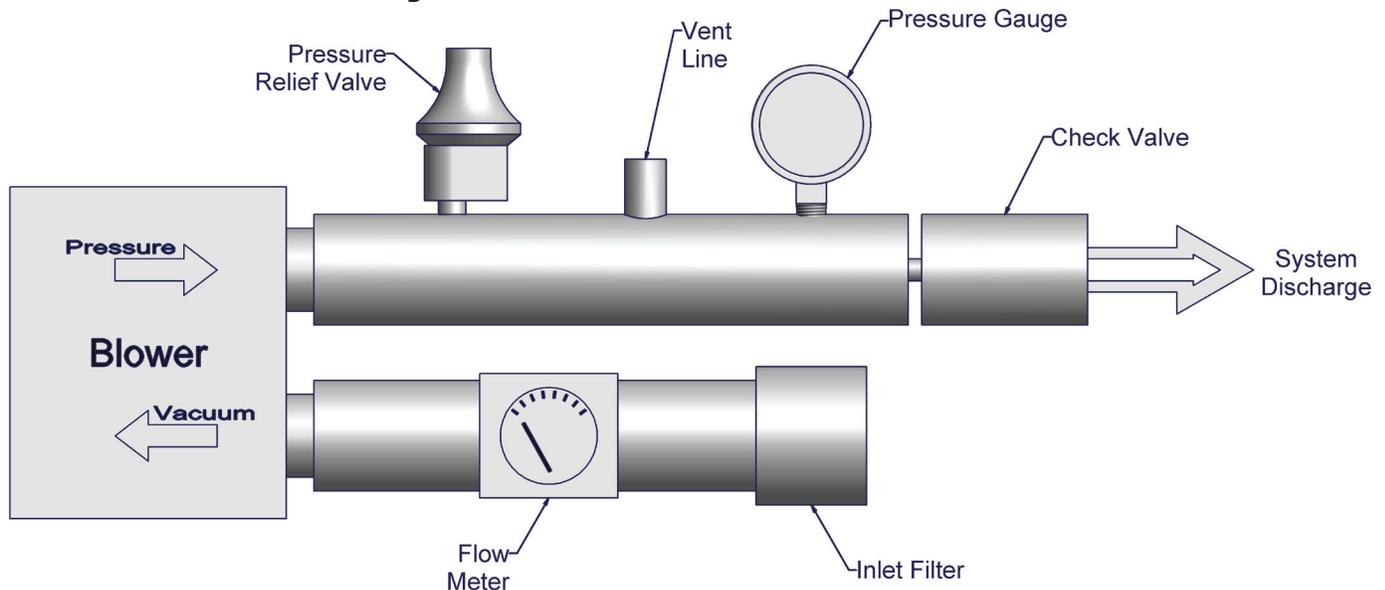
Electrical Shock Hazard

- ▲ Disconnect electrical power at the circuit breaker or fuse box before installing this product.
- ▲ Install the blower in a location where it will not come into contact with water or other liquids.
- ▲ Install the blower in a location protected from the weather.
- ▲ Electrically ground the blower.
- ▲ Failure to follow these instructions can result in death, fire or electrical shock.

Notice of Installation

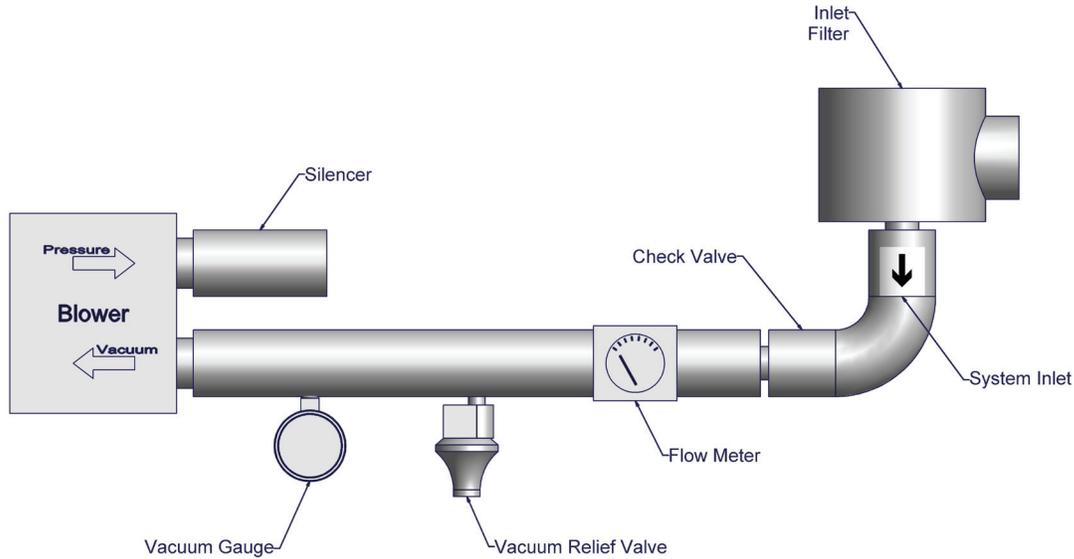
- ▲ Correct installation is your responsibility.
- ▲ Make sure you have the proper installation conditions and that installation clearances do not block air flow.
- ▲ Blocking air flow over the blower in any way can cause the product to overheat.
- ▲ The blower must be installed with the proper sized inlet filter, gauge and relief valve to protect the product from contaminants and over-heating.

Standard Installation Layout





Typical Vacuum Arrangement



1. Recommended piping should be, at minimum, the same size as the inlet and outlet ports.
2. Metal piping is recommended for the first five (5') to eight (8') feet from the blower on pressure systems.
3. Elbows increase friction. Minimizing the amount of elbows in the piping run will decrease friction loss.
4. Pressure or relief valves should be installed in a "T" that is at least one (1) pipe size larger than the port diameter.
5. Exhaust air temperature increases significantly above 65" of water column. Discharged air is typically too hot for most plastic piping. Therefore, metal piping is recommended for at least the first five (5') to eight (8') feet from the blower on the discharge side. In addition, this piping **MUST** be guarded and marked "DANGER-HOT-DO NOT TOUCH."

1-1. Installation

Install the blower on a level, stable operating surface and use the isolation pads provided to reduce noise and vibration.



Horizontal Position



Vertical Position



Position Unapproved

US EPA ARCHIVE DOCUMENT



1-2. Rotation

From the motor side of the blower, verify the blower is rotating in the direction indicated by the arrow on the motor. (The motor side is marked with an arrow on most models.) Proper rotation can also be checked by the air flow at the inlet and outlet ports. On blowers powered by a 3-phase motor, change the connection of any two (2) wires to reverse blower rotation.

1-3. Plumbing

Remove any foreign material (burrs, chips, welding drops, slag, pipe cuttings, excess sealant, sand or lime) from plumbing.

Verify the motor is securely mounted and proper blower rotation before connecting to plumbing. The inlet and outlet port are not designed to support the plumbing without proper supporting elements. Remove safety rubber plugs from the inlet and outlet ports. Connect the plumbing with properly sized fittings.

Use a relief valve to discharge excess air beyond the preset level on pressure applications. Use a vacuum relief valve to draw in excess air when preset vacuum level is achieved.

Install an intake filter to prevent foreign material from entering the blower. In applications where there is high humidity or liquids being used in the process, install a moisture separator with a drain valve.

1-4. Accessories

Install two gauges (vacuum or pressure), one before and one after the filter, to monitor differential through the filter element. As filters become clogged, performance efficiency will be reduced. Filters should be checked periodically and replaced when necessary. The recommended check valves provide minimal pressure drop, positive sealing, and are resistant to the high discharge temperatures of the blowers. (Refer to Republic Regenerative Blower Check Valves List)

1-5. Motor Control

It is your responsibility to contact a qualified electrician and assure that the electrical installation is adequate and in compliance with all national and local electrical codes.

Select fuses, motor protective switches, or thermal protective switches to provide protection. Fuses act as short circuit protection for the motor, not as protection against overload. Incoming line fuses must be able to withstand the motor's starting current. Motor starters with thermal magnetic overload or circuit breakers protect motor from overload or reduced voltage conditions. Motors without automatic restart require thermal protection or magnetic over-current cutout to prevent motor overloading from single phasing in a 3-phase circuit, high starting frequency, or locked blower.



1-6. Electrical Connection



Electrical Shock Hazard

- ▲ This product must be properly grounded.
- ▲ Do not modify the plug provided. If it will not fit the outlet, have the proper outlet installed by a qualified electrician.
- ▲ If repairing the cord or plug, do not connect the ground wire (green or green with yellow stripes) to either terminal.
- ▲ Check the condition of the power supply wires.

US EPA ARCHIVE DOCUMENT

HRB100,101,102,102/ 1,200,201,202,202/1,300,301,302,302/ 1,400,401,402,402S,500,502,600,602,700,702,802								Connection			HRB800,900,902,1000,1002,1100,1102,1200,1202, 1300,1302,1402,1502								
6 cable			Y 9 cable			Δ 9 cable			12 cable			High Voltage 440							
Low Voltage 220-220		High Voltage 380-440	Low Voltage 220		High Voltage 440	Low Voltage 220		High Voltage 440	Low Voltage 220		Middle Voltage 380		L ₁	L ₂	L ₃				
L ₁	L ₂	L ₃	L ₁	L ₂	L ₃	L ₁	L ₂	L ₃	L ₁	L ₂	L ₃	L ₁	L ₂	L ₃					
1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3		
			6-4-5				4	5	6							12	10	11	
6	4	5		7	8	9	4	5	6	6	4	5	4	5	6	4	5	6	
				4-5-6	7	8	9												
					7	8	9	7	8	9	7	8	9	4	5	6	7	8	9
													12-10-11						

Connection					
Low Voltage (2Y)			High Voltage (Y)		
110V			230V		
R	S		R	S	
1	2		4	1	
3	4		5		
6	5		2-3-6		
Reverse: R-1-3-5 S-2-4-6			Reverse: R-4 S-1-5 2-3-6		
Connect hot lead to 1. Connect neutral lead to 4.					



- ▲ Do not permanently connect this product to wiring not in good condition or that is inadequately sized for the requirements of this blower.
- ▲ Failure to follow these instructions can result in death, fire or electrical shock.
- ▲ This product must be grounded. In the event of an electrical short circuit, grounding reduces the risk of electric shock by providing an escape wire for the electric current.
- ▲ Check with a qualified electrician or serviceman if the grounding instructions are not completely understood, or if you are not sure whether the product is properly grounded.

2. Operation

WARNING

Injury Hazard

- ▲ Install proper safety guards as needed to prevent any close contact with blower suction area.
- ▲ Keep fingers and objects away from openings and rotating parts.
- ▲ Blower surfaces become very hot during operation. Allow these surfaces to cool before handling.
- ▲ Wear proper eye protection. Air stream from product may contain solid or liquid material that can result in eye or skin damage.
- ▲ Wear hearing protection. Sound level from some models may exceed 85 dBA.
- ▲ Failure to follow these instructions can result in burns, eye injury or other serious injury.
- ▲ It is your responsibility to operate this product at recommended pressures or vacuum duties and room ambient temperatures. Do not throttle discharge or suction pipe to reducer capacity. Throttle will increase differential pressure causing increasing power absorption and working temperatures.

Start Up

Operate blower for an hour and then check:

1. Ambient temperature – Increased room temperatures may require stronger ventilation especially for larger blowers. Room temperature should not exceed 100°F.
2. Pressure and vacuum valves – Adjust relief valve pressure or vacuum setting, if needed.
3. Motor current - Check that supply current matches recommended current rating on blower nameplate.
4. Electrical overload cutout – Check that current matches rating on blower nameplate.

If motor fails to start or slows down significantly under load, shut off and disconnect from power supply. Check that the voltage is correct for the motor and that the motor is turning in the proper direction.



3. Maintenance



Electrical Shock Hazard

- ▲ Disconnect electrical power supply cord before performing maintenance on the blower.
- ▲ If product is hard wired into system, disconnect electrical power at the circuit breaker or fuse box before performing maintenance on the blower.
- ▲ Failure to follow these instructions can result in death, fire or electrical shock.



Injury Hazard

- ▲ Blower surfaces become very hot during operation. Allow blower surfaces to cool before handling.
- ▲ Wear proper eye protection. Air stream from product may contain solid or liquid material that can result in eye or skin damage.
- ▲ Failure to follow these instructions can result in burns, eye injury or other serious injury.
- ▲ It is the customer's responsibility to regularly inspect and make necessary repairs to the blower in order to maintain proper operation. Make sure that pressure and vacuum is released from product before starting maintenance.

Preventive Maintenance

- ▲ After the first 500 hours of operation, the following need to be checked:
 - filter elements
 - noise absorbing foam used in mufflers
 - clean motor and blower
- ▲ Replace filter elements as needed. Mufflers should be checked on a monthly basis.



Lubrication

Lubrication Interval

To lubricate the bearings, the roller contact bearings and adjacent bearing housing should have the used grease removed and replaced with fresh grease. About 50 percent of the roller balls should be filled. No more than 65 percent of the adjacent bearing housing should be filled. Sealed bearings should be replaced within the listed conditions below with new bearings or as conditions warrant.

Hours of Service Per Year	Relubrication Intervals
5,000	3 years
Continual Normal Services	1 year
Seasonal Service (motor idle for 6+ months)	1 year at beginning of season
Continuous—high ambients, dirty or moist applications	6 months

Bearing

Bearing Types

A variety of types and lubricants are used in all Republic Regenerative Blowers. A summary of data is included in the Bearing Specification Table. Greasable bearings are supplied with a sufficient amount of lubricant at the factory to permit initial operation. The frequency of replacing the grease depends upon the conditions and application.

Grease

Grease Types

Republic Regenerative Blowers utilize proprietary lubricants from long experience. These lubricants are available from Esso or Exxon. You can check with your local supplier for a recommended equivalent. (High temperature resistance and high speed: NLGI N3 Grade). Lubricants of different manufacturers should not be mixed. If changing lubricant types, the bearing and housing should be thoroughly cleaned to remove all lubricant before adding grease from a new supplier.

US EPA ARCHIVE DOCUMENT



Bearing

Bearing Specification (Recommendable Bearing: NSK C3 Grade)

Single Stage			Double Stage		
Item	Front	Rear	Item	Front	Rear
HRB-101	6203z	6203zz	HRB-102/1	6203z	6203zz
HRB-201	6204z		HRB-202/1		
HRB-301	6205z	6205zz	HRB-302/1		
HRB-401			HRB-402/1	6204z	6205z
HRB-100	6203z	6203zz	HRB-102	6203z	6203zz
HRB-200	6204z	6203zz	HRB-202		
HRB-300	6205z	6205zz	HRB-302	6204z	6205z
HRB-400			HRB-402,S		
HRB-500	6206z		HRB-502		
HRB-600			HRB-602		
HRB-700		HRB-702			
HRB-800	6207z	6207zz	HRB-802	6206z	6208z
HRB-900			HRB-902		
HRB-1000		6208z	6208zz		
HRB-1100	HRB-1102			6207z	
HRB-1200	HRB-1202				
HRB-1300	HRB-1302			6308z	6308z
		HRB-1402			
			HRB-1502		

US EPA ARCHIVE DOCUMENT



Trouble-Shooting Trouble-Shooting Chart

Problem	Reason	Remedy
Increased sound	Noise absorbing foam is damaged Impeller rubbing inside	Replace foam Send unit to Republic Authorized Repair Facility
Excessive vibration	Damaged impeller Motor and/or impeller are dirty	Replace impeller Clean motor and impeller periodically
Ambient and exhaust temperature increases	Motor and/or blower are dirty Filters are dirty	Clean motor and blower periodically Replace filters
Decreased inlet air pressure	Inlet air filter is clogged	Clean inlet filter Replace cartridge
Unit is very hot	Wrong wiring Low voltage Inlet air filter is clogged Motor and/or blower are dirty Operating pressure or vacuum is too high	Check wiring Supply proper voltage Clean inlet filter Replace cartridge Clean motor and blower periodically Install a relief valve and pressure or vacuum gauge
Unusual sound	Impeller is damaged or dirty Bearing failure	Clean or replace impeller Send unit to Republic Authorized Repair Facility
Motor overload	Low voltage	Check power source Check wire size and wire connections
Unit does not start	Incorrect electrical connection or power source Impeller is damaged	Check wiring diagram, circuit fusing and circuit capacity Clean or replace impeller Install proper filtration



Warranty Warranty

Republic Regenerative Blowers, when properly installed and operated under normal conditions of use, are warranted by Republic to be free from defects in material and workmanship for a period of twelve (12) months from the date of purchase from Republic or an authorized Republic Representative or Distributor. In order to obtain performance under this warranty, the buyer must promptly (in no event later than 30 days after discovery of the defect) give written notice of the defect to Republic Blower Systems (Fax: 214-631-3673 or E-mail: warranty@republicsales.com) or a representative in your country. Customer is responsible for freight charges to Republic in all cases.

This warranty does not apply to electrical controls and gasoline engines not supplied by Republic and does not extend to any goods or parts which have been subjected to misuse, lack of maintenance, neglect, damage by accident or transit damage.

This express warranty excludes all other warranties or representations expressed or implied by any literature, date or person. Republic's maximum liability under this exclusive remedy shall never exceed the cost of the subject product. Republic reserves the right, at its sole discretion, to refund the purchase price in lieu of repair or replacement.

Republic is not responsible or liable for indirect or consequential damages of any kind however, including but not limited to those for use of any products, loss of time, inconvenience, lost profit, labor charges, or other incidental or consequential damages with respect to persons, business, or property, whether as a result of breach of warranty, negligence or otherwise.

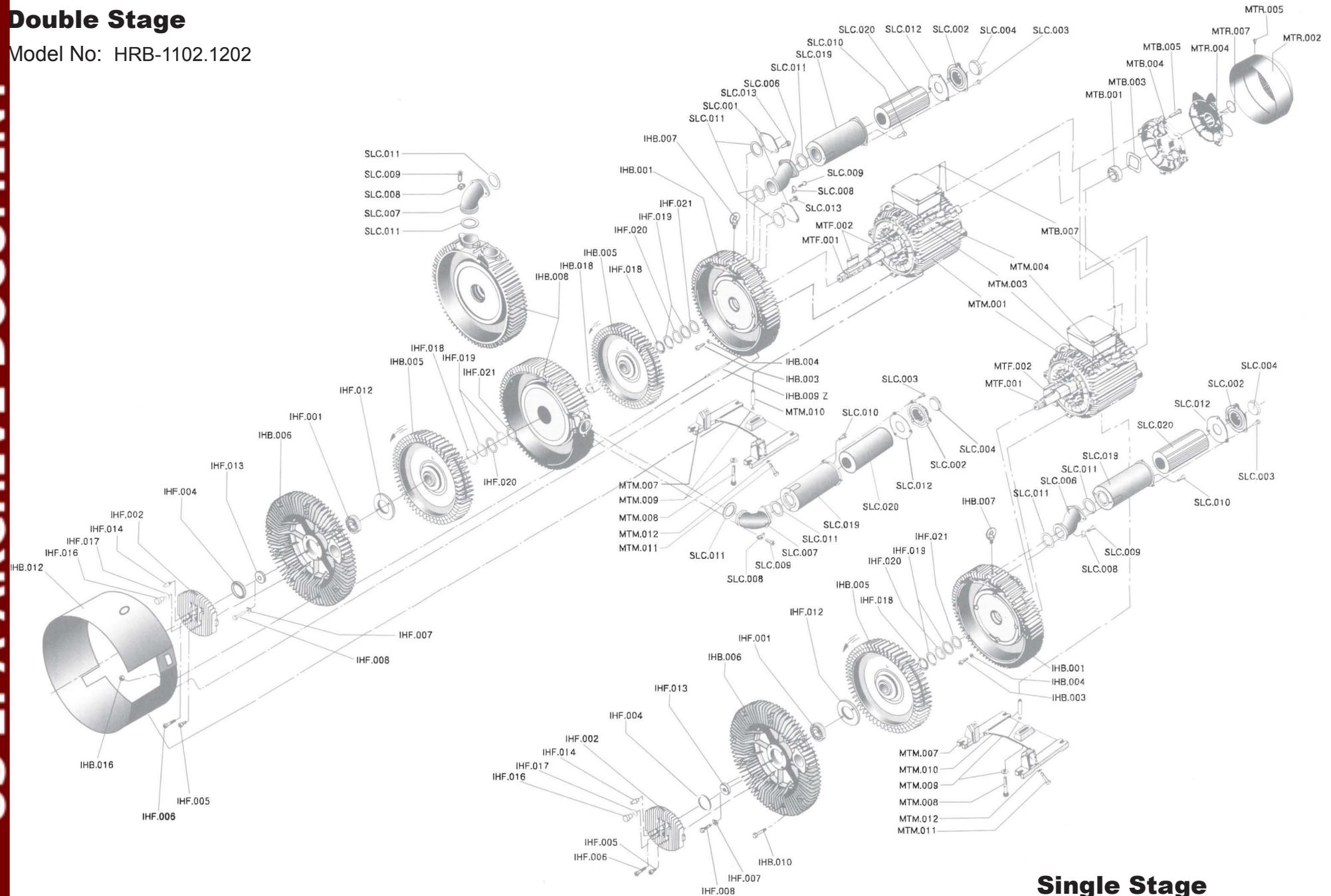
Notwithstanding any other provision of this warranty: **Customer's remedy against Republic for goods supplied or for non-deliverable goods or failure to furnish goods, whether or not based on negligence, strict liability or breach of express or implied warranty is limited solely to Republic's option, to replacement of or cure of such nonconforming or non-deliverable goods or return of the purchase price for such goods and in no event shall exceed the price or charge for such goods. Republic expressly disclaims any warranty of merchantability or fitness for a particular use or purpose with respect to the goods sold. There are no warranties that extend beyond the descriptions set forth in this warranty, notwithstanding any knowledge of Republic regarding the use or uses intended to be made of goods, proposed changes or additions to goods, or any assistance or suggestions that may have been made by Republic's personnel. Unauthorized extensions of warranties by the customer shall remain the customer's responsibility.**

Customer is responsible for determining the suitability of Republic's products for customer's use or resale, or for incorporating them into objects or applications which customer designs, assemblies, constructs or manufacturers.

This warranty can be modified only by authorized Republic personnel, by signing a specific written description of any modifications.

Exploded View Double Stage

Model No: HRB-1102.1202



Single Stage

Model No: HRB-800.900.1000



Part List

Ring Blower Part List

Part Number	Part Name
IHF.001	Bearing
IHF.002	Bearing Cover
IHF.003	Plain Washer
IHF.004	Spacer Washer
IHF.005	Cheese Head Screw
IHF.006	Socket Head Cap Screw
IHF.007	Lock Plate
IHF.008	Cap Bolt
IHF.009	O-Ring Seal
IHF.011	Spring Washer
IHF.012	Mating Ring
IHF.013	Disc
IHF.014	Grease Nipple
IHF.016	Hexa Head Bolt
IHF.017	Plain Washer
IHF.018	Internal Retaining Ring
IHF.019	Compensate Ring
IHF.020	Spring Washer
IHF.021	Sealing Ring

Part Number	Part Name
IHB.001	Compressor Housing
IHB.002	Spring Washer
IHB.003	Cap Bolt
IHB.004	Spring Washer
IHB.005	Impeller
IHB.006	Compressor Cover
IHB.007	Eye Bolt
IHB.008	Center Section
IHB.009	Threaded Rod
IHB.010	Cheese Head Screw
IHB.012	Compressor Cowl
IHB.015	Disc
IHB.016	Plain washer
IHB.018	Sleeve

Part Number	Part Name
MTF.001	Compressor Housing
MTF.002	Spring Washer
MTF.003	Cap Bolt
MTF.004	Spring Washer

Part Number	Part Name
MTB.001	Bearing
MTB.003	Resilient Preloading Plate
MTB.004	Endshield
MTB.005	Cheese Head Screw
MTB.007	Hexagonal Nut

Part Number	Part Name
MTM.001	Stator
MTM.003	Rating Plate
MTM.004	Screw
MTM.006	Square Nut
MTM.007	Foot
MTM.008	Hexagonal Head Screw
MTM.009	Spring Washer
MTM.010	Sleeve
MTM.011	Cap Bolt
MTM.012	Spring Washer
MTM.013	Square Nut

Part Number	Part Name
MTR.002	Fan Cowl
MTR.003	External Fan
MTR.004	External Fan
MTR.005	Screw
MTR.007	Circlip

Part Number	Part Name
SLC.001	Plug
SLC.002	Flange
SLC.003	Cap Bolt
SLC.004	Plug
SLC.005	Hexagonal Nut
SLC.006	Graded Tube
SLC.007	Graded Tube
SLC.008	Clip
SLC.009	Cap Bolt
SLC.010	Cap Bolt
SLC.011	Gasket
SLC.012	Gasket
SLC.013	Cap Bolt
SLC.014	Cap Bolt
SLC.015	Cap Bolt
SLC.016	Cap Bolt
SLC.017	Silencer Casing
SLC.018	Silencer Casing
SLC.019	Silencer Insert
SLC.020	Gasket
SLC.021	Flat Head Screw
SLC.022	Threaded Rod
SLC.023	Hexagon Nut
SLC.024	Hexagon Cap Nut
SLC.025	Silencer

US EPA ARCHIVE DOCUMENT



Republic Blower Systems®

5131 Cash Road

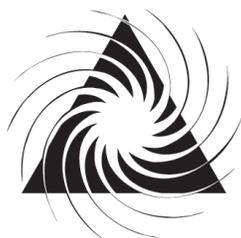
Dallas, TX 75247

800.847.0380

P. 214.631.8070

F. 214.631.3673

www.republicsales.com



R E P U B L I C
Blower Systems®

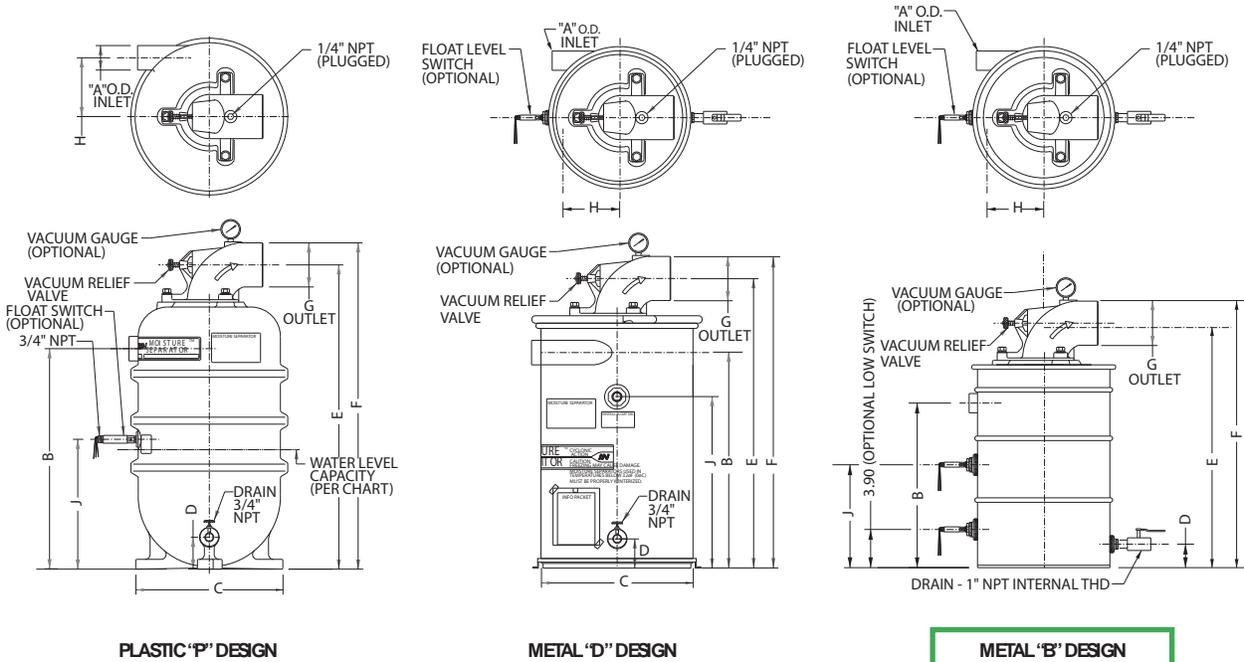
Accessories

Filtration - Moisture Separator

ROTRON®

By separating and containing entrained liquids, ROTRONSM moisture separator helps protect our regenerative blowers and the end treatment system from corrosion and mineralization damage. Recommended for all soil vacuum extraction applications.

SPECIFICATIONS:
 SEPARATION METHOD – High Efficiency Cyclonic
 RELIEF VALVE MATERIAL – Brass & Stainless Steel
 FLOAT MATERIAL – Copper
 FLOAT SWITCH – SPDT, Explosion-proof
 NEMA 7&9, 5 Amp max.



Models without float switch available. Metal MS200/300DS models are not the standard stocked, but are available.

US EPA ARCHIVE DOCUMENT

Specification	Units	Part/Model Number							
		MS200PS 038519	MS300PS 038520	MS200DS 080086	MS300DS 080087	MS350BS 038357	MS500BS 080660	MS600BS 080659	MS1000BS 038914
Dimension A	Inches	2.38	2.88	2.00	2.50	3.25	3.25	4.00	6.00
	mm	60.5	73.2	50.8	63.5	82.6	82.6	101.6	152.4
CFM Max.	CFM	200	300	200	300	350	500	600	1000
	m3/hr	340	510	340	510	595	850	1020	1700
Dimension B	Inches	22.46	22.46	22.12	22.12	28.00	28.00	27.00	31.00
	mm	570.5	570.5	561.8	561.8	711.2	711.2	685.8	787.4
Dimension C	Inches	16.00	16.00	16.75	16.75	23.00	23.00	23.00	27.00
	mm	406.4	406.4	425.5	425.5	584.2	584.2	584.2	685.8
Dimension D	Inches	3.25	3.25	2.75	2.75	4.00	4.00	4.00	4.00
	mm	82.6	82.6	69.9	69.9	101.6	101.6	101.6	101.6
Dimension E	Inches	31.05	31.05	27.92	27.92	37.25	37.37	37.37	47.32
	mm	788.7	788.7	709.2	709.2	946.2	949.2	949.2	1201.9
Dimension F	Inches	33.30	33.30	30.17	30.17	39.50	54.50	54.50	51.70
	mm	845.8	845.8	766.3	766.3	1003.3	1384.3	1384.3	1313.2
Dimension H	Inches	6	6.00	6.56	6.81	9.75	9.75	9.25	10.00
	mm	152.4	152.4	166.6	173	247.7	247.7	235	254
Dimension G	Inches	4.50 OD	4.50 D	4.50 D	4.50 OD	4.50 OD	6.63 ID	6.63 ID	8.62 OD
	mm	114.3	114.3	114.3	114.3	114.3	168.4	168.4	218.9
Dimension J	Inches	13.25	13.25	12.62	12.62	17.50	17.50	17.50	19.88
	mm	336.6	336.6	320.5	320.5	444.5	444.5	444.5	505
Drain Internal Thd	-	3/4	3/4	3/4	3/4	1	1	1	1
Shipping Weight	Lbs	42	42	42	42	82	95	96	150
	Kg	19.1	19.1	19.1	19.1	37.2	43.1	43.5	68

This document is for informational purposes only and should not be considered as a binding description of the products or their performance in all applications. The performance data on this page depicts typical performance under controlled laboratory conditions. AMETEK is not responsible for blowers driven beyond factory specified speed, temperature, pressure, flow or without proper alignment. Actual performance will vary depending on the operating environment and application. AMETEK products are not designed for and should not be used in medical life support applications. AMETEK reserves the right to revise its products without notification. The above characteristics represent standard products. For product designed to meet specific applications, contact AMETEK Technical & Industrial Products Sales department.

AMETEK TECHNICAL & INDUSTRIAL PRODUCTS
 75 North Street, Saugerties, NY 12477
 USA: +1 215-256-6601 - Europe: +44 (0) 845 366 9664 - Asia: +86 21 5763 1258
 Customer Service Fax: +1 215.256.1338
 www.ametektip.com

2.0 Moisture Separator™ Specifications

2.1 Duty

The moisture separator shall be designed for use in a soil vapor extraction system capable of continuous operation with a pressure drop of less than six inches of water at the rated flow of ____ SCFM. The separator shall be capable of operation under various inlet conditions ranging from a fine mist to slugs of water with high efficiency.

2.2 Principle of Operation

The moisture separator shall incorporate cyclonic separation to remove entrained water. The separator must protect against an overflow by fail safe mechanical means. An electrical switch or contact(s) alone is not an acceptable means of protection against overflow, but is a good backup.

2.3 Construction

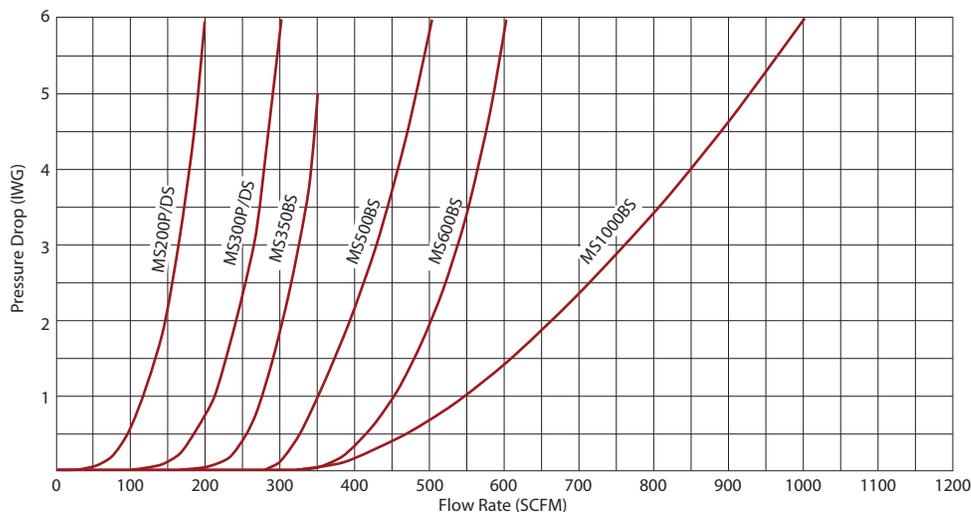
The body of the moisture separator shall be constructed of heavy wall plastic or heavy gauge cold rolled steel. The steel interior and exterior shall be epoxy (powder) coated to resist abrasion, corrosion, and chipping that might expose the surface. The inlet shall be tangentially located and welded to the body. The outlet port shall be constructed of PVC or cast aluminum alloy, flanged and sealed to the center of the top of the separator. The separator shall incorporate a non-sparking copper float ball and an adjustable relief valve to protect against overflow and overheating the blower.

For DR/EN/CP Blower Model	Selector Moisture Separator Model	Liquid-holding Capacity (gallons)	Inlet (OD)	Outlet	Max Vacuum Allow (IHG)
404 454 505 513 523 555 633 833	MS200PS	7	2.38	4.5 OD	12
656 6 757	MS200DS	10	2.0		22
808	MS300PS	7	2.88		12
858 1233 909	MS300DS	10	2.5		6.63 ID
979	MS350BS	40	3.25		
14	MS500BS		4.0		
	MS600BS	65	6.0	8.62 OD	

2.4 Capacity and Dimension

The moisture separator must have a liquid capacity of ____ gallons. The inlet shall be ____ inch OD slip-on type. The outlet shall be ____ inch OD slip-on type.

2.5 Pressure Drop



This document is for informational purposes only and should not be considered as a binding description of the products or their performance in all applications. The performance data on this page depicts typical performance under controlled laboratory conditions. AMETEK is not responsible for blowers driven beyond factory specified speed, temperature, pressure, flow or without proper alignment. Actual performance will vary depending on the operating environment and application. AMETEK products are not designed for and should not be used in medical life support applications. AMETEK reserves the right to revise its products without notification. The above characteristics represent standard products. For product designed to meet specific applications, contact AMETEK Technical & Industrial Products Sales department.

US EPA ARCHIVE DOCUMENT

SERVICE AND PARTS MANUAL FOR MOISTURE SEPARATORS



Technical & Industrial Products
627 Lake Street, Kent, Ohio 44240 U.S.A.
Telephone: 330-673-3452 Fax: 330-677-3306
e-mail: rotronindustrial@ametek.com
internet: www.ametektip.com



Your Choice. Our Commitment.™

OPERATION & MAINTENANCE MANUAL



Technical & Industrial Products

627 Lake Street, Kent, Ohio 44240 U.S.A.
Telephone: 330-673-3452 Fax: 330-677-3306

Rotron Moisture Separator

Thank you for purchasing an AMETEK Rotron MS series moisture separator. When matched with the correct Rotron blower, and properly installed and maintained, this separator will effectively and efficiently remove moisture from the air stream. To ensure good results, please take the time to read these instructions before starting the installation of your moisture separator.

Sizing for Optimal Efficiency

Separator	Max. CFM	Max. Vac	Capacity	Blowers – DR, EN & CP
MS200P(S)	200	12* IHg	7 gal.	101-555, 513, 523, 623
MS200D(S)	200	22 IHg	10 gal.	101-555, 513, 523, 623
MS300P(S)	300	12* IHg	7 gal.	606, 6, 707, 823
MS300D(S)	300	22 IHg	10 gal.	606, 6, 707, 823
MS350B(S)	350	22 IHg	40 gal.	808, 1223
MS500B(S)	500	22 IHg	40 gal.	858
MS600B(S)	600	22 IHg	40 gal.	909
MS1000B(S)	1000	22 IHg	65 gal.	14

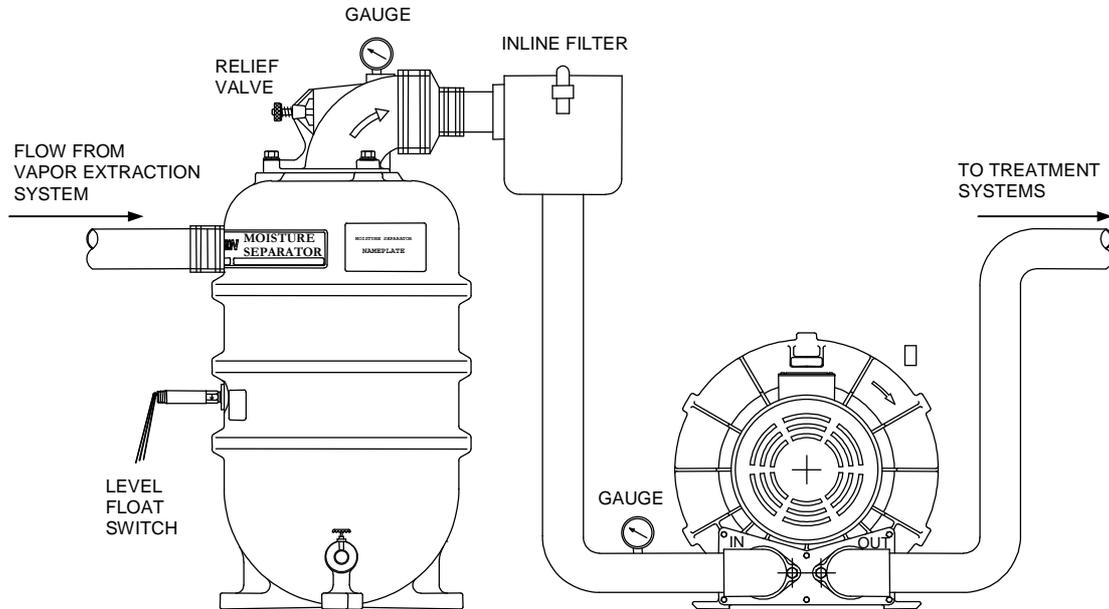
Note: "S" suffix denotes presence of XP high level switch.
* Special Construction with 20 IHg capability available.

Installation

- Unpacking** - For MS200/300, remove drain valve taped to packing material and box containing liquid level switch, if so equipped. For MS350/500/600, remove box containing valve hardware as well as box containing liquid level switch (if so equipped) and remove internal cardboard packaging and cable ties from screen assembly.
- Bolt Down** (w/ feet included) - For MS200/300 models, built-in feet or a mounting ring is included. It is recommended that these units be bolted in place. All models will only work in an upright position.
- Piping** - Attach to system piping with flexible couplings to minimize stress incurred by rigid system piping. The connections should be airtight but not sealed with an adhesive for ease of disassembly during routine maintenance. Install drain valve, using teflon tape on threads.
- Installation and Wiring of Liquid Level Switch** - Remove plug from the bulkhead fitting. Thread the switch by hand until snug with index arrow pointing down. Wire in accordance with the nameplate wiring schematic. Typically, the wiring is connected back to the starter to shut down the system but can be used for other purposes.
- Install/Adjust Relief Valve** - For MS500/600, first install the relief valve with teflon tape on threads. Use a wrench, but tighten only enough to prevent leakage. Next step for all MS units, back off the relief valve adjuster relaxing spring pressure. Then block the moisture separator inlet while measuring the motor current. Adjust the valve until the motor current is 90% of the max. nameplate blower amps.
- Continuous Service** - For cold weather service, appropriate steps should be taken to prevent freezing. Also, the maximum vacuum ratings are based on 115°F maximum. Consult factory for higher potential ambient.

Note: A moisture separator is not a substitute for an inline air filter. A Rotron inline filter should be used to remove particles that pass through the separator.

Typical Vapor Extraction System



Operation

Moisture-laden air enters the separator through the tangential inlet. Cyclonic action removes free moisture from the air stream and allows the air to discharge through the top of the separator. When the separator is full, the float valve shuts off the air flow through the separator, and the relief valve opens to limit the vacuum of the blower.

To drain the separator, turn off the blower and open the drain valve at the bottom of the separator. Caution: The liquid contained in the separator should be analyzed before it is released back into the environment. It may be considered hazardous waste in certain geographical areas and require special treatment/disposal. Once the liquid is drained, the unit can be reset by turning the blower back on.

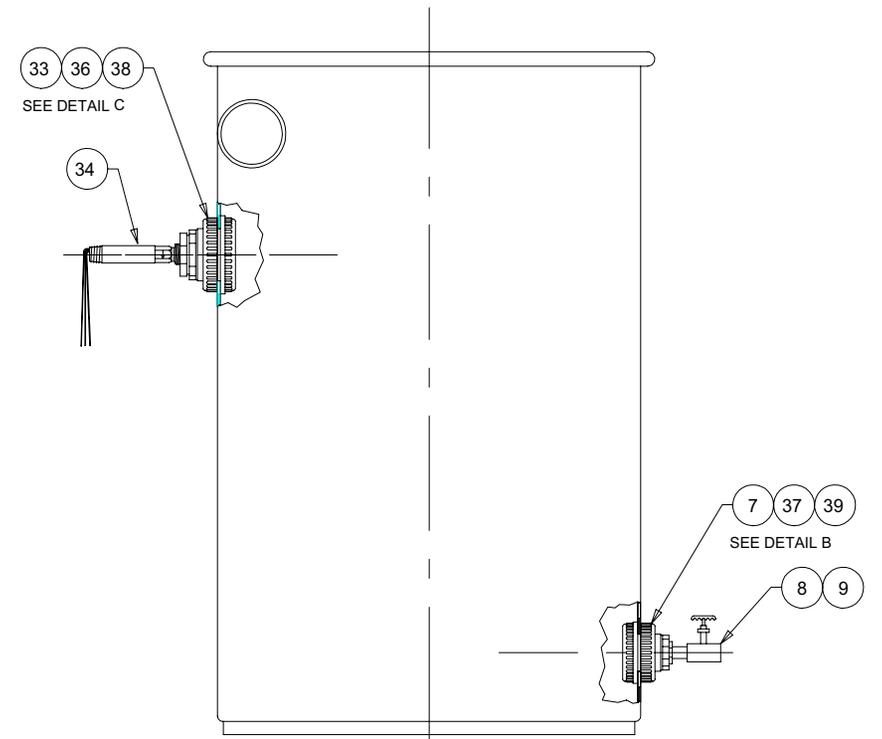
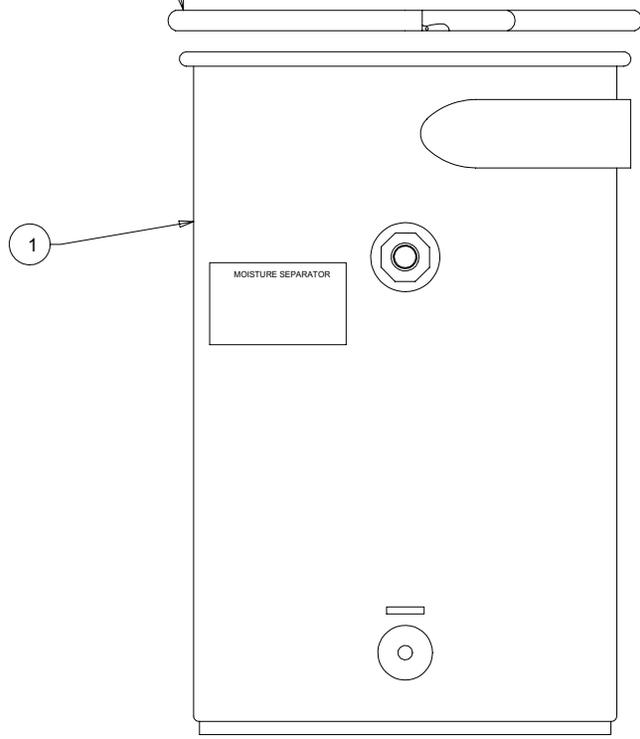
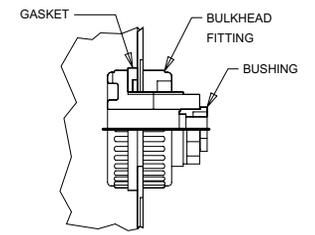
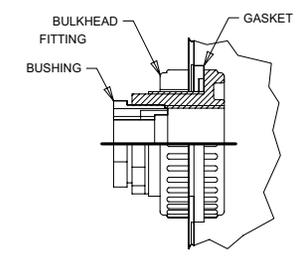
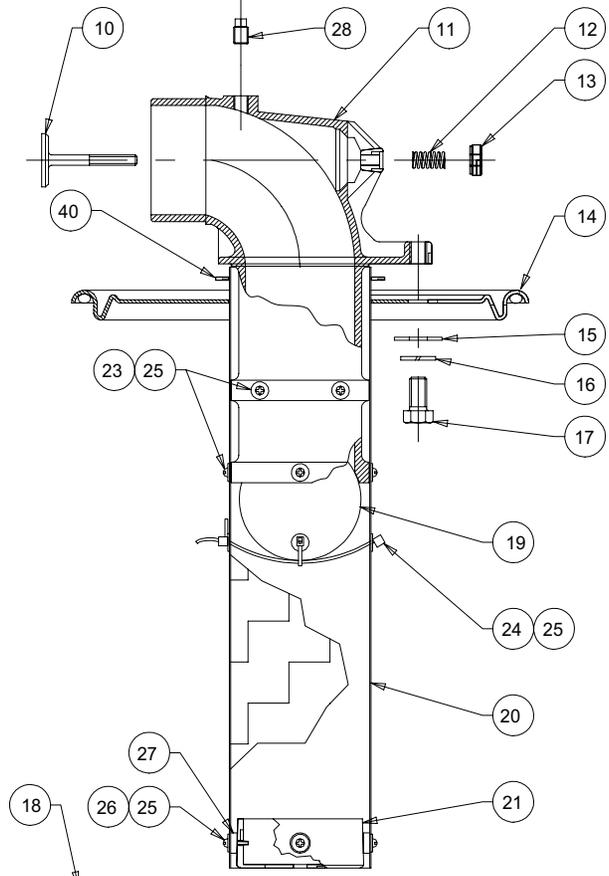
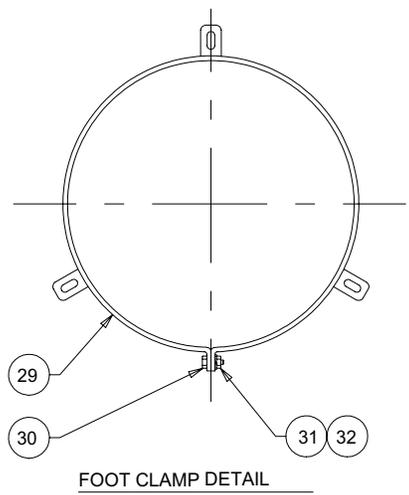
Automatic draining options are at the discretion of the customer.

Maintenance

This MS series moisture separator has been designed to require minimal maintenance. During normal operation a layer of sludge may build up on the bottom of the separator. As necessary, the top assembly of the moisture separator should be removed and the inside cleaned out with water. Keeping the inside clean will prevent the valve from becoming clogged with sediment. The relief valve should be inspected upon emptying the separator and readjusted (per installation instruction 5) upon restart.

If you have any questions regarding this product, contact your local sales representative or our Application Engineering Department at the factory.

AMETEK ROTRON MOISTURE SEPERATOR



**Moisture Separator
Service and Parts Manual**

Model:
Part No.:

		Parts Breakdown				
	MS200/300D_	MS350B_	MS200/300P_	MS500/600B	MS1000	
	038355	038277	038517	038353	038914	
	038356	038357	038518	038354	038916	
	038275		038519	038003	080019	
	038276		038520	038075		
	080086			080657		
	080087			080658		
				080659		
				080660		
				080661		
				080662		
				OBSOLETE		

Item No.	Qty. Req'd	Description	MS200/300D_	MS350B_	MS200/300P_	MS500/600B	MS1000
1	1	Drum Assembly	See Next Page	See Next Page	See Next Page	See Next Page	See Next Page
7	1	Bulkhead Fitting Drain	529830	529830	Not Used	529830	529830
8	1	Drain Valve	523374	523407	523374	523407	523407
9	1	Pipe Nipple Drain	551140	523406	155416	523406	523406
10	1	Relief Valve Stem	529318	529318	529318	Not Used	550621
11	1	Outlet	529323	529323	529323	See Outlet Assy #42 Below	550646
12	1	Spring - Relief Valve	155339	155339	155339	Not Used	155476
13	1	Nut-Knurled Relief Valve	155342	155342	155342	Not Used	155471
14	1	Lid	550674	523403	Not Used	523404	550566
	1	Gasket for lid	Not Used	551102	Not Used	551102	551640
15	3	Washer, Flat, Lid/Outlet	155159	155159	155091	Not Used	155159
16	3	Washer, Lock, Lid/Outlet	120338	120338	251787	Not Used	120338
17	3	Bolt, Lid/Outlet	155343	155343	120255	Not Used	155343
18	1	Lock Ring - Lid	See Next Page	528926	Not Used	528926	550652
19	1	Float Ball	528803	528803	528803	528956	550569
20	1	Cage, Float	551138	528957	529887	528958	550568
21	1	Endcap	529884	529884	529884	528954	550678
23	6	Screws Cage	251645	251645	251645	(9 pcs) 251645	(11 pcs) 251645
24	4	Tie Cable *	155276	155276	Not Used	155276	155276
25	13	Washer Cage - Various Places	155115	155115	(9 pcs) 155115	(16 pcs) 155115	(18 pcs) 155115
26	3	Screws Endcap	155415	155415	155415	(3 pcs) 251645	(3 pcs) 251645
27	3	Spacer Endcap	155417	155417	155417	Not Used	Not Used
28	1	Pipe Plug - Outlet	155344	155344	155344	Not Used	155344
29	1	Foot Clamp	See Next Page	Not Used	Not Used	Not Used	Not Used
30	1	Bolt, Foot Clamp	120325	Not Used	Not Used	Not Used	Not Used
31	1	Nut, Foot Clamp	155049	Not Used	Not Used	Not Used	Not Used
32	1	Lockwasher, Foot Clamp	120203	Not Used	Not Used	Not Used	Not Used
33	1	Bulkhead Fitting Float Switch	See Next Page	See Next Page	Not Used	See Next Page	See Next Page
34	1	Float Switch	See Next Page	See Next Page	See Next Page	See Next Page	See Next Page
36	1	Bushing, Float Switch	See Next Page	See Next Page	Not Used	See Next Page	See Next Page
37	1	Gasket, Bulkhead Fitting - Drain Spigot	529831	529831	Not Used	529831	529831
38	1	Gasket, Bulkhead Fitting	See Next Page	See Next Page	Not Used	See Next Page	See Next Page
39	1	Bushing, Drain Valve	529849	Not Used	Not Used	Not Used	Not Used
40		Gasket, Outlet	529514	529514	529514	Not Used	550653
41		Pipe Plug, Float Switch	Not Used	Not Used	See Next Page	Not Used	Not Used
42		Outlet Assembly (consists of one each of the following)				Tee - 523402 Pipe - 116135 Seat Float - 528955 Reducer, Relief Valve - 528959 Bushing, Relief Valve - 551639	
43		Relief Valve Complete	Not Used	Not Used	Not Used	523230	Not Used

*As Needed **Viewed looking at inlet/outlet ports

Model	Model Part No.	Item No.	Item Part #	Model	Model Part No.	Item No.	Item Part #				
MS200DS	038355	1	529463	MS200PS	038519	1	529435				
		14	529006			34	529461				
		18	529004			41	Not Used				
		29*	529367			MS300P	038518	1	529668		
		33	529841					34	Not Used		
		34	529461					41	155405		
		36	552634					MS200P	038517	1	529435
		38	529842							34	Not Used
		41	155405								
MS300DS	038356	1	529464	MS500B	038354 (Obsolete)	1	529465				
		14	529006			33	529841				
		18	529004			34	529461				
		29*	529367			36	552634				
		33	529841	080660 (New P/N)	38	529842					
		34	529461	MS600BS	038353 (Obsolete)	1	529466				
		36	552634			33	529841				
		38	529842			34	529461				
		36	552634								
MS200D	038275	1	523362	080659 (New P/N)	38	529842					
		14	529006	MS500B	038075(Obsolete)	1	523399				
		18	529004			33	Not Used				
		29*	529367			34	Not Used				
		33	Not Used			36	Not Used				
		34	Not Used	080658 (New P/N)	38	Not Used					
		36	Not Used	MS600B	038003 (Obsolete)	1	551143				
		38	Not Used			33	Not Used				
		34	Not Used								
		36	Not Used								
MS300D	038276	1	551141	080657 (New P/N)	38	Not Used					
		14	529006	MS1000BS	038914	1	550561				
		18	529004			33	529841				
		29	529367			34	529461				
		33	Not Used			36	552634				
		34	Not Used	MS300DS	080087	38	529842				
		36	Not Used			1	550672				
		38	Not Used			18	523296				
		29	550688								
MS350BS	038357	1	529465	33	529841						
		33	529841	34	529461						
		34	529461	36	552634						
		36	552634	38	529842						
		38	529842	MS200DS	080086	1	550669				
MS350B	038277	1	523399			18	523296				
		33	Not Used			29	550688				
		34	Not Used			33	529841				
		36	Not Used			34	529461				
		38	Not Used	36	552634						
MS300PS	038520	1	529668	38	529842						
		34	529461	MS500B2S	080662	1	550650				
		41	Not Used			33 (2 pcs)	529841				
MS1000B	038916	1	550560			34 (2 pcs)	529461				
		33,34,36,38	Not Used			36 (2 pcs)	552634				
						38 (2 pcs)	529842				
MS1000B2S	080019	1	550566								
		18	Not Used								
		33 (2 pcs)	529841								
		34 (2 pcs)	529461								
		36 (2 pcs)	552634								
		38 (2 pcs)	529842								

*As Needed **Viewed looking at inlet/outlet ports

Accessories

Filtration - Inline Filter (Dual Connection)

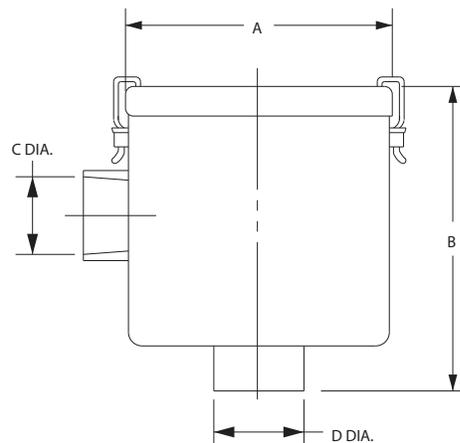
ROTRON®

Inline Filters protect the blower from harmful dust and other particles that may be drawn into the blower through the air distribution system. Normally used in vacuum systems.

SPECIFICATIONS:

- HOUSING – Steel
- MEDIA – Polyester
- EFFICIENCY – 97-98% (8 to 10 micron particle size)
- FILTER ELEMENT – Replaceable (see filter elements)
- NOTE: "Z" MEDIA (1 to 3 micron particle size) available

Inline filter PN 271200 is a straight through design
Inlet is directly opposite of outlet



* Feature 1/4" threaded tap for gauge connection on inlet and outlet

Specification	Units	Part/Model Number							
		271200	516461	515254	515255	515256	516463*	516465*	517611*
Filter Element	-	271078	516434	516434	516435	516435	515135	515135	516515
Ref Blower Model	-	A	B	C, D	E	F	G	H	H
Inlet Connection	-	1.75 SO	1.00 NPSC-F	1.50 NPSC-F	2.00 NPSC-F	2.50 NPSC-F	3.00 NPT-M	4.00 NPT-M	6.00 NPT-M
Outlet Connection	-	2.00 SO	1.00 NPSC-F	1.50 NPSC-F	2.00 NPSC-F	2.50 NPSC-F	3.00 NPT-M	4.00 NPT-M	6.00 NPT-M
Dimension A	Inches	5.25	7.25	7.00	8.00	8.00	14.00	14.00	18.00
	mm	133.4	184.2	177.8	203.2	203.2	355.6	355.6	457.2
Dimension B	Inches	8.31	6.50	6.50	10.25	10.25	26.50	27.00	28.00
	mm	211.1	165.1	165.1	260.4	260.4	673.1	685.8	711.2
Dimension C	Inches	2.00	1.00	1.50	2.00	2.50	3.00	4.00	6.00
	mm	50.8	25.4	38.1	50.8	63.5	76.2	101.6	152.4
Dimension D	Inches	1.75	1.00	1.50	2.00	2.50	3.00	4.00	6.00
	mm	44.5	25.4	38.1	50.8	63.5	76.2	101.6	152.4
Z Media Filter PN	-		517886	517887	517888	517889	517890	517891	517892

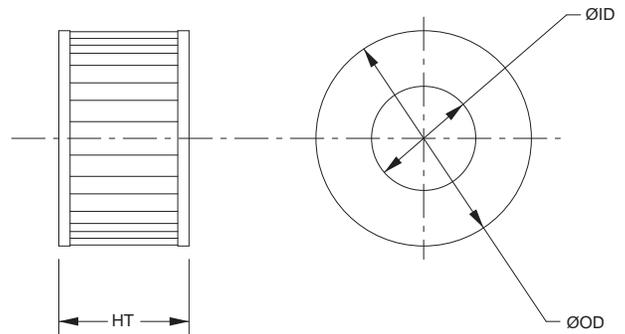
Blower Model Reference Key	
A = SPIRAL	E = DR/EN/CP 656, 6, 633, S7
B = DR/EN/CP 068, 083, 101, 202	F = DR/EN/CP 757, 808, 858, S9, P9 (Inlet Only)
C = DR/EN/CP 303, 312, 313, 353	G = DR/EN/CP 833, S13, P13 (Inlet Only)
D = DR/EN/CP 404, 454, 513, 505, 555, 523	H = DR/EN/CP 909, 979, 1233, 14, S15, P15 (Inlet Only)

US EPA ARCHIVE DOCUMENT

This document is for informational purposes only and should not be considered as a binding description of the products or their performance in all applications. The performance data on this page depicts typical performance under controlled laboratory conditions. AMETEK is not responsible for blowers driven beyond factory specified speed, temperature, pressure, flow or without proper alignment. Actual performance will vary depending on the operating environment and application. AMETEK products are not designed for and should not be used in medical life support applications. AMETEK reserves the right to revise its products without notification. The above characteristics represent standard products. For product designed to meet specific applications, contact AMETEK Technical & Industrial Products Sales department.

All ROTRON Air Filters and Filter/ Silencers have replaceable filter elements. The filter media is polyester designed for high efficiency over a wide spectrum of industrial applications. See filter element cross reference table. Filter elements supplied with foam pre-filter.

Standard Replacement Filter Element Cross Reference Table					
Filter	Element	Filter	Element	Filter	Element
271200	271078	515158	515134	516489	515132
477411	271078	515254	516434	516491	515133
515122	515132	515255	516435	516493	515134
515123	515133	515256	516435	516495	515134
515124	515134	516461	516434	516497	515134
515125	515134	516463	515135	516499	515135
515145	515134	516465	515135	516511	516515
515151	515135	516466	515132	516513	516515
515157	515133	516487	515132	517611	516515



For DR Blower Models

Specification	Units	Part/Model Number						
		515132	515133	515134	515135	516434	516435	516515
Z Media Filter PN	-	517873	517874	517875	517876	517893	517894	517877
Dimension ID	Inches	3.00	3.63	3.5	4.75	2.56	3.50	8.00
	mm	76.2	92.2	88.9	120.7	65	88.9	203.2
Dimension OD	Inches	4.38	5.88	5.88	7.88	5.00	5.88	11.75
	mm	111.3	149.4	149.4	200.2	127	149.4	298.5
Area	Sq/Ft	4.75	4.75	9.50	9.63	4.75	8.75	9.63
	Sq/M	0	0	1	1	0	1	1
Dimension HT	Inches	1.5	2.3	4.5	8.3	2.0	4.5	19.0
	mm	38.1	58.4	114.3	210.8	50.8	114.3	482.6

US EPA ARCHIVE DOCUMENT

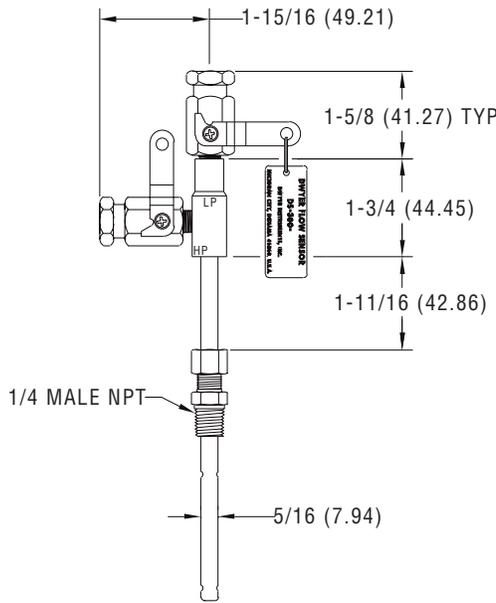
This document is for informational purposes only and should not be considered as a binding description of the products or their performance in all applications. The performance data on this page depicts typical performance under controlled laboratory conditions. AMETEK is not responsible for blowers driven beyond factory specified speed, temperature, pressure, flow or without proper alignment. Actual performance will vary depending on the operating environment and application. AMETEK products are not designed for and should not be used in medical life support applications. AMETEK reserves the right to revise its products without notification. The above characteristics represent standard products. For product designed to meet specific applications, contact AMETEK Technical & Industrial Products Sales department.

Instruments



Series DS-300 Flow Sensors

Installation and Operating Instructions Flow Calculations



Series DS-300 Flow Sensors are averaging pitot tubes that provide accurate, convenient flow rate sensing. When purchased with a Dwyer Capsuhelic® for liquid flow or Magnehelic® for air flow, differential pressure gage of appropriate range, the result is a flow-indicating system delivered off the shelf at an economical price. Series DS-300 Flow Sensors are designed to be inserted in the pipeline through a compression fitting and are furnished with instrument shut-off valves on both pressure connections. Valves are fitted with 1/8" female NPT connections. Accessories include adapters with 1/4" SAE 45° flared ends compatible with hoses supplied with the Model A-471 Portable Capsuhelic® kit. Standard valves are rated at 200°F (93.3°C). Where valves are not required, they can be omitted at reduced cost. Series DS-300 Flow Sensors are available for pipe sizes from 1" to 10".

INSPECTION

Inspect sensor upon receipt of shipment to be certain it is as ordered and not damaged. If damaged, contact carrier.

INSTALLATION

General - The sensing ports of the flow sensor must be correctly positioned for measurement accuracy. The instrument connections on the sensor indicate correct positioning. The side connection is for total or high pressure and should be pointed upstream. The top connection is for static or low pressure.

Location - The sensor should be installed in the flowing line with as much straight run of pipe upstream as possible. A rule of thumb is to allow 10 - 15 pipe diameters upstream and 5 downstream. The table below lists recommended up and down piping.

PRESSURE AND TEMPERATURE

Maximum: 200 psig (13.78 bar) at 200°F (93.3°C).

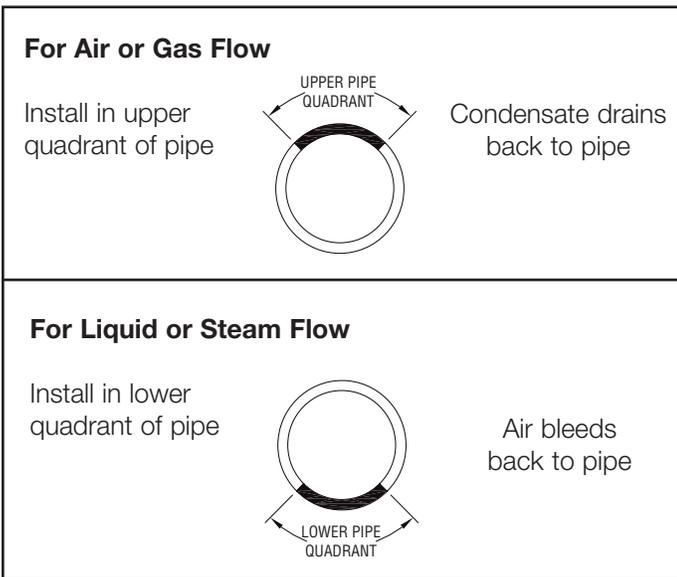
Upstream and Downstream Dimensions in Terms of Internal Diameter of Pipe*			
Upstream Condition	Minimum Diameter of Straight Pipe		
	Upstream		Downstream
	In-Plane	Out of Plane	
One Elbow or Tee	7	9	5
Two 90° Bends in Same Plane	8	12	5
Two 90° Bends in Different Plane	18	24	5
Reducers or Expanders	8	8	5
All Valves**	24	24	5

* Values shown are recommended spacing, in terms of internal diameter for normal industrial metering requirements. For laboratory or high accuracy work, add 25% to values.
 ** Includes gate, globe, plug and other throttling valves that are only partially opened. If valve is to be fully open, use values for pipe size change. **CONTROL VALVES SHOULD BE LOCATED AFTER THE FLOW SENSOR.**

POSITION

Be certain there is sufficient clearance between the mounting position and other pipes, walls, structures, etc, so that the sensor can be inserted through the mounting unit once the mounting unit has been installed onto the pipe.

Flow sensors should be positioned to keep air out of the instrument connecting lines on liquid flows and condensate out of the lines on gas flows. The easiest way to assure this is to install the sensor into the pipe so that air will bleed into, or condensate will drain back to, the pipe.



INSTALLATION

1. When using an A-160 thred-o-let, weld it to the pipe wall. If replacing a DS-200 unit, an A-161 bushing (1/4" x 3/8") will be needed.
2. Drill through center of the thred-o-let into the pipe with a drill that is slightly larger than the flow sensor diameter.
3. Install the packing gland using proper pipe sealant. If the packing gland is disassembled, note that the tapered end of the ferrule goes into the fitting body.
4. Insert sensor until it bottoms against opposite wall of the pipe, then withdraw 1/16" to allow for thermal expansion.
5. Tighten packing gland nut finger tight. Then tighten nut with a wrench an additional 1-1/4 turns. Be sure to hold the sensor body with a second wrench to prevent the sensor from turning.

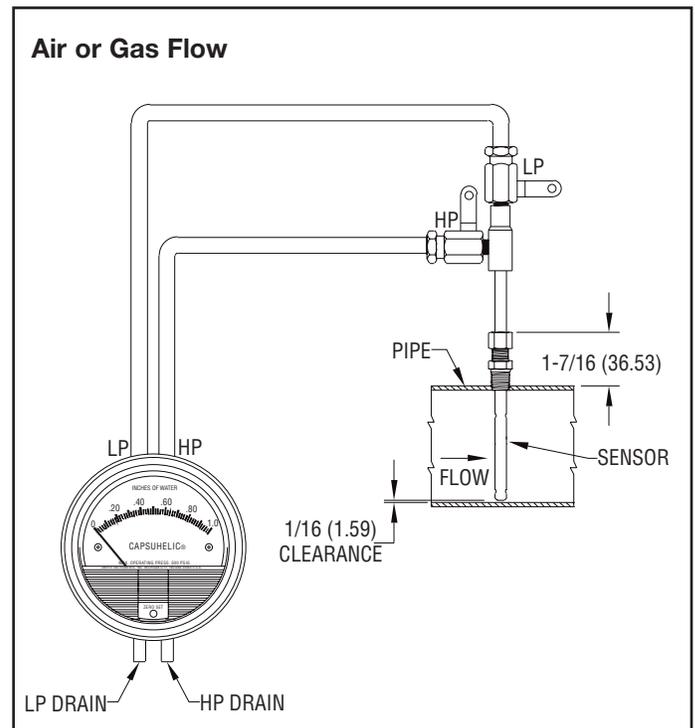
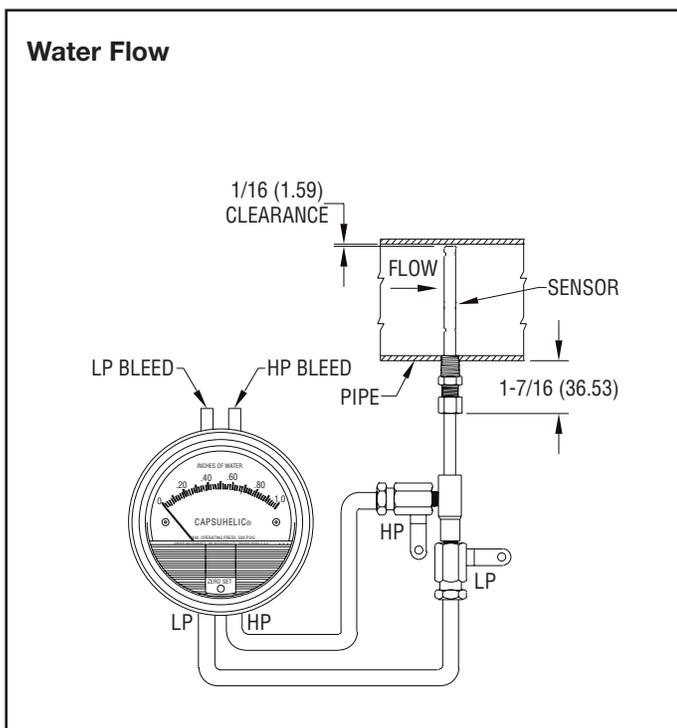
INSTRUMENT CONNECTION

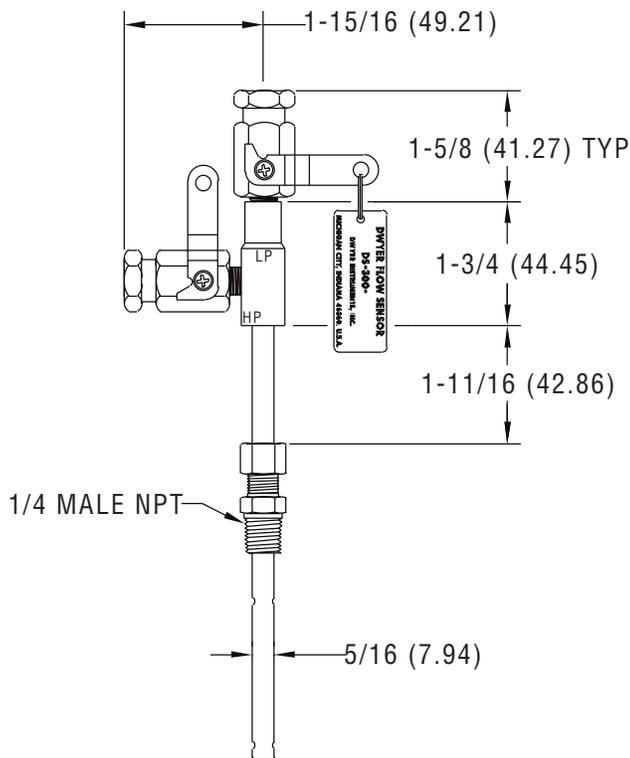
Connect the slide pressure tap to the high pressure port of the Magnehelic® (air only) or Capsuhelic® gage or transmitting instrument and the top connection to the low pressure port.

See the connection schematics below.

Bleed air from instrument piping on liquid flows. Drain any condensate from the instrument piping on air and gas flows.

Open valves to instrument to place flow meter into service. For permanent installations, a 3-valve manifold is recommended to allow the gage to be zero checked without interrupting the flow. The Dwyer A-471 Portable Test Kit includes such a device.





Flow Calculations and Charts

The following information contains tables and equations for determining the differential pressure developed by the DS-300 Flow Sensor for various flow rates of water, steam, air or other gases in different pipe sizes.

This information can be used to prepare conversion charts to translate the differential pressure readings being sensed into the equivalent flow rate. When direct readout of flow is required, use this information to calculate the full flow differential pressure in order to specify the exact range of Dwyer Magnehelic® or Capsuhelic® gage required. Special ranges and calculations are available for these gages at minimal extra cost. See bulletins A-30 and F-41 for additional information on Magnehelic® and Capsuhelic® gages and DS-300 flow sensors.

For additional useful information on making flow calculations, the following service is recommended: Crane Valve Co. Technical Paper No. 410 "Flow of Fluids Through Valves, Fittings and Pipe." It is available from Crane Valve Company, www.cranvalve.com.

Using the appropriate differential pressure equation from Page 4 of this bulletin, calculate the differential pressure generated by the sensor under normal operating conditions of the system. Check the chart below to determine if this value is within the recommended operating range for the sensor. Note that the data in this chart is limited to standard conditions of air at 60°F (15.6°C) and 14.7 psia static line pressure or water at 70°F (21.1°C). To determine recommended operating ranges of other gases, liquids an/or operating conditions, consult factory.

Note: the column on the right side of the chart which defines velocity ranges to avoid. Continuous operation within these ranges can result in damage to the flow sensor caused by excess vibration.

Pipe Size (Schedule 40)	Flow Coefficient "K"	Operating Ranges Air @ 60°F & 14.7 psia (D/P in. W.C.)	Operating Ranges Water @ 70°F (D/P in. W.C.)	Velocity Ranges Not Recommended (Feet per Second)
1	0.52	1.10 to 186	4.00 to 675	146 to 220
1-1/4	0.58	1.15 to 157	4.18 to 568	113 to 170
1-1/2	0.58	0.38 to 115	1.36 to 417	96 to 144
2	0.64	0.75 to 75	2.72 to 271	71 to 108
2-1/2	0.62	1.72 to 53	6.22 to 193	56 to 85
3	0.67	0.39 to 35	1.43 to 127	42 to 64
4	0.67	0.28 to 34	1.02 to 123	28 to 43
6	0.71	0.64 to 11	2.31 to 40	15 to 23
8	0.67	0.10 to 10	0.37 to 37	9.5 to 15
10	0.70	0.17 to 22	0.60 to 79	6.4 to 10

FLOW EQUATIONS

1. Any Liquid

$$Q \text{ (GPM)} = 5.668 \times K \times D^2 \times \sqrt{\Delta P / S_f}$$

2. Steam or Any Gas

$$Q \text{ (lb/Hr)} = 359.1 \times K \times D^2 \times \sqrt{p \times \Delta P}$$

3. Any Gas

$$Q \text{ (SCFM)} = 128.8 \times K \times D^2 \times \sqrt{\frac{P \times \Delta P}{(T + 460) \times S_s}}$$

DIFFERENTIAL PRESSURE EQUATIONS

1. Any Liquid

$$\Delta P \text{ (in. WC)} = \frac{Q^2 \times S_f}{K^2 \times D^4 \times 32.14}$$

2. Steam or Any Gas

$$\Delta P \text{ (in. WC)} = \frac{Q^2}{K^2 \times D^4 \times p \times 128,900}$$

3. Any Gas

$$\Delta P \text{ (in. WC)} = \frac{Q^2 \times S_s \times (T + 460)}{K^2 \times D^4 \times P \times 16,590}$$

Technical Notations

The following notations apply:

ΔP = Differential pressure expressed in inches of water column

Q = Flow expressed in GPM, SCFM, or PPH as shown in equation

K = Flow coefficient— See values tabulated on Pg. 3.

D = Inside diameter of line size expressed in inches.

$$\text{For square or rectangular ducts, use: } D = \sqrt{\frac{4 \times \text{Height} \times \text{Width}}{\pi}}$$

P = Static Line pressure (psia)

T = Temperature in degrees Fahrenheit (plus 460 = °Rankine)

p = Density of medium in pounds per square foot

S_f = Sp Gr at flowing conditions

S_s = Sp Gr at 60°F (15.6°C)

SCFM TO ACFM EQUATION

$$\text{SCFM} = \text{ACFM} \times \left(\frac{14.7 + \text{PSIG}}{14.7} \right) \left(\frac{520^*}{460 + ^\circ\text{F}} \right)$$

$$\text{ACFM} = \text{SCFM} \times \left(\frac{14.7}{14.7 + \text{PSIG}} \right) \left(\frac{460 + ^\circ\text{F}}{520} \right)$$

$$\text{POUNDS PER STD. CUBIC FOOT} = \text{POUNDS PER ACT. CUBIC FOOT} \times \left(\frac{14.7}{14.7 + \text{PSIG}} \right) \left(\frac{460 + ^\circ\text{F}}{520^*} \right)$$

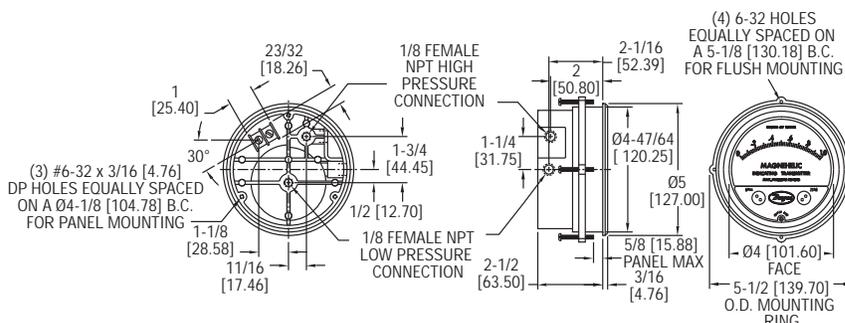
$$\text{POUNDS PER ACT. CUBIC FOOT} = \text{POUNDS PER STD. CUBIC FOOT} \times \left(\frac{14.7 + \text{PSIG}}{14.7} \right) \left(\frac{520^*}{460 + ^\circ\text{F}} \right)$$

1 Cubic foot of air = 0.076 pounds per cubic foot at 60° F (15.6°C) and 14.7 psia.

* (520° = 460 + 60°) Std. Temp. Rankine



Series 605 Magnehelic® Differential Pressure Indicating Transmitter
Specifications - Installation and Operating Instructions



The Series 605 Magnehelic® Indicating Transmitter simultaneously provides local indication on a large, easily read analog scale while also converting that pressure into a standard two-wire, 4-20 mA signal for ranges from 0-0.5 to 0-50" w.c. Positive, negative or differential air and compatible gas pressure can be measured with accuracies as low as ±.5% of full scale. The basic mechanical components of the Series 605 Magnehelic® indicating transmitter are similar to those used in the popular, time-proven Magnehelic® differential pressure gage.

STANDARD ACCESSORIES

- Mounting ring
- Snap ring
- (4) 6-32 x 1-1/4 screws (panel mtg.)
- (3) 6-32 x 5/16 screws (surface mtg.)
- (2) Tubing to 1/8" NPT adapters
- (2) 1/8" NPT plugs
- Adjustment key

SPECIFICATIONS

GAGE SPECIFICATIONS

- Service:** Air and non-combustible, compatible gases.
- Wetted Materials:** Consult factory.
- Accuracy:** See chart.
- Stability:** ±1% F.S./yr.
- Pressure Limits:** See chart.
- Temperature Limits:** 20 to 120°F (-6.67 to 48.9°C).
- Process Connections:** 1/8" female NPT.
- Size:** 4" (101.6 mm) dial face, 5" (127 mm) O.D. x 2-11/16" (68.3 mm).
- Weight:** 1 lb, 12.6 oz (811 g).
- Agency Approvals:** CE.

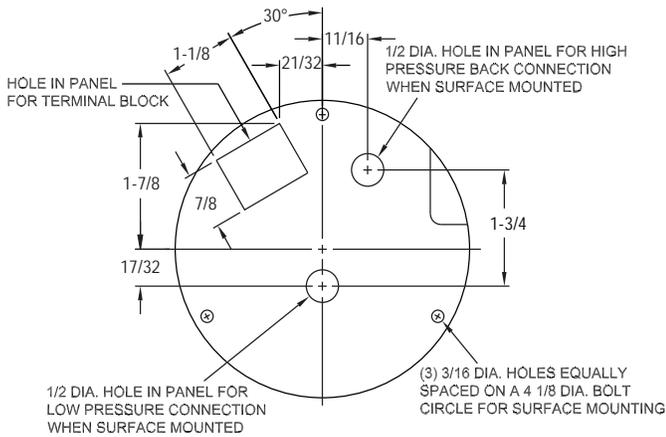
TRANSMITTER SPECIFICATIONS

- Accuracy:** See chart (includes linearity, hysteresis, repeatability).
- Temperature Limits:** 20 to 120°F (-6.67 to 48.9°C).
- Compensated Temperature Range:** 32 to 120°F (0 to 48.9°C).
- Thermal Effect:** ±0.025% F.S./°F (0.045% F.S./°C).
- Power Requirements:** 10-35 VDC (2-wire).
- Output Signal:** 4 to 20 mA.
- Zero and Span Adjustments:** Protected potentiometers.
- Loop Resistance:** DC; 0-1250 ohms maximum.
- Current Consumption:** DC; 38 mA maximum.
- Electrical Connections:** Screw terminal block.
- Mounting Orientation:** Diaphragm in vertical position. Consult factory for other position orientations.

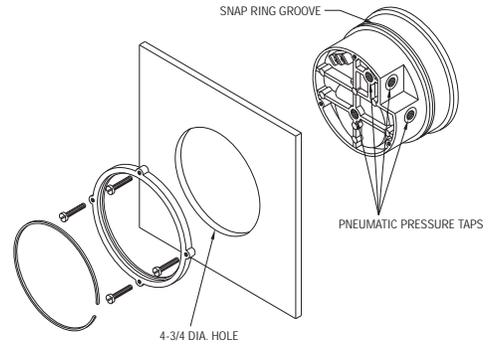
Model	Range in w.c.	Maximum Pressure	Electrical Accuracy +/-%	Mechanical Accuracy +/-%	Model	Range in w.c.	Maximum Pressure	Electrical Accuracy +/-%	Mechanical Accuracy +/-%
605-00N	.05-0-.20	25 psi (1.7 bar)	2	4	605-20	0-20.0	11 psi (75.8 kPa)	0.5	2
605-11	.25-0-.25	25 psi (1.7 bar)	2	3	605-30	0-30	11 psi (75.8 kPa)	0.5	2
605-0	0-.50	25 psi (1.7 bar)	2	3	605-50	0-50	11 psi (75.8 kPa)	0.5	2
605-1	0-1.0	25 psi (1.7 bar)	2	2	Range in Pa				
605-2	0-2.0	2 psi (13.79 kPa)	0.5	2	605-60PA	0-60	25 psi (1.7 bar)	2	4
605-3	0-3.0	2 psi (13.79 kPa)	0.5	2	605-125PA	0-125	25 psi (1.7 bar)	2	3
605-6	0-6.0	2 psi (13.79 kPa)	0.5	2	605-250PA	0-250	25 psi (1.7 bar)	2	2
605-10	0-10	2 psi (13.79 kPa)	0.5	2	605-500PA	0-500	2 psi (13.79 kPa)	0.5	2

INSTALLATION

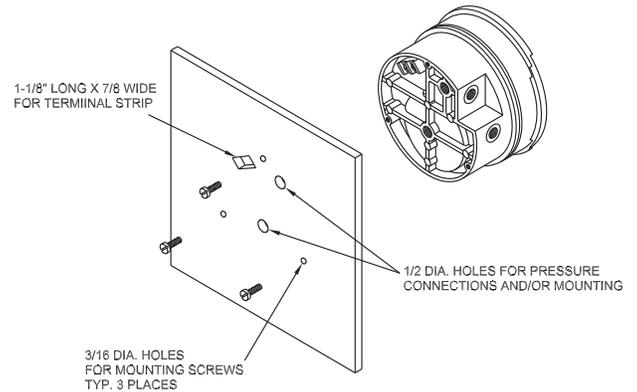
- 1. LOCATION:** Select a location where the temperature of the unit will be between 20°F and 120°F. Distance from the receiver is limited only by total loop resistance. See "Electrical Connections". The tubing feeding pressure to the instrument can be run practically any length required but long lengths will increase response time slightly. Avoid surfaces with excessive vibration.
- 2. POSITION:** All standard models are calibrated with the diaphragm vertical and should be used in that position for maximum accuracy. If your application requires mounting in other than a vertical position, be sure to specify this when ordering.
- 3. PRESSURE CONNECTIONS:** For convenience, two sets of 1/8" female NPT ports are available. Plug the unused set with pipe plugs provided. Attach tubing from positive pressure source to port marked "HI" or from negative (Vacuum) source to port marked "LOW". In either case, opposite port must be vented to atmosphere. In dusty environments, we recommend use of an A-331 Filter Vent Plug to keep interior of instrument clean. For differential pressures the higher source is connected to the "HI" port and lower to the "LOW" port.



- 4. MOUNTING:** The Series 605 Transmitter may be either panel mounted or surface mounted.



- A. PANEL MOUNTING:** Cut a 4-3/4" or 120mm dia. hole in panel and insert the complete unit from the front. Slip on the mounting ring and install the split snap ring in the groove on the bezel. Seat the mounting ring against the snap ring and thread the four screws through the tapped holes. Tighten screws against rear of panel.



- B. SURFACE MOUNTING:** Drill (3) 3/16" dia. holes for mounting screws and cut (1) 7/8" x 1-1/8" hole for access to terminal strip as shown in hole location drawing. Insert screws from rear of panel and thread into tapped holes on back of transmitter case. If rear pressure connections are to be used, make 1/2" dia. holes located as shown in hole location drawing in left column.

- 5. ZEROING:** Once gage/transmitter is mounted in its final position, check to be sure pointer aligns with zero on scale, when no pressure is applied and both low and high pressure ports are vented to atmosphere. To adjust, turn small slotted screw at center-bottom of gage face. **Do not** move the larger black knobs labeled SPAN and ZERO. These are for use only if a calibration check shows the 4-20 mA output signal to need adjustment. See page 3 under heading OUTPUT RANGING.

ELECTRICAL CONNECTIONS

CAUTION: DO NOT EXCEED SPECIFIED SUPPLY VOLTAGE RATINGS. PERMANENT DAMAGE NOT COVERED BY WARRANTY WILL RESULT. THIS UNIT IS NOT DESIGNED FOR AC VOLTAGE OPERATION.

Electrical connections to the Series 605 Transmitter are made to the two-screw terminal strip on the rear of the case. Polarity is indicated by + and - signs stamped on side. The schematic diagram of the Series 605 transmitter is illustrated in Figure B.

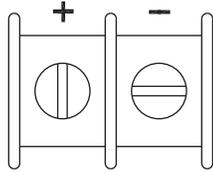


Figure A

An external power supply delivering 10.0 to 35 VDC with a minimum current capability of 40 milliamps must be used to power the control loop in which the Series 605 transmitter is connected. Refer to Fig. B for connection of the power supply, transmitter and receiver. The range of appropriate receiver load resistances (R_L) for the power supply voltage available is given by the formula and graph in Fig. C. Shielded two wire cable is recommended for control loop wiring and the negative side of the loop may be grounded if desired. Note also that the receiver may be connected in either the negative or positive side of the loop, whichever is most convenient. Should polarity of the transmitter or receiver be inadvertently reversed, the loop will not function properly but no damage will be done to the transmitter.

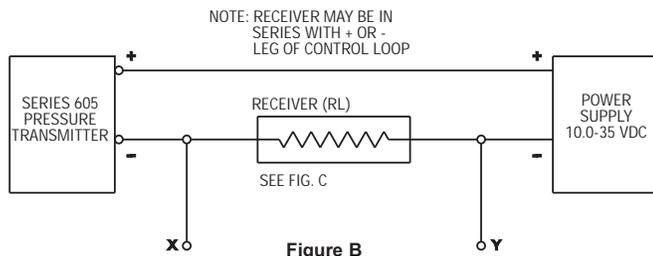


Figure B

The maximum length of connecting wire between the transmitter and the receiver is a function of wire size and receiver resistance. That portion of the total current loop resistance represented by the resistance of the connecting wires themselves should not exceed 10% of the receiver resistance. For extremely long runs (over 1,000 feet), it is desirable to select receivers with higher resistances in order to keep the size and cost of the connecting leads as low as possible. In installations where the connecting run is no more than 100 feet, connecting lead wire as small as No. 22 Ga. can be used.

The Series 605 transmitters can be used with receivers requiring 1-5 volt input rather than 4-20 mA. If the receiver requires a 1-5 volt input, insert a 250 ohm, 1/2 watt resistor in series with the current loop but in parallel with the receiver input. Referring to Figure B, R_L becomes the 250 ohm resistor and point X and Y are connected to the receiver input, point X being positive (+) and point Y negative (-) or ground. The resistor should be connected at the panel end of the transmitter current loop close to the receiver input to take advantage of the immunity of the current loop to electrical noise pickup. Most electronic component distributors stock a 249 r, 1/2 watt, $\pm 1\%$ tolerance metal film resistor which is adequate for this application.

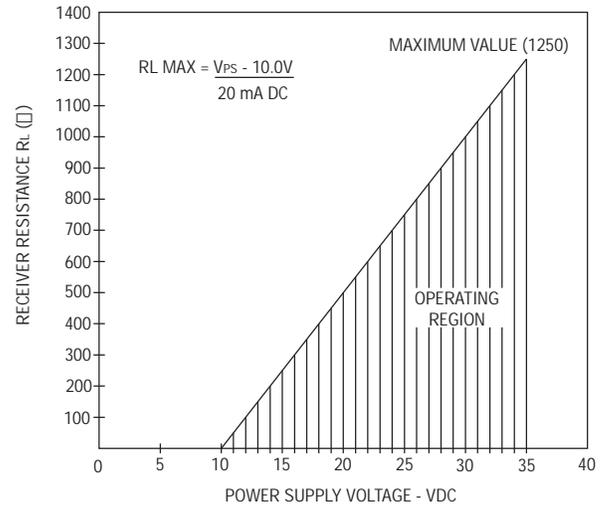


Figure C

OUTPUT RANGING

Each Series 605 Magnehelic® indicating transmitter is factory calibrated to produce 4 mA at zero scale reading and 20 mA at full scale reading. The following procedure should be used if the pressure versus output signal relationship needs to be checked.

1. With unit connected to the companion receiver per preceding instructions, insert an accurate milliammeter with a full scale reading of approximately 30 mA in series with the current loop.
2. Vent both pressure ports to atmosphere and, if necessary, adjust pointer zero screw to align pointer with zero on scale. A controllable pressure source capable of reaching the full scale range should be connected to either high pressure port. Plug the other high pressure port and vent one or both low pressure ports to atmosphere. The instrument must be ranged in the same position in which it will be used. Standard factory calibration and ranging is done with unit vertical.
3. Apply electrical power to the system and check for proper operation by slowly increasing pressure and observing whether the loop current increases above the 4 mA zero pressure reading.
4. A spanner type key is supplied to adjust span and zero. This helps to reduce unauthorized tampering. Apply pressure until pointer aligns with full scale reading and adjust the SPAN knob for a 20 mA reading.
5. Relieve all pressure, allow a few seconds for setting and adjust the ZERO knob for a 4 mA current loop reading.
6. The SPAN and ZERO controls are slightly interactive so steps 4 & 5 should be repeated a few times until readings of 4 and 20 mA are obtained consistently.
7. Remove the milliammeter from the current loop and proceed with final installation of the transmitter and receiver.

MULTIPLE UNITS WITH COMMON POWER SUPPLY

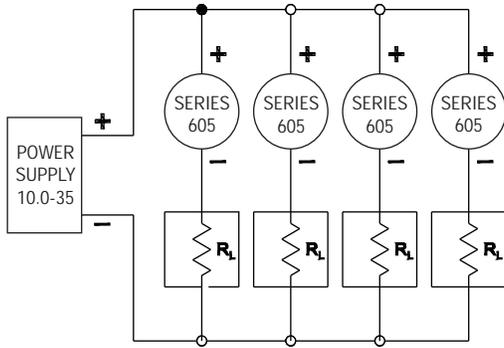
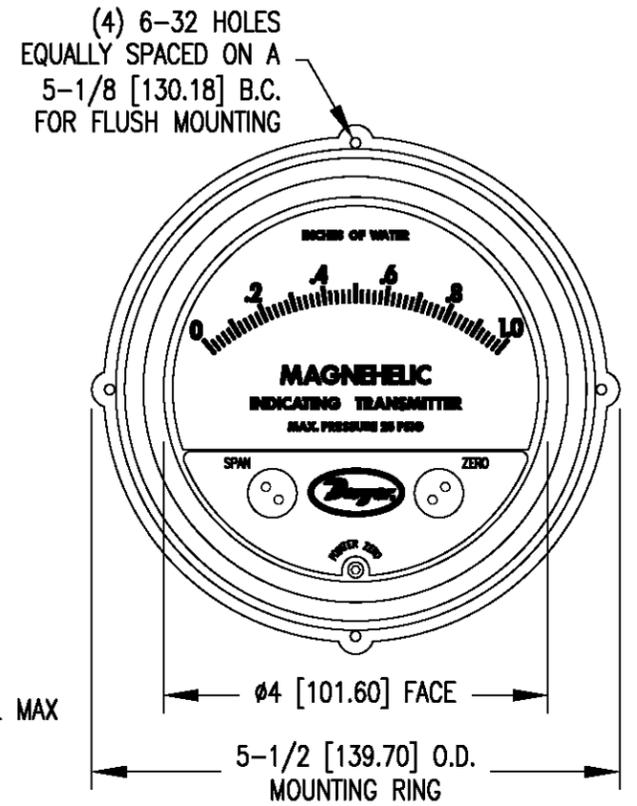
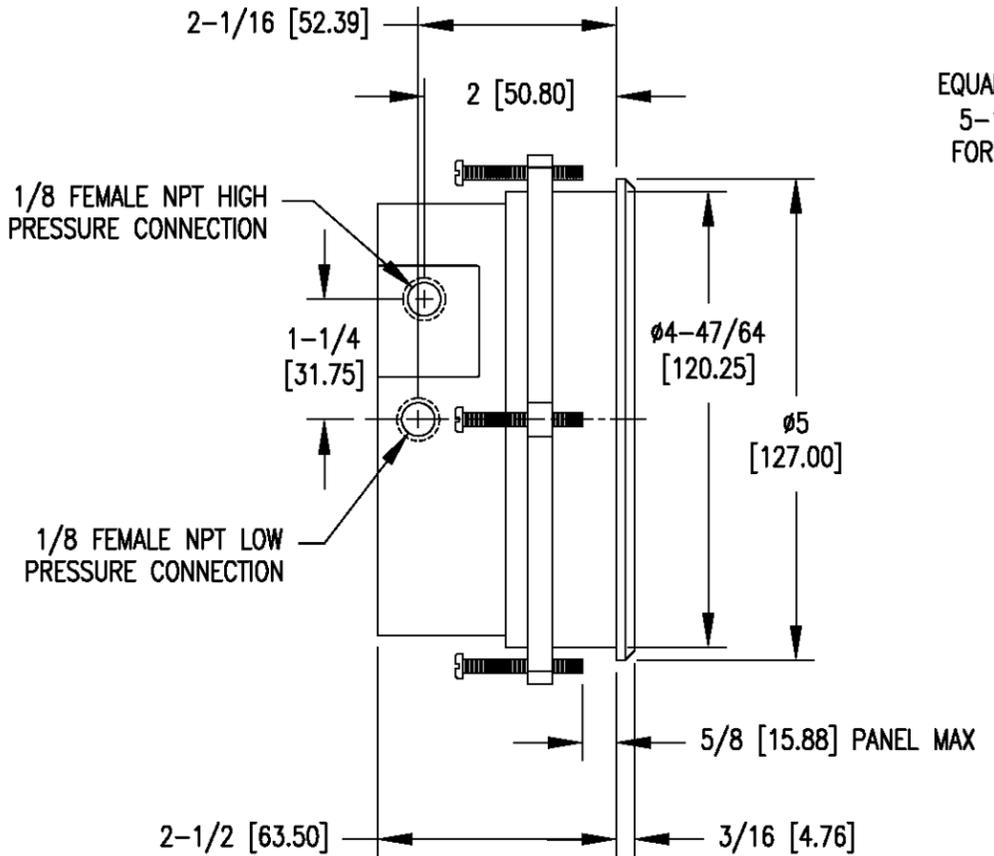
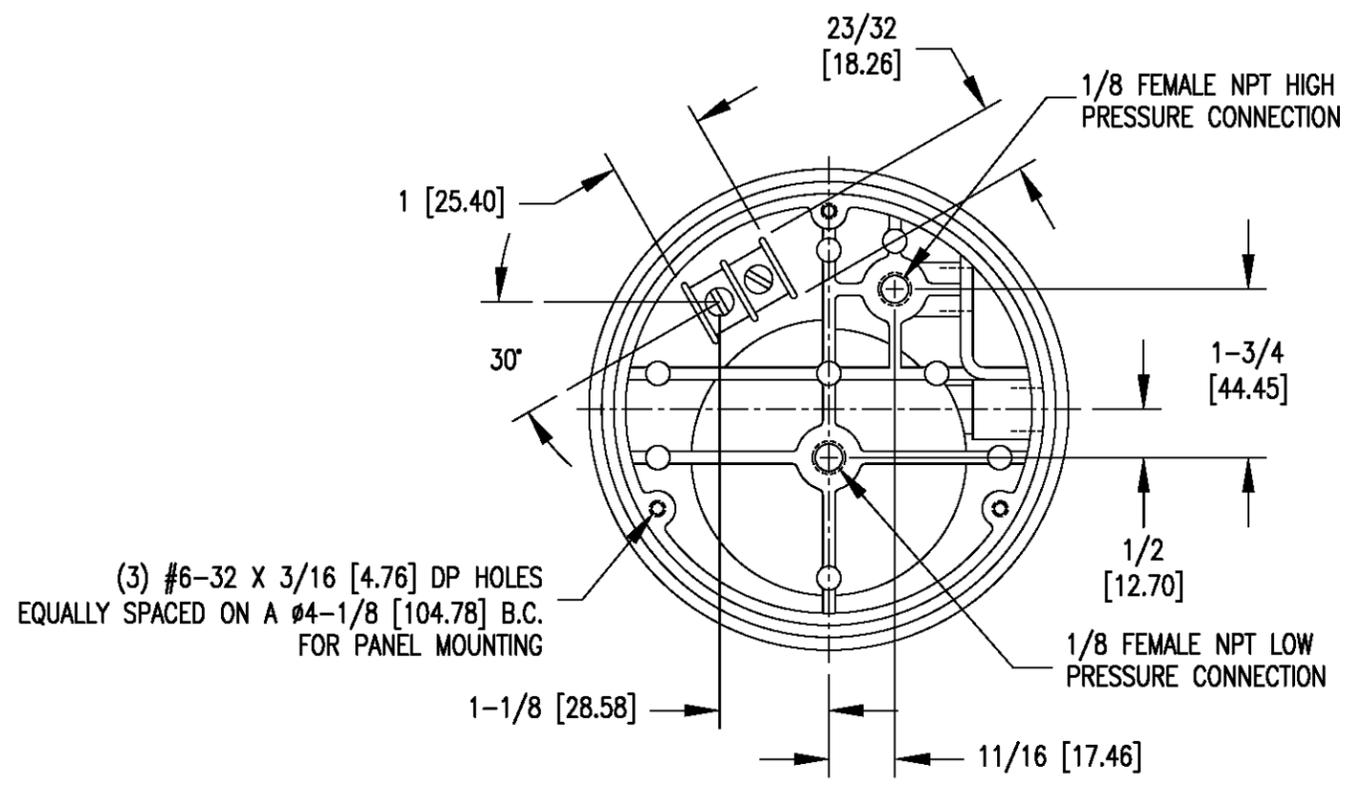


Figure D

Several Series 605 transmitters can be operated with a single power supply as depicted above in Figure D. Be careful to specify a supply with sufficient capacity. The minimum current requirement at a given voltage can be calculated by multiplying the number of units x 20 mA. In the example shown this would be 4 x 20 or 80 mA minimum.

MAINTENANCE

Upon final installation of the Series 605 Transmitter and the companion receiver, including the A-701 Digital Readout, no routine maintenance is required. A periodic check of system calibration is recommended. The Series 605 Differential Pressure Transmitter is not field repairable and should be returned, freight prepaid, to the factory if repair is needed (field repair should not be attempted and may void warranty). Be sure to include a brief description of the problem plus any relevant application notes. Contact customer service to receive a return goods authorization (RGA) number before shipping.



STANDARD TOLERANCES UNLESS NOTED:
ALL DECIMAL DIMENSIONS $\pm .005$
ALL ANGLES $\pm 1^\circ$

SCALE 1:2

		DATE	NAME	MATERIAL
		DWN BY	605 TRANSMITTER	FINISH
		CHKD		
		APPD		
NO.	CHANGES	BY/DATE		
			ACAD2002	FR. NO.

NOTICE: This drawing and the principles and elements of design embodied therein are the exclusive property of DWYER INSTRUMENTS, INC. and are not to be communicated, disclosed, reproduced or used except as previously authorized in writing by such corporation and must not be submitted to outside parties for examination without the written consent of said corporation.



DWYER INSTRUMENTS, INC



Cart



Quick Order/Quote



Log In/Register



Digital Catalog



RIGHT CHOICE. RIGHT PRICE. RIGHT NOW.

800/872-9141 • 219/879-8000

SEARCH

Products

Technical Resources

News

About Us

Contact Us

Video Library



Series DS Flow Calculator

You can print this page and include it with your order. For media other than Air, you should multiply your differential pressure by the Specific Gravity of your media.

Flow Results	
DS Flow Sensor Selected	DS300-4.00
Flow Media	Air
Maximum Flow Rate	350 SCFM
Differential Pressure	2.32126211069 " W.C.
Static Line Pressure	14.7 PSIA
Temperature	85 F

[Change Your Flow Characteristics](#)

[Home](#)

[Free Literature](#)
[Terms & Conditions of Sale](#)

[International Distribution](#)
[Website Terms of Use](#)
© Copyright 2014 Dwyer Instruments, Inc. All rights reserved.

[About SSL Certificates](#)

[What's New](#)

[About Us](#)

[Careers](#)
[Privacy Policy](#)

[Contact Us](#)



DWYER INSTRUMENTS, INC



Cart



Quick Order/Quote



Log In/Register



Digital Catalog



RIGHT CHOICE. RIGHT PRICE. RIGHT NOW.

800/872-9141 • 219/879-8000

SEARCH

Products

Technical Resources

News

About Us

Contact Us

Video Library



Series DS Flow Calculator

You can print this page and include it with your order. For media other than Air, you should multiply your differential pressure by the Specific Gravity of your media.

Flow Results	
DS Flow Sensor Selected	DS300-4.00
Flow Media	Air
Maximum Flow Rate	350 SCFM
Differential Pressure	2.23607818002 " W.C.
Static Line Pressure	14.7 PSIA
Temperature	65 F

[Change Your Flow Characteristics](#)

[Home](#)

[Free Literature](#)
[Terms & Conditions of Sale](#)

[International Distribution](#)
[Website Terms of Use](#)
© Copyright 2014 Dwyer Instruments, Inc. All rights reserved.

[About SSL Certificates](#)

[What's New](#)

[About Us](#)

[Careers](#)
[Privacy Policy](#)

[Contact Us](#)

RUGGED SOLID STATE TRANSDUCERS

WITH AMPLIFIED OUTPUTS

STANDARD AND METRIC MODELS

EXCLUSIVE!

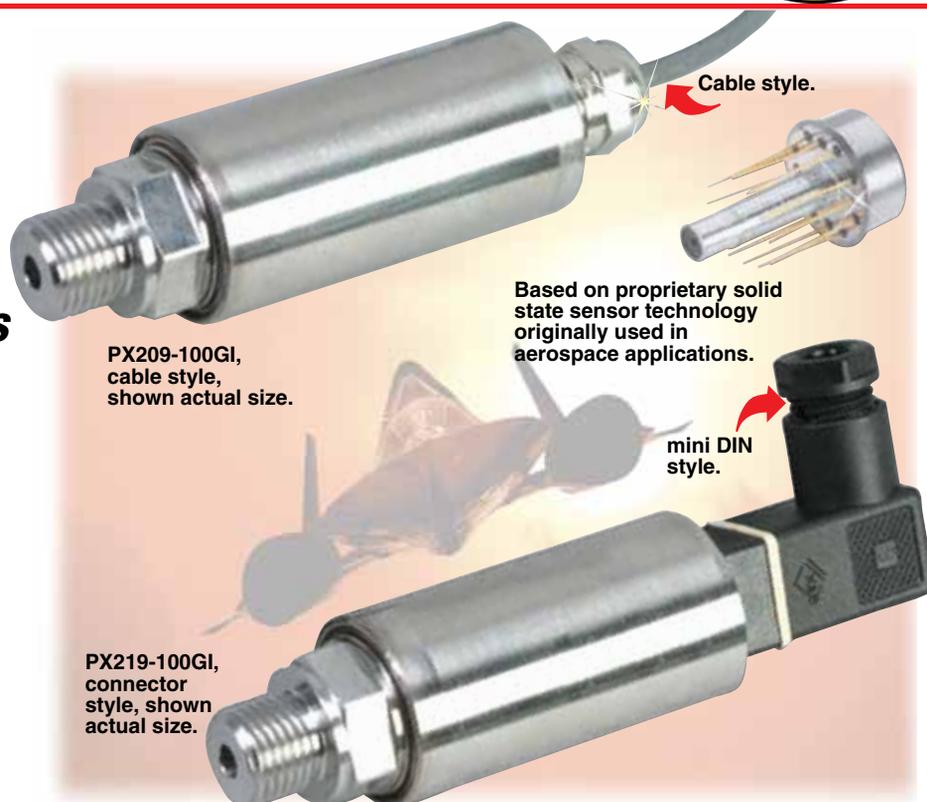
0-15 to 0-300 psi-Standard Units
0-1 to 0-20 bar-Metric Units
Gage, Absolute, and
Compound Ranges

PX209/PXM209 Series



- ✓ **Stainless Steel Fitting and Body**
- ✓ **5-Point NIST-Traceable Calibration Included**
- ✓ **Solid State Media Isolation (Suitable for Use with Many Industrial Liquids and Gases)**
- ✓ **Broad Temperature-Compensated Range of -20 to 80°C (-4 to 176°F) Yields High Stability with Changing Temperatures**
- ✓ **Electrical Isolation to 100 MΩ Ensures Long-Term Reliability**
- ✓ **Rugged High Shock and Vibration Design for Tough OEM Applications**
- ✓ **100,000 Hr MTBF Typical**

Based on proprietary sensor technology developed by OMEGA to meet the high reliability and accuracy demanded by aerospace applications, the PX209/PXM209 Series voltage and current output pressure transducer offers superior performance in non-corrosive applications, including: engine/powertrain testing, well monitoring, and ground and race water monitoring. The transducer uses a 4-active-arm bridge sensor with a



micro-machined diffused silicon diaphragm and proprietary thin-film media, plus dielectric isolation barriers.

This same core sensing element technology, which includes multiple types of signal conditioning and the ability to survive extremes of shock and vibration, provides a modular building block for OMEGA's revolutionary family of pressure-sensing instruments.

SPECIFICATIONS

Voltage Output

Excitation: 24 Vdc @ 15 mA

5 Vdc Output: 7 to 35 Vdc

10 Vdc Output: 12 to 35 Vdc

Output: 0 to 5 Vdc or 0 to 10 Vdc, ±1.5% FSO, 3-wire

Zero Balance: 0 Vdc ±2% FSO

4 to 20 mA Output

Excitation: 24 Vdc (7 to 35 Vdc) reverse polarity protected

Output: 4 to 20 mA (2-wire) ±1% FSO

Zero Balance: 4 mA ±2% FSO

Max Loop Resistance:

50 x (supply voltage - 10) Ω

Common Specifications

Accuracy: 0.25% full scale (including linearity, hysteresis and repeatability)

Operating Temperature: -54 to 121°C (-65 to 250°F)

Compensated Temperature: -20 to 80°C (-4 to 176°F)

Thermal Effects: 0.04% full scale/°C (0.02% FS/°F)

Proof Pressure: 150%

Burst Pressure: 300% range maximum

Response Time: 2 ms typical

Vibration Sensitivity: At 20 g peak sinusoidal vibration from 10 Hz to 2000 Hz (½" D.A.), the output shall not exceed 0.04% FS/g for 15 psi range to 0.005% FS/g for 100 psi and above

Natural Frequency: >35 kHz for 100 psi range

Gage Type: Diffused silicon strain gages

Wetted Parts: 316 stainless steel, borosilicate glass, silicon nitride, epoxy

Pressure Port: See dimensional drawing, on page B-150

Electrical Connections:

PX209/PXM209: 1 m (36") shielded 4-conductor cable

PX219/PXM219: DIN 40050 plug connector supplied

Weight: 128 g (4.5 oz)



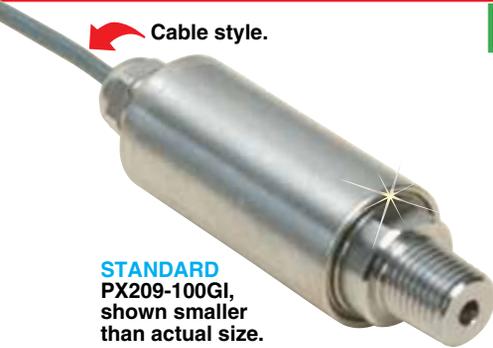
CURRENT OUTPUT
PRESSURE TRANSDUCERS
B

STANDARD MODELS

AVAILABLE FOR FAST DELIVERY!

To Order (Specify PX209 for Cable or PX219 for DIN Connector)

psi	bar	CABLE STYLE	CONN. STYLE	COMPATIBLE METERS*
GAGE PRESSURE RANGES (psia) WITH 4 TO 20 mA OUTPUT				
0 to 15	0 to 1.0	PX209-015GI	PX219-015GI	DPI8, DP41-E, DP25B-E
0 to 30	0 to 2.1	PX209-030GI	PX219-030GI	DPI8, DP41-E, DP25B-E
0 to 60	0 to 4.1	PX209-060GI	PX219-060GI	DPI8, DP41-E, DP25B-E
0 to 100	0 to 6.9	PX209-100GI	PX219-100GI	DPI8, DP41-E, DP25B-E
0 to 200	0 to 13.8	PX209-200GI	PX219-200GI	DPI8, DP41-E, DP25B-E
0 to 300	0 to 20.7	PX209-300GI	PX219-300GI	DPI8, DP41-E, DP25B-E
ABSOLUTE PRESSURE RANGES (psia) WITH 4 TO 20 mA OUTPUT				
0 to 15	0 to 1.0	PX209-015AI	PX219-015AI	DPI8, DP41-E, DP25B-E
0 to 30	0 to 2.1	PX209-030AI	PX219-030AI	DPI8, DP41-E, DP25B-E
0 to 60	0 to 4.1	PX209-060AI	PX219-060AI	DPI8, DP41-E, DP25B-E
0 to 100	0 to 6.9	PX209-100AI	PX219-100AI	DPI8, DP41-E, DP25B-E
0 to 200	0 to 13.8	PX209-200AI	PX219-200AI	DPI8, DP41-E, DP25B-E
0 to 300	0 to 20.7	PX209-300AI	PX219-300AI	DPI8, DP41-E, DP25B-E
VACUUM AND COMPOUND RANGES WITH 4 TO 20 mA OUTPUT				
-14.7 to 0	-1 to 0	PX209-30VACI	PX219-30VACI	DPI8, DP41-E, DP25B-E
-14.7 to 15	-1 to 1.0	PX209-30V15GI	PX219-30V15GI	DPI8, DP41-E, DP25B-E
-14.7 to 45	-1 to 3.1	PX209-30V45GI	PX219-30V45GI	DPI8, DP41-E, DP25B-E
-14.7 to 85	-1 to 5.9	PX209-30V85GI	PX219-30V85GI	DPI8, DP41-E, DP25B-E
-14.7 to 135	-1 to 9.3	PX209-30V135GI	PX219-30V135GI	DPI8, DP41-E, DP25B-E



STANDARD
PX209-100GI,
shown smaller
than actual size.

**Order a snubber
to protect your
pressure transducer!**



PS-4G, shown actual size.

Comes complete with 5-point NIST traceable calibration. * Visit us online for compatible meters.

Ordering Example: PX219-015AI, 4 to 20 mA output transducer for absolute pressure with a 0 to 15 psia range, PS-4G snubber and TX4-100 shielded wire.

METRIC MODELS

AVAILABLE FOR FAST DELIVERY!

To Order (Specify PXM209 for Cable or PXM219 for DIN Connector)

bar	CABLE STYLE	CONN. STYLE	COMPATIBLE METERS*
GAGE PRESSURE RANGES (bar) WITH 4 to 20 mA OUTPUT			
0 to 1.0	PXM209-001GI	PXM219-001GI	DPI8, DP41-E, DP25B-E
0 to 1.6	PXM209-1.60GI	PXM219-1.60GI	DPI8, DP41-E, DP25B-E
0 to 2.5	PXM209-2.50GI	PXM219-2.50GI	DPI8, DP41-E, DP25B-E
0 to 4.0	PXM209-004GI	PXM219-004GI	DPI8, DP41-E, DP25B-E
0 to 6.0	PXM209-006GI	PXM219-006GI	DPI8, DP41-E, DP25B-E
0 to 10.0	PXM209-010GI	PXM219-010GI	DPI8, DP41-E, DP25B-E
0 to 16.0	PXM209-016GI	PXM219-016GI	DPI8, DP41-E, DP25B-E
0 to 20.0	PXM209-020GI	PXM219-020GI	DPI8, DP41-E, DP25B-E
ABSOLUTE PRESSURE RANGES (bar) WITH 4 to 20 mA OUTPUT			
0 to 1.0	PXM209-001AI	PXM219-001AI	DPI8, DP41-E, DP25B-E
0 to 1.6	PXM209-1.60AI	PXM219-1.60AI	DPI8, DP41-E, DP25B-E
0 to 2.5	PXM209-2.50AI	PXM219-2.50AI	DPI8, DP41-E, DP25B-E
0 to 4.0	PXM209-004AI	PXM219-004AI	DPI8, DP41-E, DP25B-E
0 to 6.0	PXM209-006AI	PXM219-006AI	DPI8, DP41-E, DP25B-E
0 to 10.0	PXM209-010AI	PXM219-010AI	DPI8, DP41-E, DP25B-E
0 to 16.0	PXM209-016AI	PXM219-016AI	DPI8, DP41-E, DP25B-E
0 to 20.0	PXM209-020AI	PXM219-020AI	DPI8, DP41-E, DP25B-E
VACUUM AND COMPOUND RANGES (bar) WITH 4 to 20 mA OUTPUT			
VAC to 0	PXM209-VAC000GI	PXM219-VAC000GI	DPI8, DP41-E, DP25B-E
VAC to 1	PXM209-VAC001GI	PXM219-VAC001GI	DPI8, DP41-E, DP25B-E
VAC to 3	PXM209-VAC003GI	PXM219-VAC003GI	DPI8, DP41-E, DP25B-E
VAC to 6	PXM209-VAC006GI	PXM219-VAC006GI	DPI8, DP41-E, DP25B-E
VAC to 9	PXM209-VAC009GI	PXM219-VAC009GI	DPI8, DP41-E, DP25B-E

Comes complete with 5-point NIST traceable calibration. * Visit us online for compatible meters.

Note: The current output versions of the vacuum and compound sensors generate 4 mA at vacuum and 20 mA at full scale.

Ordering Example: PXM219-001AI, 4 to 20 mA output transducer for absolute pressure with a 0 to 1 bar range, PS-4G-MG snubber and TX4-100 shielded wire.

STANDARD ACCESSORIES

MODEL	DESCRIPTION
PS-4G	¼ NPT pressure snubber for gaseous media
PS-4E	¼ NPT pressure snubber for water and light oils
PS-4D	¼ NPT pressure snubber for dense liquids (motor oil)
TX4-100	30 m (100') of 4-conductor shielded wire

METRIC ACCESSORIES

MODEL	DESCRIPTION
PS-4G-MG	¾ pressure snubber for gaseous media
PS-4E-MG	¾ pressure snubber for water and light oils
PS-4D-MG	¾ pressure snubber for dense liquids (motor oil)
TX4-100	30 m (100') of 4-conductor shielded wire

ROTRON has a variety of gauges for pressure, vacuum and temperature measurements in various ranges. These gauges are reliable and rugged.

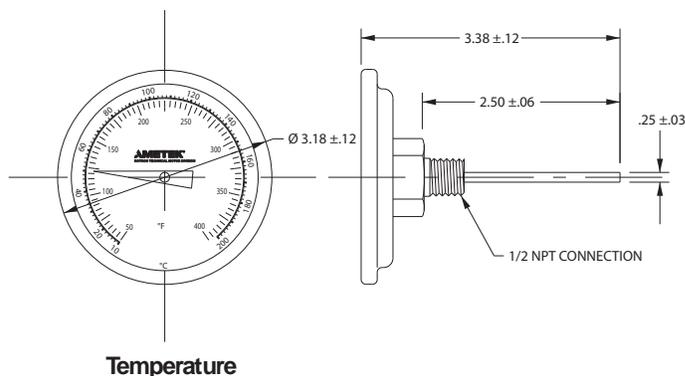
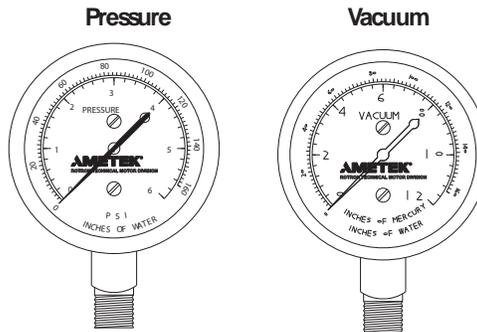
SPECIFICATIONS:

Pressure/ Vacuum

CASE – Drawn Steel Finished
in Black Enamel
DIAPHRAGM – Bronze
LENS – Clear Plastic
ACCURACY – 2%
WEIGHT – 1/2 lb.
CONNECTION – 1/4" NPT
FACE – 2 1/2" dia.

Temperature

CASE – Steel
LENS – Glass
ACCURACY – 1%
WEIGHT – 1/4 lb.
CONNECTION – 1/2" NPT
FACE – 3" Dial



US EPA ARCHIVE DOCUMENT

Specification	Units	Part/Model Number						
		551376	271949	550407	529428	271950	550408	551368
Range	-	Pressure	Pressure	Pressure	Vacuum	Vacuum	Vacuum	Temperature
Description	-	0-60 IWG	0-160 IWG	0-280 IWG	0-60 IWG	0-160 IWG	0-280 IWG	0-200 Deg C

This document is for informational purposes only and should not be considered as a binding description of the products or their performance in all applications. The performance data on this page depicts typical performance under controlled laboratory conditions. AMETEK is not responsible for blowers driven beyond factory specified speed, temperature, pressure, flow or without proper alignment. Actual performance will vary depending on the operating environment and application. AMETEK products are not designed for and should not be used in medical life support applications. AMETEK reserves the right to revise its products without notification. The above characteristics represent standard products. For product designed to meet specific applications, contact AMETEK Technical & Industrial Products Sales department.

APPENDIX 3

**CONSTRUCTION SPECIFICATIONS
(provided on CD only)**

SPECIFICATIONS
TABLE OF CONTENTS

DIVISION 1 — GENERAL REQUIREMENTS

01010	Summary of Work
01200	Project Meetings
01300	Submittals and Substitutions
01400	Testing Laboratory Services
01500	Temporary Facilities
01560	Control of Work
01600	Products
01700	Environmental Protection

DIVISION 2 — SITE WORK

02221	Excavation, Trenching, and Backfilling
02222	Exploratory Excavation
02500	Imported Soils
02600	Restoration of Paving and Surfacing
02989	Miscellaneous Work and Cleaning Up
02995	Decontamination

DIVISION 3 — CONCRETE

03200	Concrete Reinforcement
03300	Cast-in-Place Concrete

DIVISION 4 — MASONRY

04100	Utility Mortar and Grout
-------	--------------------------

DIVISION 7 — THERMAL AND MOISTURE PROTECTION

07840	Firestopping
-------	--------------

DIVISION 15 — MECHANICAL

15064	Exterior Polyvinyl Chloride Pipe and Fittings
15203	Interior Piping and Plumbing

DIVISION 16 — ELECTRICAL

16000	Electrical
-------	------------

**SECTION 01010
SUMMARY OF WORK**

PART 1.00 GENERAL

1.01 LOCATION OF WORK

All of the work covered by this Contract is located in the City of Woburn, Massachusetts as shown on the project plans.

1.02 WORK INCLUDED

The work of this Contract includes, but is not necessarily limited to the following:

Site preparation and mobilization as necessary to complete the Work including work necessary to protect the health and safety of construction workers and the public, who will have access to the building during construction.

Construction of new soil vapor extraction points and reconfiguration of existing soil vapor extraction points. Trenching, bedding, installing, and backfilling vapor extraction piping outside the existing building. Restoration of bituminous concrete and portland cement concrete pavement. Installation of risers and overhead piping in the building interior including sample ports, fittings, and valves. Pipe penetrations through exterior walls with associated protective structures.

Installation of a soil vapor extraction blower (provided by others) with associated valves, gauges, controls, knockout tank, and condensate transfer pump. Installation of a vapor phase activated carbon treatment system for blower exhaust.
Demobilization and cleanup as necessary.

1.03 SEQUENCE OF WORK

As part of the bid, the Contractor shall prepare and submit a detailed Construction Sequence of Work Schedule including sequence of work, manpower and equipment to be used.

1.04 ABBREVIATIONS AND REFERENCES

A. The following abbreviations may be used in these Specifications:

CISPI	-	Cast Iron Soil Pipe Institute
AASHTO	-	The American Association of State and Highway Transportation Officials
ACI	-	American Concrete Institute
AGA	-	American Gas Association, Inc.
AGMA	-	American Gear Manufacturers Association
AIEE	-	American Institute of Electrical Engineers
AISC	-	American Institute of Steel Construction, Inc.
AISI	-	American Iron and Steel Institute
AOT	-	State of Vermont Agency of Transportation
API	-	American Petroleum Institute
ASA	-	American Standards Association
ASCE	-	American Society of Civil Engineers

ASME	-	American Society of Mechanical Engineers
ASTM	-	American Society of Testing Materials
AWS	-	American Welding Society, Inc.
AWWA	-	American Water Works Association
AOAC	-	Association of Official Agricultural Chemists
CIPRA	-	Cast Iron Pipe Research Association
Fed. Spec.	-	Federal Specifications
NEWWA	-	New England Water Works Association
NEC	-	National Electrical Code
NEMA	-	National Electrical Manufacturers Association
NEMI	-	New England Masonry Institute, Inc.
NFPA	-	National Fire Protection Association
SCPI	-	Structural Clay Products Institute
U.L.	-	Underwriters Laboratory
SDI	-	Steel Door Institute
AWI	-	Architectural Woodwork Institute
NAAMM	-	National Association of Architectural Metal Manufacturers
AAMA	-	Architectural Aluminum Manufacturers Association
AA	-	Aluminum Association
AITC	-	American Institute of Timber Construction
ASHRAE	-	American Society of Heating, Refrigerating, Air Conditioning Engineers
ARI	-	Air Conditioning and Refrigeration Institute
SMACNA	-	Sheet Metal and Air Conditioning Contractors National Association
AMCA	-	Air Moving and Conditioning Association
AWPB	-	American Wood Preservers Bureau
OSHA	-	Occupational Health & Safety Administration

B. Where reference is made to a specification by one of the above mentioned or other organizations, it is understood that the latest revisions thereof shall apply.

C. In the case of conflict in these specifications, the more stringent shall apply.

PART 2.00 PRODUCTS

None in this Section.

PART 3.00 EXECUTION

None in this Section.

END OF SECTION

**SECTION 01200
PROJECT MEETINGS**

PART 1.00 GENERAL

1.01 PRECONSTRUCTION MEETING

Following contract signing, and before beginning the work, a preconstruction meeting at the site shall be scheduled by the Engineer.

The meeting shall be attended by the following:

1. Owner or Representative
2. Engineer
3. Contractor

The minimum agenda will consist of the following:

1. Distribute and discuss the tentative construction schedule.
2. Critical work sequencing.
3. Relationships and coordination with other contracts and/or work.
4. Designation of responsible personnel.
5. Processing of field decisions and change orders.
6. Submittal of Shop Drawings, project data and samples.
7. Procedures for maintaining record documents.
8. Laboratory testing requirement and sequencing.
9. Major equipment deliveries and priorities.
10. Safety and first aid procedures, including compliance with 29 CFR 1910.120.
11. Security procedures.
12. Completion time for contract and liquidated damages.
13. Requests for extension of contract time.
14. Procedures for making partial payments.
15. Guarantee on completed work.
16. Equipment to be used.
17. Staking of work.
18. Project Inspection.
19. As-built drawings.
20. Labor requirements.
21. Rights-of-way and easements.

1.02 PROGRESS MEETINGS

Contractor and/or resident Supervisor shall attend progress meetings as may be scheduled by the Engineer. These may be scheduled as frequently as weekly during active construction.

PART 2.00 PRODUCTS

None in this Section.

PART 3.00 EXECUTION

None in this Section.

END OF SECTION

**SECTION 01300
SUBMITTALS AND SUBSTITUTIONS**

PART 1.00 GENERAL

1.01 DESCRIPTION

A. Work Included:

To ensure that specified products and materials are furnished and installed in accordance with design intent, procedures are established herein for advance submittal of product or material information to be reviewed and approved or rejected by the Engineer.

Wherever possible, minimum acceptable quality of workmanship and materials has been defined either by manufacturer's name and catalog number or by reference to recognized industry standards.

B. Related work described elsewhere:

1. Individual submittals required are identified in pertinent sections of these Specifications.

1.02 PRODUCT HANDLING

All submittals of Shop Drawings, samples, requests for substitutions, and other items shall be in strict accordance with the provisions of this Section.

PART 2.00 PRODUCTS

2.01 SHOP DRAWINGS

A. Scale Required:

Unless otherwise specifically directed by the Engineer or Owner, make all Shop Drawings accurately to a scale sufficiently large enough to show all pertinent features of the item and its method of connection to the work and submit one (1) hard copy and a digital copy to the Engineer for review.

2.02 MANUFACTURER'S CERTIFICATIONS

- A. For pipe, cement, steel reinforcement, paint and similar materials which are normally tested in the shop by the manufacturer, furnish the Engineer certified records of physical, chemical and other pertinent tests and/or certified statements from the manufacturer that the materials have been manufactured and tested in conformity with the specifications. Where such a small quantity of material is required as to make physical tests or chemical analyses impractical, a certificate from the manufacturer stating the results of such tests or analyses of similar materials which were concurrently produced may, at the discretion of the Owner, be considered as the basis for acceptance of such materials.

- B. Each manufacturer's certificate shall be endorsed or accompanied by the Contractor's certificate that the material certified by the manufacturer will be the material incorporated in the work.

2.03 SAMPLES

- A. Accuracy of sample:

Unless otherwise specifically directed by the Owner, all samples shall be of the precise article proposed to be furnished.

2.04 SUBSTITUTIONS

- A. Engineer's approval required:

1. The Contract is based on the materials, equipment and methods described in the Contract Documents.
2. The Engineer will consider proposals for substitution of materials, equipment, and methods only when such proposals are accompanied by full and complete technical data and all other information required by the Engineer to evaluate the proposed substitution.
3. Do not substitute materials, equipment, or methods unless such substitution has been specifically approved for this work by the Engineer.

- B. "Or Equal":

1. Where the phrase "or equal" occurs in the Contract Documents, do not assume that material, equipment or methods will be approved as equal by the Engineer unless the item has been specifically approved for this work by the Engineer.
2. The decision by the Engineer will be final.

- C. Availability of specified items:

1. Verify prior to bidding that all specified items will be available in time for installations during orderly and timely progress of the work.
2. In the event specified item or items will not be so available, so notify the Engineer prior to receipt of bids.

2.05 ELECTRONIC SUBMITTALS

- A. Electronic submittals may be substituted for required paper submittals.
- B. Contact the Engineer to obtain email addresses for electronic submittals prior to submission. The Engineer will not be responsible for late responses to submittals sent to incorrect email addresses.

PART 3.00 EXECUTION

3.01 IDENTIFICATION OF SUBMITTALS

- A. Completely identify each submittal and resubmittal by showing at least the following information:
1. Name and address of submitter, plus name and telephone number of the individual who may be contacted for further information.
 2. Name of project as it appears on these Specifications.
 3. Drawing number and Specifications Section number to which the submittal applies.
 4. Whether this is an original submittal or resubmittal.

3.02 COORDINATION OF SUBMITTALS

- A. General:

Prior to submittal for Engineer's review, use all means necessary to fully coordinate all material, including the following procedures:

1. Determine and verify all field dimensions and conditions, materials, catalog numbers, and similar data.
2. Coordinate as required with all trades and with all public agencies involved.
3. Secure all necessary approvals from public agencies and others, and signify by stamp, or other means, that they have been secured.
4. Clearly indicate all deviations from the Contract Documents.

- B. Grouping of Submittals:

Unless otherwise specifically permitted by the Engineer make all submittals in groups containing all associated or related items; the Engineer may reject partial submittals as not complying with the provisions of the Contract Documents.

3.03 TIMING OF SUBMITTALS

- A. General:

Make all submittals far enough in advance of scheduled dates of installation to provide all required time for reviews, for securing necessary approvals, for possible revision and resubmittal, and for placing orders and securing delivery.

B. Delays:

Costs of delays occasioned by tardiness of submittals will not be borne by the Owner.

3.04 SUBMITTAL SCHEDULE

- A. A schedule and descriptions of required Contractor Submittals shall be prepared by the Contractor and provided to the Engineer for review and approval prior to the first submittal. This schedule shall be updated by the Contractor as needed during the course of the project.

END OF SECTION

SECTION 01400
TESTING LABORATORY SERVICES

PART 1.00 GENERAL

1.01 DESCRIPTION

A. Work included:

From time to time during progress of the work, the Owner will require that testing be performed to determine that materials provided for the work meet the specified requirements; such testing may include, but is not necessarily limited to, backfill gradation and compaction, topsoil, potable water quality, and portland cement concrete.

B. Related work described elsewhere:

Requirements for testing are described in various Sections of these Specifications; where no testing requirements are described but the Owner decides that testing is required, testing will be performed under current pertinent standards for testing.

C. Selection of Laboratory :

1. Selection of testing laboratory:

The Engineer will select a prequalified independent testing laboratory. All testing will be accomplished by the selected testing laboratory unless otherwise approved by the Engineer.

1.02 QUALITY ASSURANCE

A. Qualifications of testing laboratory:

The testing laboratory will be sufficiently qualified, to the satisfaction of the Owner, to meet the requirements of ASTM and AASHTO testing standards.

B. Codes and standards:

Testing, when required, will be in accordance with all pertinent codes and regulations and with selected standards of the American Society of Testing and Materials (ASTM) and the American Association of State and Highway Transportation Officials (AASHTO).

1.03 PRODUCT HANDLING

All required copies of test reports and related instructions will be promptly processed and distributed to ensure all necessary retesting and/or replacement of materials with the least possible delay in progress of the work.

PART 2.00 PRODUCTS

2.01 PAYMENT FOR TESTING SERVICES

- A. The Owner will pay for all initial construction quality testing services unless otherwise specified. Material testing where results are required to be submitted prior to the start of construction will be at the Contractor's expense.
- B. When initial tests indicate noncompliance with the Contract Documents, all subsequent retesting occasioned by the noncompliance will be performed by the same testing laboratory at the Contractor's expense.

2.02 CODE COMPLIANCE TESTING

Inspections and tests required by codes or ordinances, or by any local or State regulatory authority, shall be the responsibility of and shall be paid for by the Contractor, unless otherwise provided in the Contract Documents.

2.03 CONTRACTOR'S CONVENIENCE TESTING

Inspection or testing performed exclusively for the Contractor's convenience shall be the sole responsibility of the Contractor.

PART 3.00 EXECUTION

3.01 COOPERATION WITH TESTING LABORATORY

Representatives of the testing laboratory shall have access to the work at all times. Facilities shall be provided in order that the laboratory may properly perform its functions.

3.02 SCHEDULES FOR TESTING

- A. Establishing schedule:
 - 1. By advance discussion with the testing laboratory selected by the Owner, determination of the time required for the laboratory to perform its tests and issue each of its findings will be made.
 - 2. All testing time required will be provided within the construction schedule.
- B. Revising schedule:

When changes of construction schedule are necessary during construction, coordinate all such changes of schedule with the testing laboratory as required.
- C. Adherence to schedule:

When the testing laboratory is ready to test according to the determined schedule but is prevented from testing or taking specimens due to incompleteness of the work, all extra costs for testing attributable to the delay may be back-charged to the Contractor and shall not be borne by the Owner.

3.03 TAKING SAMPLES

- A. Where the testing laboratory does not take samples, samples for testing, unless otherwise provided in these Contract Documents, will be controlled by the Engineer. All sampling equipment and personnel will be the responsibility of the Engineer and all deliveries of samples to the testing laboratory will be the responsibility of the Engineer.

END OF SECTION

**SECTION 01500
TEMPORARY FACILITIES**

PART 1.00 GENERAL

1.01 DESCRIPTION

A. Work included:

Potable water and electricity are available at the Site for use by the Contractor. The Contractor shall provide temporary sanitary facilities.

B. Related work described elsewhere:

Section 01700: Environmental Protection

PART 2.00 PRODUCTS

2.01 UTILITIES

Temporary water supply and electricity are available for use by the Contractor with coordination of the Engineer.

2.02 TEMPORARY FIELD OFFICE FACILITY

The Contractor may provide a temporary field office for convenience; however, there is no requirement for one.

2.03 SANITARY FACILITIES

Contractor to furnish and install all required temporary sanitary toilets and hand washing facilities for use of all workers; comply with all minimum requirements of the Health Department or other public agency having jurisdiction; and maintain in a sanitary condition at all times.

PART 3.00 EXECUTION

3.01 MAINTENANCE

Maintain all temporary facilities as long as they are needed for the safe and proper completion of the work.

END OF SECTION

**SECTION 01560
CONTROL OF WORK**

PART 1.00 GENERAL

1.01 EQUIPMENT

The Contractor shall furnish manpower and equipment which shall be efficient, appropriate and capable of securing a satisfactory quality of work and a rate of progress that will ensure the completion of the work within the time stipulated in the Contract.

1.02 SUBSURFACE LOCATIONS

Proposed subsurface installations shall be located substantially as indicated on the Drawings, but modifications may be made in locations by the Engineer as may be found desirable to avoid interference with existing structures or for other reasons.

1.03 TEST PITS

Test pits for the purpose of locating underground pipeline or structures in advance of the construction, if needed, shall be excavated and backfilled by the Contractor. Test pits shall be backfilled immediately after their purpose has been satisfied and the surface restored and maintained.

1.04 OPEN EXCAVATIONS

- A. All open excavations shall be adequately safeguarded by providing temporary barricades, caution signs, lights and other means to prevent accidents to persons and damage to property. The Contractor shall provide suitable and safe bridges and other crossings for accommodating travel by pedestrians and workmen where necessary. Bridges provided for access to private property during construction shall be removed when no longer required. The length of open trench will be controlled by the particular surrounding conditions. If the excavation becomes a hazard as defined by trenching regulations, or if it excessively restricts traffic at any point, special construction procedures may be required such as limiting the length of open trench, construction of shoring, prohibiting stacking excavated material in the street or active driveways, and/or requiring that the trench not remain open overnight.
- B. The Contractor shall take precautions to prevent injury to the public due to open trenches. All trenches, excavated material, equipment, or other obstacles which could be dangerous to the public shall be well lighted at night. The Contractor is responsible for compliance with all trench safety standards prescribed by OSHA, including, but not limited to, 29 CFR 1926 (Subpart P).

1.05 EXCESS SOIL DISPOSAL

Prior to any soil excavation, the Contractor shall identify a disposal facility for excess soil from pipe trenching or other soil disturbance activities. The Contractor shall provide the Engineer with the disposal facility's characterization testing requirement and a Sampling Plan for characterization sample collection. If the excess soil is characterized as hazardous waste, the Contractor shall provide the Engineer with any treatment methods and/or the final disposal

location from the permitted Treatment Storage and Disposal Facility to receive the soils prior to any soil being shipped off-site. Hazardous soil shipment shall be by a licensed hazardous waste hauler under manifest.

1.06 HEALTH AND SAFETY

The Contractor shall prepare a site-specific Site Safety and Health Plan (SSHP) that covers all aspects of the Contractors' on-site activities and is compliant with the requirements as set forth in 29CFR1910.120 and 29CFR1926. The Contractor will be required to submit documentation that all site workers who may come in contact with contaminated soil or other media meet the 40 hour training requirements as set forth in 29CFR1910.120 "Hazardous Waste Operations and Emergency Response" and are enrolled in a baseline medical monitoring program, as well as documentation that all site workers are cleared for respirator use and have current "fit test" certification. The Contractor is also responsible to assure remedial activities are conducted in accordance with the Federal and State regulations for general construction as they may pertain.

1.07 CARE AND PROTECTION OF PROPERTY

- A. The Contractor shall be responsible for the preservation of all public and private property, and shall use every precaution necessary to prevent damage thereto. If any direct or indirect damage is done to public or private property within or beyond the limits of work by or on account of any act, omission, neglect, or misconduct in the execution of the work on the part of the Contractor, the Contractor shall restore the property, at its expense, to a condition equal to that existing before the damage was done and at least meeting the specifications contained herein.
- B. All sidewalks, driveways, and curbing which are disturbed by the Contractor's operations shall be restored to their original condition by the use of similar or comparable materials and constructed according to the specifications contained therein.
- C. Along the location of this work all fences, walks, bushes, trees, shrubbery, and other physical features shall be protected and restored in a thorough and workmanlike manner. Fences and other features removed by the Contractor shall be replaced in their original location. All grass areas beyond the limits of construction which have been damaged by the Contractor shall be regraded and seeded.

1.08 PROTECTION OF EXISTING STRUCTURES AND UTILITIES

The Contractor shall assume full responsibility for the protection of all buildings, structures, and utilities, public or private, including poles, signs, services to buildings, treatment plant piping, water pipes, hydrants, sewers, drains, and electric and telephone cables. The Contractor shall carefully support and protect all such structures and utilities from injury of any kind.

1.09 MAINTENANCE OF FLOW

The Contractor shall provide for the flow of sewers, drains, and water courses interrupted during the progress of the work, and shall immediately cart away and remove all offensive matter.

1.10 PROTECTION OF STORM DRAINS, SEWERS AND WATER LINES

Where storm drains, water and/or sewer lines exist in the immediate area of construction, care must be taken not to disturb the pipes. In addition, any hydrants, valve boxes, manholes or other appurtenances at the ground surface must be protected from damage during construction.

1.10 DUST AND NOISE CONTROL

- A. The Contractor shall minimize noise to the greatest extent practicable. The City of Woburn has enacted a noise ordinance that applies to construction activities. The Contractor is responsible for complying with the ordinance or obtaining permits as required.
- B. Dust control shall be as specified in Section 01700.

1.11 CLEANUP

During the course of the work, the Contractor shall keep the work site in as clean and neat a condition as is possible, and shall dispose of all solid waste resulting from the construction work. At the conclusion of the work, the Contractor shall remove and haul away any broken pavement, lumber, equipment, temporary structures, and any other refuse remaining from the construction operations, and shall leave the entire site of the work in a neat and orderly condition.

1.12 TRAFFIC SAFETY

- A. Construction shall be scheduled and excavated material shall be placed so that vehicular and pedestrian traffic can be maintained at all times. If disruption of vehicular or pedestrian traffic is necessary to complete the work, coordinate and obtain required approvals from State or local entities as appropriate prior to working within the right of way.
- B. Traffic shall be protected by barricades and advance warning signs conforming to the Manual on Uniform Traffic Control Devices as published by the Federal Highway Administration and applicable State Highway Standards.
- C. The project site is actively used by the building tenant. Maintain traffic and pedestrian flow so as not to interfere with tenant use of the property. Obtain prior approval from the Owner if disruption of vehicular or pedestrian traffic on the site is necessary.

1.13 UNIFORMED TRAFFIC OFFICER

The Contractor may need to employ a uniformed traffic officer on a state or local highway or street when public safety or convenience requires the services of a uniformed officer. These services may be required but are not limited to situations where normal two-way traffic is reduced to one lane, or where interference with normal traffic flow pattern can be expected, such as equipment entering, leaving or crossing roads, or the delivery of oversize equipment or materials.

1.14 AS-BUILT DRAWINGS

As-built drawings and survey will be prepared by the Engineer. The Contractor shall provide access to the site as necessary to the survey crew and incidental assistance as needed (e.g., relocating equipment to clear lines of site, maintenance of survey control points without disturbance, etc.).

PART 2.00 PRODUCTS

None in this Section.

PART 3.00 EXECUTION

3.01 WORK HOURS

All work will be conducted between the hours of 7:00 A.M. and 6:00 P.M. on weekdays, and between 8:00 A.M. and 6:00 P.M. on Saturdays. No construction is allowed on Sundays or legal holidays.

3.02 CONSTRUCTION QUALITY ASSURANCE

Construction quality assurance testing will be conducted by the Owner or Engineer in accordance with the Contract Documents. Retesting of work that does not comply with the specifications shall be at the Contractor's expense. See also Section 01400 for additional details.

END OF SECTION

**SECTION 01600
PRODUCTS**

PART 1.00 GENERAL

1.01 QUALITY

- A. Only new materials and equipment shall be used in the work unless otherwise specified. All materials and equipment furnished by the Contractor shall be subject to the inspection and approval of the Engineer. Refer to Section 01300.
- B. All facilities and labor for the handling and inspection of all materials and equipment shall be furnished by the Contractor.

PART 2.00 PRODUCTS

None in this Section.

PART 3.00 EXECUTION

3.01 HANDLING AND STORAGE OF MATERIALS

- A. All materials and equipment to be incorporated in the work, before, during, and after shipment shall be handled and stored in a manner to prevent warping, twisting, bending, breaking, chipping, rusting, and any injury, theft, or damage of any kind whatsoever to the material or equipment.
- B. Cement and lime shall be stored under a roof and off the ground and kept completely dry at all times. All miscellaneous steel and reinforcing steel shall be stored off the ground or otherwise to prevent accumulations of dirt or grease, and in a position to prevent accumulations of standing water and to minimize rusting. Brick, block, and similar masonry products shall be handled and stored in a manner to reduce breakage, chipping, cracking, and keep spalling to a minimum.
- C. All mechanical equipment subject to corrosive damage by the atmosphere when stored outdoors shall be stored in an enclosed building.
- D. All materials which have become so damaged as to be unfit for the use intended or specified shall be removed promptly from the site. The Contractor shall not receive compensation for the damaged material or its removal.
- E. All materials delivered to the job shall be unloaded and placed in a manner which shall not hamper the normal operation, or interfere with the flow of necessary traffic.
- F. The Contractor shall provide suitable equipment and labor, and shall handle material at all times so as to avoid damage. Under no circumstances shall pipe be dropped.
- G. The Contractor shall be fully responsible for all material until final acceptance of the completed work.

END OF SECTION

SECTION 01700
ENVIRONMENTAL PROTECTION

PART 1.00 GENERAL

1.01 DESCRIPTION

- A. The Contractor shall follow all disposal, noise, water, and air pollution best management practices to assure environmental protection, and take appropriate actions during the Project to control and avoid adverse environmental impacts due to Work activities.
- B. The Contractor shall be responsible for developing, administering, implementing and monitoring Environmental Protection activities and policies. Environmental Protection shall address, but not be limited to, the following items, as described more fully herein:
 - 1. Land and water resource protection
 - 2. Identification, handling, management, transportation, and disposal of all material waste, including but not limited to hazardous waste or material generated, released or encountered in-situ by the Contractor.
 - 3. Spill prevention and emergency response procedures including, but not limited to, response actions and prevention measures for Site accidents, emergencies, and chemical spills or releases. Special emphasis shall be given to preventing fuel spills when refueling equipment.
 - 4. Environmental monitoring for workers employed by the Contractor or subcontractors.

PART 2.00 PRODUCTS

None in this section

PART 3.00 EXECUTION

3.01 CARE AND PROTECTION OF WATER RESOURCES

- A. The Contractor shall be responsible for the preservation of all public and private property and the protection of water resources. The Contractor shall not allow any construction site debris to enter any stream or discharge any water wastes, sediment, or other material from the construction site into any stream except by permit.
- B. During the Work, the Contractor shall prevent damage to land resources outside the areas to be excavated. The Contractor shall not deface, destroy, remove, or cut trees or shrubs other than only that needed to perform the Work.
- C. During all times of the year, all water resources shall be protected from any construction debris including, but not limited to, asphalt, concrete, blast media, the leaching of chemical pollutants, and Site erosion. Storage of chemicals, fuels, oil, greases, bituminous materials, solids, wastewater, and concrete shall be handled to prevent leaching or surface runoff into public waters, in the event of a spill.
- D. The Contractor shall maintain all excavations, embankments, stockpiles, laydown areas, haul roads, access roads, borrow areas, and all other Work areas inside or outside the Site free from dust. Dust control methods specified in Paragraph 3.03 and temporary methods

of stabilization consisting of sprinkling, chemical treatment, or similar methods are acceptable for dust control.

- E. All dewatering operations shall conform to Mass DEP requirements. Dewatering operations which discharge to the ground surface, surface waters, or wetlands, which shall only be done with appropriate permits and with explicit approval by the Engineer, shall be provided with filter bags or other sediment trapping devices as approved by the Engineer.

3.02 CONTROL OF SOIL EROSION AND SILTATION

It shall be the Contractor's responsibility to take all necessary precautions to prevent and control erosion and to construct sediment basins, diversion ditches or such other construction to satisfactorily accommodate runoff from any area subject to erosion during the construction of this project. All such precautionary measures include, but are not necessarily limited to, construction of sediment basins, diversion ditches, benches and berms, installation of silt fence and/or hay bales or laying fiber matting on slopes until vegetation is established.

3.03 DUST CONTROL

- A. The Contractor shall control the generation of dust to the greatest extent practicable. If dust is created, the Contractor will need to provide control measures. These measures will consist of treating traveled, excavation, stockpiling, backfilling and soil load out areas to control dust.
- B. Materials for dust suppression include water and calcium chloride.
- C. **DUST CONTROL WITH WATER.** Water shall be applied to designated traveled areas or disturbed areas as necessary. The number of applications and the amount of water used shall be based upon field and weather conditions.
- D. **DUST CONTROL WITH CALCIUM CHLORIDE.** Dust Control with calcium chloride shall be applied in such a manner and by such devices that uniform distribution is obtained over the entire area being treated. Calcium chloride shall be applied at a rate not to exceed 270 g/m^2 ($\frac{1}{2}$ pound per square yard) for dust control. In general, calcium chloride shall be used on roadways under construction. It shall not be used on surfaces on which bituminous material will be applied.

3.04 CLEANUP

Cleanup shall be in accordance with Sections 01560 and 02989.

3.05 EQUIPMENT

- A. The Contractor's equipment shall be clean and well maintained and free of fuel, hydraulic and gear oil leaks.
- B. All equipment brought on-site is subject to the Engineer's approval. Any equipment declared by the Engineer as not suitable for on-site use shall be immediately removed from the Site and replaced with acceptable equipment, at no additional cost to the Owner.

3.06 MATERIAL AND WASTE MANAGEMENT

- A. The Contractor shall provide a Material Safety Data Sheet (MSDS) for any and each chemical product furnished under or otherwise associated with the Work.
- B. Products shall be brought on the Site and stored in their original containers with original labels.
- C. Products shall be stored in a manner consistent with their labeling and in a manner which shall provide protection from accidental release to the environment.
- D. The Contractor shall be responsible for management and daily inspection of chemical products, equipment and waste generation (and associated accumulation and storage areas). All wastes shall be cleaned up daily and disposed of at a lawful disposal facility on a regular basis. All waste labeling, packaging and transport shall be completed by the Contractor in accordance with all applicable federal, state and local regulations. There shall be no onsite disposal of wastes. All wastes shall be disposed of at disposal facilities that have been properly licensed by the U.S. Environmental Protection Agency and/or the Commonwealth. The Contractor shall provide evidence of disposal at the facility using either hazardous waste manifest, bill of lading, and/or a certificate of disposal, as appropriate.

3.07 REFUELING POLICY

This policy shall be posted at all refueling points:

- A. Refueling or greasing shall not take place over surface water, within ten feet of surface water, or in locations where spilled materials could flow into surface water. If possible, refueling shall take place over impermeable surfaces such as asphalt or concrete, but in any event over areas that provide sufficient containment capacity.
- B. Prior to re-fueling or greasing, petroleum sorbent pads shall be placed to catch any incidental spills.
- C. All refueling operation equipment shall be in the immediate control (e.g., with the nozzle or shut off switch in hand) of the person performing the refueling.
- D. In the event of a release not collected by the sorbent pads, the Engineer will be immediately informed, and the procedures outlined in Article 3.08 below shall be followed, and at a minimum, affected soils shall be immediately dug up and placed in a labeled DOT approved drum. A photoionization detector will be used to screen soils left in place to insure all contaminated materials are removed. A record of the release, the response, and the personnel involved and the temporary disposition of the materials will be prepared by the Engineer as part of the daily report. Costs associated with spill response and remediation will be borne by the Contractor.

3.08 **SPILLS**

- A. In the event of a spill or release of a hazardous substance, pollutant, contaminant, or oil, Contractor shall notify the Engineer and Owner immediately. If the spill exceeds the reporting threshold, immediately report the spill or release to the appropriate authorities, and contain the spill to the maximum extent possible. Immediate containment actions shall be taken to minimize the effect of any spill or leak. Cleanup shall be in accordance with applicable federal, state, and local regulations. Additional sampling and testing shall be performed to verify spills have been cleaned up per the direction of the Engineer. Spill cleanup and testing shall be at no additional cost to the Owner.

3.09 **TRAINING**

- A. All Contractor employees who handle, transport or in any way manage hazardous wastes or substances, or participate in the cleanup of hazardous substances, are required to be trained in the proper management of hazardous wastes and substances. The Contractor training in management of hazardous waste and substances shall follow the requirements of the federal and state hazardous waste regulations in addition to applicable OSHA requirements. Training shall cover hazardous waste management, hazard communication standard, right-to-know laws and OSHA hazardous response training requirements.
- B. As specified in the various regulations issued by EPA and OSHA, certain Contractor employees require different levels of training depending on the employee's exposure potential and frequency of exposure to hazardous materials. The following Contractor employees shall be required to attend appropriate hazardous waste training.

Under federal and state hazardous waste management rules, all employees who have hazardous waste management responsibilities, including the implementation of emergency procedures, must be provided with supervisor level training under 29 CFR 1910.120. In addition, employees designated as hazardous waste cleanup personnel must first receive training in accordance with 29 CFR 1910.120.

New Contractor employees or reassigned employees shall be given hazardous waste training within six (6) months of employment or reassignment. No unsupervised tasks involving management of hazardous waste shall be undertaken by the new or reassigned employee until the employee has undergone training. It is the responsibility of the Contractor to ensure that annual hazardous waste training for all Contractor employees who handle or manage hazardous waste is conducted.

- C. Records of personnel training shall be kept by the Contractor. The Contractor shall also be responsible for maintenance of the records of training and ensuring that all Contractor employees are trained.

3.10 **AIR MONITORING**

- A. Contractor Employee Monitoring: The Contractor shall be responsible for monitoring its employees for exposure to hazardous substances in accordance with OSHA standards.

- B. Ambient Air Monitoring: The Engineer/Owner will be responsible for conducting ambient air monitoring as necessary.

END OF SECTION

SECTION 02221
EXCAVATION, TRENCHING, AND BACKFILLING

PART 1.00 GENERAL

1.01 DESCRIPTION

A. Work included:

The work of this section consists of preparation, excavating, trenching, backfilling and surface restoration associated with the construction of roadways, pipelines, and appurtenant structures including footing walls and slabs.

All material, equipment, supplies and accessories required are to be provided. All excavations shall be open cut. Work items may include clearing and grubbing; removal of pavements and structures; protection of trees, utilities, and structures to remain; stripping and stockpiling topsoil; excavation; controlled stockpiling of excavated materials; trench protection; dewatering; backfill materials and installation; foundation preparation; bedding preparation; scarification; finish grading; and incidental work.

It also includes surface restoration including pavement replacement, curb replacement, path replacement, machine and hand grading and shaping, dressing with topsoil, and disposal of excess materials.

B. Related work specified elsewhere:

Section 02222 – Exploratory Excavation
Section 02550 – Imported Soils
Section 02600 – Restoration of Paving and Surfacing
Section 02995 – Decontamination

1.02 JOB CONDITIONS

A. Bidders:

Bidders are expected to examine the project to determine the character of materials to be encountered, trees to be removed or protected, and nature of the work in general.

B. Over-Excavation:

If unauthorized over-excavation occurs, the Contractor shall be responsible for the repair of the area by backfilling with approved bedding material and compacting to 90 percent maximum density (ASTM D-1557).

C. Dust Control:

All means to control dust on and near the work will be used. Dust control measures are specified in Section 1700.

D. Protection:

All means necessary shall be used to protect all materials, utilities, pavements and structures. Particular care shall be exercised to protect tree root systems and tree trunks. In the event of damage, all repairs and replacements necessary shall be made immediately to the approval of the Engineer and at no additional cost to the Owner.

E. Backfilling Prior to Approvals:

Any of the work performed or installed shall not be covered up or enclosed before all required inspections and approvals have been performed. Should any of the work be so enclosed or covered up before it has been approved, all such work shall be uncovered at no additional cost to the Owner. After the work has been completely tested, inspected and approved, all repairs and replacements necessary to restore the work to the condition in which it was found at the time of uncovering shall be made, all at no additional cost to the Owner.

1.04 SUBMITTALS

The results of testing of samples of all materials which require approval of the Engineer shall be submitted ten (10) days prior to the date of anticipated use. See Section 02500.

1.05 QUALITY ASSURANCE

References:

American Association of State Highway and Transportation Officials (AASHTO).
American Society for Testing and Materials (ASTM).

1.05 DEFINITIONS

A. Excavation Classification:

For payment purposes excavation shall include materials of every description, and of whatever substances encountered, to the depths and of the areas required for the construction work. No classification will be made of the materials excavated either as to depth, nature, composition, hardness, nor degree of water content.

B. Bedding:

Material placed in the excavation around a pipe or below a structure.

C. Compaction Density:

Reference to densities will be as determined by ASTM D-1557.

PART 2.00 MATERIALS

2.01 GENERAL

Imported fill materials are specified under Section 02500.

2.02 WATER

Water shall be clean and free from harmful substances. If water is supplied from a source other than a municipal system, the source and quality of the water shall be provided to the Engineer for approval prior to use.

PART 3.00 EXECUTION

3.01 PREPARATION

- A. In natural areas, strip all topsoil to a minimum depth of 6 inches, or in the absence of topsoil, strip the top surface material and store separately from other excavated materials in stockpile areas designated by the Owner.
- B. The Contractor is to field verify by excavation the location of all utility crossings, service connections, connections to existing lines at least 100 feet in advance of the pipe laying and trench excavation before proceeding. Protect existing utility lines that are indicated to remain from damage. Notify the Engineer immediately of damage to, or an encounter with, a known or unknown existing utility line.

3.02 TRENCH EXCAVATION

A. General:

Trenches shall be excavated to lines, grades, and elevations as shown on the design drawings after their location has been staked or otherwise indicated in the field. The trench bottom shall be fine graded by hand throughout its entire length.

B. Trenching Guidelines:

For excavation, trench width and depth shall be as follows: width, ample to allow a minimum free working space of 1 foot on each side of pipe barrel, depth as indicated or staked. Trenches for pipe shall be excavated to the bottom of pipe with no over-excavation. The trench shall have vertical side walls from 12-inches above pipe to the bottom where feasible. Upper trench walls may be sloped back for safety and access. Trenches excavated to over width or over depth are the Contractor's responsibility to repair at no extra cost to the Owner.

C. Types of Excavation:

The Contractor shall perform excavation with capable equipment. Hand excavation is required around tree roots inside the tree drip line, for thrust blocks, and adjacent to existing utilities and structures.

D. Unstable Trench Bottom:

If it is the opinion of the Engineer that the trench bottom is unstable and unable to support the pipe, the Contractor shall over-excavate and supply crushed rock bedding to the pipe bottom. Water in the trench shall not be interpreted as evidence of unstable trench bottom.

E. Soil Screening

The Engineer will screen excavated soils with a photoionization detector (PID) equipped with an 11.7 eV lamp. Where PID readings are more than 10 ppmV above background levels, soils will be considered contaminated and managed accordingly.

3.03 DEWATERING

- A. For all excavations, the Contractor shall provide suitable equipment to remove any water that may accumulate in the excavation, and shall keep the excavation dewatered so that pipe laying and all other required activities in the excavation can be completed under dewatered conditions.

3.04 STORAGE OF EXCAVATED MATERIALS

- A. Generally, excavated material shall be placed so that no amount will be lost or will spoil terrain adjacent to the work area. Place excavated material on the uphill side of the trench. Any excess excavated material shall be stored in a covered roll-off or other watertight container until adequate characterization testing has been performed. See section 01560 for soil characterization and disposal.
- B. Where differing types of material are removed from the excavation (e.g., pavement base gravel and native soils) they shall be segregated to the maximum extent possible.

3.05 FILL AND COMPACTION

- A. Wherever possible, and following approval by the Engineer, excavated material will be used to backfill trench excavations. Replace material in the order it was removed from the excavation.
- B. All backfill under concrete or bituminous pavement shall be compacted to 95% of the Modified Proctor density of the material being placed per ASTM D1557. In-situ density tests will be conducted by the Owner's independent testing agency under the direction of the Engineer.

- C. Backfill shall be placed in maximum 6" compacted thickness lifts. One in-situ density test will be conducted on each lift for every 500' of trench length.
- D. Each layer shall be compacted to specified levels adding water or drying if necessary, and compacting with hand, pneumatic, or mechanical compactors. Puddling or flooding excavation for consolidation of backfill or use of wheel rolling by construction equipment shall not be permitted. In natural areas, excavated areas shall be mounded slightly at the surface to allow settlement to adjacent grades.

3.06 UNSUITABLE MATERIALS

- A. At locations where unstable or undesirable conditions are encountered, and as designated by the Owner or Engineer, the Contractor shall excavate and dispose of excavated materials. Materials to be disposed of shall be tested for characterization prior to disposal. This material shall be replaced by suitable materials. The suitable materials shall be placed and compacted according to the requirements of the item of work involved.

3.07 RESTORATION

- A. Restoration of paved areas shall be as specified in Section 02600.

3.08 CLEANUP

- A. Prior to final inspection and acceptance, all rubbish and excess materials shall be removed and the area will be left in a neat and satisfactory condition.

3.09 SHRINKAGE AND MAINTENANCE

- A. Contractor shall be responsible for preventing trench settlement or structural backfill settlement and for making any repairs due to such settlement.

END OF SECTION

SECTION 02222
EXPLORATORY EXCAVATION

PART 1.00 GENERAL

1.01 DESCRIPTION

- A. Exploratory excavation shall be performed for the purpose of determining the location of underground structures and utilities using tight control machinery supplemented by hand labor.
- B. The Contractor shall provide all labor, equipment and materials necessary to perform exploratory excavation as needed or directed by the Engineer.
- C. Damage to existing structures and utilities shall be avoided during exploratory excavation. Any such structure or utility damaged by the Contractor shall be replaced or repaired at no cost to the Owner.
- D. Related work described elsewhere:

Section 02221 – Excavating, Trenching, and Backfill

Section 02995 – Decontamination

PART 2.00 PRODUCTS

None in this Section.

PART 3.00 EXECUTION

3.01 SCHEDULING

- A. The Contractor shall consult frequently with the Engineer as to the location of the exploratory excavations so that this work may be scheduled sufficiently in advance of installation of other items of the work.
- B. All available information on the location of existing underground structures and utilities shall be obtained prior to starting this type of excavation. Utility locating services shall be contacted between 3 and 10 days before scheduled exploratory excavation work.
- C. The owners of structures and/or utilities to be affected shall be notified in sufficient time to allow their representatives to observe the exploratory excavations.
- D. Exploratory excavations shall be scheduled to be the first work performed in an area of excavation, if required to locate utilities or other underground infrastructure near the planned excavation. Exploratory excavations shall be scheduled to facilitate an immediate transition to normal excavation activities once the exploratory excavations are complete.

3.02 EXCAVATION

- A. All excavations shall be conducted with extreme care so as not to damage any existing structure or utility. If damage occurs, the Engineer and the respective utility owner shall be notified immediately. Any repairs shall be made promptly.
- B. The Contractor shall use hand or vacuum excavation techniques while conducting excavations within one foot of the buried utility.
- C. The Engineer shall be notified when the location of underground structures or utilities has been determined.
- D. Excavated materials shall be returned to the excavation in the approximate order that they were removed. Should any soil or water be removed from the excavation and not replaced, it shall be adequately characterized and disposed of in accordance with state and federal law.
- E. The Contractor shall decontaminate all equipment before it leaves the area in accordance with Section 02995, Decontamination.

3.03 BACKFILL AND RESTORATION

- A. Exploratory excavations shall be backfilled to the existing ground surface unless otherwise directed by the Engineer.
- B. Exploratory excavations shall be restored using the same methods and materials as those employed for other soil excavation.

END OF SECTION

**SECTION 02500
IMPORTED SOILS**

PART 1.00 GENERAL

1.01 DESCRIPTION

A. Work Included:

All labor, materials, equipment and incidentals necessary to supply the soil materials necessary to backfill excavations and prepare the surface for vegetation or asphalt pavement as shown on the Drawings and specified herein.

B. Related work described elsewhere:

Section 02221 – Excavating, Trenching, and Backfilling

1.02 JOB CONDITIONS

A. Materials shall be delivered to the site as needed and/or stockpiled in identified staging areas in a manner that prevents wind erosion of soil from the stockpile location(s) including covering stockpiles if necessary.

B. When necessary, erosion control devices shall be implemented to prevent stormwater driven erosion and/or migration of the stockpiled materials.

1.03 DEFINITIONS

A. Structural Fill:

Imported soil for use as a base immediately under asphalt and concrete paving and slabs.

B. Pipe Bedding

Imported soil for use in backfilling around installed piping.

C. Topsoil:

Imported soil for use in backfilling the top 6 inches in areas to be re-vegetated.

1.04 SUBMITTALS

A. Fill source documentation and test results as described in Part 2.00.

B. One sample per 1,000 cubic yards of all proposed imported soils (except top soil) used in the Work shall be submitted by the Contractor to an independent, qualified soil testing laboratory for gradation and moisture/density analysis by ASTM D422 and ASTM D1775, respectively. This testing is at the Contractor's expense. The results shall be submitted to the Engineer a minimum of ten days prior to the date of anticipated use.

- C. Representative samples of topsoil (minimum of one per source) shall be submitted by the Contractor to an independent, certified environmental testing laboratory for analysis of gradation and total organic content. This testing is at the Contractor's expense. The results shall be submitted to the Engineer a minimum of ten days prior to the date of anticipated use.

PART 2.00 PRODUCTS

2.01 CHEMICAL QUALITY

- A. No imported soil shall contain any detectible VOC or petroleum constituents. A certification must be provided for each source of imported soil that the material meets these chemical quality requirements and that the source is native soil material, is not contaminated to the knowledge of the owner of the source, has not been a hazardous or petroleum waste or spill site, and has not been used for disposal of wastes. Acceptance of off-site materials shall be at the sole discretion of the Engineer based upon the analytical results and environmental history of the sources.

2.02 PHYSICAL QUALITY

- A. Imported fill materials shall be well graded from coarse to fine, of sound structural quality, free from organic matter (except top soil) or other deleterious substances, free of frost and ice, with no greater than 30% thin or elongated particles, and generally suitable for the intended use. The Engineer reserves the right to reject imported fill material with unacceptable physical properties.

2.03 STRUCTURAL FILL

- A. The Contractor must submit the source of structural fill and a representative sample to the Engineer for approval prior to bringing structural fill on-Site.
- B. Structural Fill shall be stone and coarse sand that meets the MassDOT material specification M1.03.0 Type b and meet the following gradation requirements:

<u>Sieve Size</u>	<u>Percent Passing by Weight</u>
1/2"	50-85
No. 4	40-75
No. 50	8-28
No. 200	0-6

Structural fill shall have a maximum particle size of three (3) inches.

2.04 PIPE BEDDING

- A. The Contractor must submit the source of pipe bedding and a representative sample to the Engineer for approval prior to bringing structural fill on-Site.

- B. Pipe bedding shall be well-graded clean sand that meets the requirements of the MassDOT material specification M1.04.0 Type b and meet the following gradation requirements:

<u>Sieve Size</u>	<u>Percent Passing by Weight</u>
1/2"	100
3/8"	90-100
No. 200	0-6

2.05 TOPSOIL

- A. Topsoil shall be fertile, natural soil, typical of the locality, substantially free of stones, roots, or sticks greater than 2 inches in diameter or length, clay, peat, weeds and sod, and obtained from upland areas and free of exotic and invasive plant seeds. It shall not be excessively acidic or alkaline, and shall contain a minimum of 6 % and a maximum of 12 % organic matter. A topsoil mixture, enriched or blended with organic compost, may be acceptable provided it meets the specifications and it can be certified not to contain any waste materials (e.g., non-clean fill, sewage or other sludge). The Contractor must submit the source of topsoil and a representative sample to the Engineer for approval prior to bringing topsoil on-Site.

- B. The Contractor must provide certification that the source of topsoil is free from invasive and exotic plants, including roots and rhizomes. This certification is subject to review and approval by the Engineer.

PART 3.00 EXECUTION

3.01 GENERAL

- A. See Section 02221 – Excavating, Trenching, and Backfilling.

END OF SECTION

SECTION 02600
RESTORATION OF PAVING AND CONCRETE SURFACING

PART 1.00 GENERAL

1.01 DESCRIPTION

- A. Work included:
1. All materials, labor, equipment, and incidentals required to furnish, place and compact the base and replace Portland cement concrete and bituminous concrete pavement surfacing where disturbed during construction shall be provided by the Contractor.
 2. Except as otherwise specified, all necessary repairs due to trenching in private paved roads, drives, and parking lots shall be constructed in accordance with the Drawings. Contractor shall restore pre-existing conditions to match the thickness and type of material.
 3. Concrete and paved surfaces shall be placed in accordance with dimensions shown on the Drawings and approved by the Engineer or as necessary to restore disturbed surfaces to their original condition.
- B. Related work described elsewhere:
1. Excavation, Trenching and Backfill - Section 02221

1.02 SUBMITTALS

- A. Submit job-mix data from the batching plant for hot-mix bituminous concrete pavement showing compliance with the appropriate sections of Massachusetts Department of Transportations' Standard Specifications for Highways and Bridges - 1988 English Edition, 2012 Supplemental Specifications to the Standard Specifications for Highways and Bridges, and 2013 Interim Supplemental Specifications.
- B. Submit mix design data from the concrete plant for portland cement concrete pavement showing required compressive strength and compliance with the appropriate sections of Massachusetts Department of Transportations' Standard Specifications for Highways and Bridges - 1988 English Edition, 2012 Supplemental Specifications to the Standard Specifications for Highways and Bridges, and 2013 Interim Supplemental Specifications.

1.03 JOB CONDITIONS

- A. Water and/or calcium chloride shall be applied to prevent dust from being a nuisance to the public or workers, as directed by the Engineer.
- B. Traffic shall be directed throughout the project by warning signs, barricades and a uniformed traffic officer in a manner providing maximum safety for the workers and traffic with the least interruption of the work.
- C. Tack coat shall be applied to edges of existing pavement which are to be adjacent to new pavement.

- D. If excavation or removal of temporary pavement is necessary to complete unfinished work, affected areas shall be repaved at the Contractor's expense.
- E. The Contractor shall maintain all pavement and concrete surfacing placed under this Contract during the guarantee period of one year and shall promptly refill and repave areas or otherwise repair which have settled or are otherwise unsatisfactorily for traffic.

PART 2.00 PRODUCTS

2.01 BITUMINOUS PAVEMENT AND CONCRETE SURFACING

- A. Products used for the patching of paved or concrete surfaced roads shall conform to the appropriate Massachusetts Department of Transportations' Standard Specifications for Highways and Bridges - 1988 English Edition, 2012 Supplemental Specifications to the Standard Specifications for Highways and Bridges, and 2013 Interim Supplemental Specifications.

2.02 WATER

- A. All water used for dust control shall be reasonably clear and free of harmful amounts of oil, salt, acids, alkalis, sugar, organic matter or other substances injurious to plant life or the establishment of vegetation.

PART 3.00 EXECUTION

3.01 BITUMINOUS CONCRETE PAVEMENT

- A. Where pavement and or concrete surface restoration is required any utility trench shall be backfilled with competent structural fill as shown on the Drawings and specified in Section 02221.
- B. Bituminous surfaces, including highways, streets, drives, parking lots, and sidewalks shall be restored with compacted courses to match existing type and thickness of adjacent asphalt, or a minimum of 1.75" compacted thickness of MassDOT HMA Base/Intermediate Course – Binder overlain with 1.25" compacted thickness of MassDOT HMA Surface Course – Standard Top. Prior to restoring the pavement the existing pavement shall be saw cut one foot beyond the trench excavation on each side. The pavement compaction shall be a minimum of 95% of the maximum theoretical density of the mix.
- C. Bituminous concrete paving mixture shall be placed only when the proper density can be obtained. Precautions shall be taken at all times to compact the mixture before it cools too much to obtain the required density.

Bituminous material shall not be placed on a wet, dirty, or frozen surface; or when weather or other conditions would prevent the proper handling, finishing, or compacting of the material, unless otherwise approved by the Engineer.

- D. All edges of the adjacent pavements shall be trimmed to neat straight lines and cleaned to provide a firm, regular and clean surface to bond the new pavement. The adjacent pavement shall be tack coated with bituminous material to improve the bond between the old and new pavement
- E. The final pavement shall butt or overlap the existing pavement along all edges providing a smooth surface joint.

3.02 PORTLAND CEMENT CONCRETE PAVEMENT

- A. Where pavement and or concrete surface restoration is required any utility trench shall be backfilled with competent structural fill as shown on the Drawings and specified in Section 02221.
- B. Prior to restoring the surfacing the existing concrete shall be sawn 1 foot beyond the trench excavation on each side. Drill and grout 2 foot long, #4 rebar dowels into 1 foot deep holes at 18 inch centers, at the midpoint of the depth of the existing slab, along each edge of the sawn concrete, alternating sides of the trench. Place grout with an injection tool which allows grout to be placed at the back of the hole. Turn rebar one complete revolution during installation to ensure proper distribution of grout. Allow grout to cure for a minimum of three days before placing concrete patch.
- C. Concrete surfaces, including highways, streets, drives, parking lots, and sidewalks shall be restored with minimum 4,000 psi (28 day) compressive strength Portland cement concrete.
- D. Concrete shall not be placed on a wet or frozen surface or when weather or other conditions would prevent the proper handling, finishing, or compacting of the material, unless otherwise approved by the Engineer.
- E. The final concrete surface shall butt the existing surface along all edges providing a smooth surface joint. Finish the top surface to match the existing concrete. Seal all joints to prevent the infiltration of water.

3.03 GUARANTEE

- A. The Contractor shall maintain pavement under this Contract during the guarantee period of one year, and shall promptly refill and repave areas which have settled or are otherwise unsatisfactory for traffic.

END OF SECTION

**SECTION 02989
MISCELLANEOUS WORK AND CLEANING UP**

PART 1.00 GENERAL

1.01 DESCRIPTION

A. Work Included:

All labor, materials, equipment and incidentals required to do all miscellaneous work and cleaning up not otherwise specified will be furnished by the Contractor. The work in this Section includes, but is not limited to, the following:

1. Cleaning up.
2. Incidental work.

B. Related work described elsewhere:

1. Control of Work - Section 01560.

PART 2.00 PRODUCTS

None in this Section.

PART 3.00 EXECUTION

3.01 CLEANUP

- A. Maintain the site of the work free of debris and rubbish as possible during construction. At the conclusion of the work, the Contractor shall remove all construction material, excess excavation soils, equipment and all other debris remaining on the job as a result of construction operations, unless otherwise specified herein or directed by the Engineer.

3.02 INCIDENTAL WORK

- B. Do all incidental work not otherwise specified but obviously necessary to achieve proper completion of the Contract as specified and as shown on the Drawings.

END OF SECTION

**SECTION 02995
DECONTAMINATION**

PART 1.00 GENERAL

1.01 DESCRIPTION

- A. The work of this section consists of planning, preparing, and performing decontamination activities required to support the remedial action performed at the site. Work described in this section also includes collection, temporary storage and disposal of decontamination wash water.
- B. The Contractor shall submit a Decontamination Plan, which at a minimum, shall identify decontamination pad design and location on the Site, proposed methods for decontaminating equipment and personnel, proposed methods for managing decontamination water, and a logistical sequence for decontaminating equipment during construction.
- C. Related work described elsewhere:
 - Section 02525 – Excavating, Trenching, and Backfilling
 - Section 02222 – Exploratory Excavation

1.02 JOB CONDITIONS

- A. Decontamination of all materials, equipment, and transport that come into contact with contaminated soils: 1) prior to arrival at the site; 2) prior to placing backfill; or 3) prior to leaving an individual excavation area.
- B. Soils will be considered contaminated based on the screening procedure described in Section 02525.

PART 2.00 PRODUCTS

2.01 MATERIALS

- A. Decontamination Pad. - The decontamination pad shall consist of a contained basin with a minimum 6 inch high curb or berm and a sloped bottom and sump. The sump capacity must be adequate to contain wash water required to clean the construction equipment used to excavate contaminated soil. The sump shall be easily accessible to allow pumping and containerizing of the collected decontamination and rinse water. A minimum 10 mil continuous poly sheeting liner shall underlie the entire decontamination pad and the liner shall be protected from damage, both from the underlying native ground surface and from the equipment to be decontaminated. The Contractor is responsible for the cleanup of any spills and infiltration into underlying soils at the Contractor's expense.
- B. Decontamination Water – water used during the decontamination process. This water may be used as wash water and rinse water to decontaminate equipment and materials which contact the contaminated soils. The Contractor shall identify the water source to be used for decontamination and provide evidence it is free of contaminants or is municipally supplied water. Documentation relating to decontamination water shall be submitted to the Engineer.

- C. After the Decontamination Plan is approved, further changes, including decontamination pad design or location, must be made in writing to the Engineer (and approval obtained) no less than 30 days prior to any associated Site Work.

PART 3.00 EXECUTION

- A. Any equipment mobilized to the Site shall be inspected by the Engineer for cleanliness before it is unloaded. Any equipment that has soil, excess grease or fluid leaks shall not be allowed.
- B. Decontamination water shall be stored and transported in tanks and trucks dedicated for clean water use.
- C. The Contractor shall decontaminate all equipment which contacts contaminated soils, sediments, and liquids before said equipment leaves the discrete excavation area or contacts imported clean soil materials. The Contractor shall obtain Engineer approval of equipment decontamination activities prior to transporting the equipment off site or using equipment in other areas or with imported or clean soil materials. Based on field observations, the Engineer may require the Contractor to conduct additional decontamination activities.
- D. The Contractor shall capture, collect, and store all water used during decontamination activities. Decontamination water shall be stored in DOT approved containers. Stored decontamination water shall be sampled for waste characterization and disposed of in accordance with applicable State and Federal regulations.
- E. Construction equipment working in areas where contaminated soil is exposed at the surface shall be situated on a suitable barrier so that equipment tires and/or tracks do not come in contact with contaminated soils. Any tires and/or tracks of excavation equipment that do contact contaminated soils shall be decontaminated before the equipment leaves the delineated extent of the contaminated soil or must travel on a barrier that prevents contact with underlying clean soil.
- F. The Contractor shall supply all equipment and materials necessary to properly decontaminate equipment used in areas where contaminated soil is encountered. The Contractor shall construct or provide decontamination structures on site that can accommodate all types of equipment used.
- G. Once all on-site decontamination activities have been completed, the Contractor shall remove the decontamination pad. Waste materials shall be disposed of as contaminated waste in accordance with applicable State and Federal regulations.
- H. After removing the decontamination pad, the Contractor shall reclaim the area in the vicinity of the pad, if necessary. Reclamation activities include, but are not limited to, restoring the original topography and establishment of growth.

END OF SECTION

**SECTION 03200
CONCRETE REINFORCEMENT**

PART 1.00 GENERAL

1.01 DESCRIPTION

- A. Work included: The Contractor shall furnish and place all the reinforcing steel required for the complete construction of the concrete work as specified and as shown on the Drawings or as directed.
- B. Related work described elsewhere:

Section 03300 – Cast-In-Place Concrete

1.02 QUALITY ASSURANCE

- A. Qualifications of workmen: Provide at least one person who shall be present at all times during execution of this portion of the work and who shall be thoroughly familiar with the type of materials being installed and the best methods for their installation and who shall direct all work performed under this Section.
- B. Codes and Standards:
 - 1. In addition to complying with all pertinent codes and regulations, comply with all pertinent recommendations contained in ACI 315-80, "Details and Detailing of Concrete Reinforcement".
 - 2. Where provisions of pertinent codes and standards conflict with this Specification, the more stringent provisions shall govern.

1.03 SUBMITTALS

- A. None required for concrete surface patching.

1.04 PRODUCT HANDLING

- A. Protection:
 - 1. Use all means necessary to protect concrete reinforcement before, during and after installation and to protect the installed work and materials of all other trades.
 - 2. Store in a manner to prevent excessive rusting and fouling with dirt, grease and other bond-breaking coatings.
 - 3. Use all necessary precautions to maintain identification after the bundles are broken.
- B. Replacements: In the event of damage, immediately make all replacements necessary at no additional cost to the Owner.

PART 2.00 PRODUCTS

2.01 CONCRETE REINFORCEMENT

- A. All concrete reinforcement materials shall be new, free from rust, and complying with the following reference standards:
1. Bars for reinforcement: ASTM A615, 60 ksi yield grade, deformed steel bars per ASTM A305.
 2. Wire fabric: ASTM A185.

2.02 OTHER MATERIALS

All other materials not specifically described but required for a complete and proper installation of concrete reinforcement shall be subject to the review and approval of the Engineer.

PART 3.00 EXECUTION

3.01 SURFACE CONDITIONS

- A. Inspection:
1. Prior to installation of the work of this Section, carefully inspect the installed work of all other trades and verify that all such work is complete to the point where this installation may properly commence.
 2. Verify that concrete reinforcement is installed in strict accordance with design details on the Drawings.
- B. Discrepancies:
1. In the event of discrepancy, immediately notify the Engineer.
 2. Do not proceed with installation in areas of discrepancy until all such discrepancies have been fully resolved.

3.02 BENDING

- A. General:
1. Do not use bars with kinks or bends not shown on the Drawings or on the shop drawings.
 2. Do not bend or straighten steel in a manner that will injure the material.

3.03 PLACING

- A. General:
1. Before the start of concrete placement, accurately place all concrete reinforcement, positively securing and supporting by metal or plastic chairs or spacers, or by metal hangers.
 2. Tie all bar crossings securely with wire.
 3. Welding of cross bars (tack welding) shall not be permitted.

4. No concrete shall be placed before the placing and tying of reinforcement has been inspected by the Engineer. Contractor shall notify the Engineer not less than 48 hours prior to placing of concrete.

B. Splicing:

1. Splices shall be made only as required or permitted on the Drawings and as indicated on the shop drawings.
2. Unless otherwise shown on the Drawings, tension lap splices shall be provided in accordance with the Building Code Requirements for Reinforced Concrete (ACI 318-08).
 - a. Class B tension lap splices shall be provided if no more than one half the bars are spliced within the lap length.
 - b. Class C tension lap splices shall be provided if more than one half the bars are spliced within the lap length.
3. Lapped ends of bars may be placed in contact and securely wired or may be separated sufficiently to permit the embedment of the entire surface of each bar in concrete.
4. Wire fabric: Make all splices in wire fabric at least 1 1/2 meshes wide with the outermost cross wire of one fabric overlapping and the second cross wire of the other fabric by 2 inches minimum.

C. Dowels:

Place all required steel dowels and securely anchor them into position before the concrete is placed.

D. Obstructions:

In the event conduits, piping, inserts, sleeves, or any other items interfere with placing reinforcement as indicated on the Drawings or as otherwise required, immediately consult the Engineer and obtain concurrence for new procedure before placing concrete.

3.04 CLEANING REINFORCEMENT

Steel reinforcement, at the time concrete is placed around it, shall be free from rust scale, loose mill scale, oil, paint, and all other coatings which will destroy or reduce bond between steel and concrete.

END OF SECTION

**SECTION 03300
CAST-IN-PLACE CONCRETE**

PART 1.00 GENERAL

1.01 DESCRIPTION

A. Work Included:

The Contractor shall furnish all labor, materials, equipment and incidentals required to place all concrete, reinforcing steel, forms, water stops and miscellaneous related items, including sleeves, ringlets, anchor bolts, inserts and embedded items specified under other Sections.

B. Related work described elsewhere:

Section 02221 – Excavation, Trenching and Backfilling
Section 03200 – Concrete Reinforcement

1.02 QUALITY ASSURANCE

A. Personnel:

1. Provide at least one person who shall be present at all times during execution of this portion of the work and who shall be thoroughly trained and experienced in placing the types of concrete specified and who shall direct all work performed under this Section.
2. For finishing of exposed surfaces of the concrete, use only thoroughly trained and experienced journeymen concrete finishers.

B. Codes and Standards:

1. Perform the work of this Section in accordance with all applicable provisions of the most recent following standards and any other pertinent ACI concrete codes and specifications:

ACI 318 "Building Code Requirements for Reinforced Concrete"
ACI 301 "Specifications for Structural Concrete for Buildings"
ACI 306 "Cold Weather Concreting"
ACI 304 "Recommended Practice for Measuring, Mixing and Placing Concrete"
ACI 305 "Hot Weather Concreting"
ACI 308 "Standard Practice for Curing Concrete"

2. Where provisions of pertinent codes and standards conflict with this Specification, the more stringent provisions shall govern.

1.03 SUBMITTALS

- A. Submit mix design from concrete batch plant and results from testing of trial batches for the ready-mixed concrete proposed for use if requested by the Engineer.
- B. Submit manufacturer's literature for any admixtures proposed for use.

1.04 PRODUCT HANDLING

A. Protection:

Use all means necessary to protect cast-in-place concrete materials before, during and after installation and to protect the installed work and materials of all other trades.

B. Replacements:

In the event of damage, immediately make all repairs and replacements necessary at no additional cost to the Owner. No repairs or replacements are to be made before the damage has been inspected by the Engineer.

PART 2.00 PRODUCTS

2.01 CONCRETE

A. General:

1. All concrete, unless otherwise specifically permitted by the Engineer, shall be ready-mixed concrete in accordance with ASTM C-94.

B. Materials:

1. Cement:

All cement shall be Portland cement conforming to ASTM C 150, Type II, and shall be the product of one manufacturer, shall be from one source and shall have one color.

2. Aggregates:

Fine and coarse aggregate shall conform to the requirements of ASTM Specification C 33.

Nominal maximum size of coarse aggregate shall be not larger than:

- a. 1/5 the narrowest dimension between sides of forms nor
- b. 1/3 the depth of slabs, nor
- c. 3/4 the minimum clear spacing between individual reinforcing bars or wires, bundles of bars, or prestressing tendons or ducts.

These limitations may be waived if, in the judgment of the Engineer, workability and methods of consolidation are such that concrete can be placed without honeycomb or voids.

3. Water:

Mixing water for concrete shall meet the requirements of ASTM C 94.

4. Admixtures:
 - a. All concrete shall contain an approved air-entraining admixture conforming to ASTM C 260.
 - b. All concrete shall contain an approved water reducing admixture conforming to ASTM C 494, Type A or D.
 - c. An approved water reducing set retarder may be required by the Engineer in hot weather.

- C. Proportioning:
 1. Required Compressive Strength: For patching of surfacing, the concrete shall have a minimum 28 day compressive strength of 4,000 pounds per square inch.
 2. Concrete proportions shall be established on the basis of previous field experience or laboratory trial batches in accordance with Section 3.9 of ACI 301-84.
 3. All concrete shall be air entrained and shall conform to the air content limits of ACI 301-84, Table 3.4.1
 4. During the progress of the work, the Engineer may order such changes in proportions, materials, or both, as may be necessary to secure the desired properties. All changes so ordered shall be made at the Contractor's expense.

2.02 MEMBRANES

- A. Vapor barrier:

All vapor barrier membrane under concrete slabs shall be 6 mil weight polyethylene in sheets as wide as possible to avoid or minimize joints.
- B. Curing membrane:

All curing membrane shall be waterproof paper, polyethylene film or white burlap-polyethylene sheet conforming to ASTM C171.
- C. Jointing material:

All cement or tape used for sealing membrane joints shall be only as recommended by the manufacturer of the membrane being joined.

2.03 JOINT MATERIALS

Premolded joint filler shall be 1/2 inch thick or as shown on the Drawings and shall be a self-expanding cork joint filler conforming to ASTM D1752.

2.04 WATERSTOP

Waterstop shall be a sodium bentonite based waterstop designed to stop water infiltration through cast-in-place concrete construction joints by expanding upon contact with water to form a positive seal against the concrete.

Waterstop shall be “Waterstop-RX 101” produced in a rectangular shape measuring 1” x 3/4” by CETCO.

2.05 OTHER MATERIALS

All other materials, not specifically described but required for a complete and proper installation of cast-in-place concrete, shall be subject to the review and approval of the Engineer.

PART 3.00 EXECUTION

3.01 SURFACE CONDITIONS

- A. Inspection:
 - 1. Prior to all work of this Section, carefully inspect the installed work of all other trades and verify that all such work is complete to the point where this installation may properly commence.
 - 2. Verify that all items to be embedded in concrete are in place.
 - 3. Verify that concrete may be placed to the lines and elevations indicated on the Drawings, with all required clearance from reinforcement.
- B. Discrepancies:
 - 1. In the event of discrepancy, immediately notify the Engineer.
 - 2. Do not proceed with installation in areas of discrepancy until all such discrepancies have been fully resolved.

3.02 PREPARATION

- A. General:
 - 1. Remove all wood scraps and debris from the areas in which concrete will be placed.
 - 2. Thoroughly clean the areas to ensure proper placement and bonding of concrete.
 - 3. Thoroughly wet the forms (except in freezing weather), and remove all standing water.
 - 4. Thoroughly clean all transporting and handling equipment.
- B. Joints:

The surface of all joints shall be thoroughly cleaned prior to placing adjoining concrete as described under
- C. Notification:

Notify the Engineer at least 48 hours before placing concrete.

3.03 PLACING CONCRETE

- A. Method:

1. Convey concrete from mixer to place of final deposit by methods that will prevent separation and loss of materials.
 2. For chuting, pumping and pneumatically conveying concrete, use only equipment of such size and design as to ensure a practically continuous flow of concrete at the delivery end without loss or separation of materials.
 3. Chutes shall be metal or metal lined and shall have a slope not exceeding 1 vertical to 2 horizontal and not less than 1 vertical to 3 horizontal. Chutes more than 20 feet long and chutes not meeting the slope requirements may be used provided they discharge into a hopper before distribution.
 4. Deposit concrete as nearly as possible in its final position to avoid segregation due to rehandling and flowing.
 5. Place concrete as dry as possible consistent with good workmanship, never exceeding the maximum specified slump.
- B. Rate of Placement:
1. Place concrete at such a rate that concrete is at all times plastic and flows readily between bare bars.
 2. When placing is once started, carry it on as a continuous operation until placement of the panel or section is complete.
 3. Do not pour a greater area at one time than can be properly finished without checking; this is particularly important during hot or dry weather.
 4. Do not, in any case, pour a slab length greater than 60 feet without construction joints.
- C. Compaction:
1. Thoroughly consolidate all concrete by suitable means during placement, working it around all embedded fixtures and into corners of forms.
 2. During placement, thoroughly compact the concrete by hand tamping and by mechanical vibration.
- D. Acceptability:
- Do not use retempered concrete or concrete that has been contaminated by foreign materials.

3.05 CONSTRUCTION JOINTS

- A. When fresh concrete is to be placed upon or against old concrete surfaces, the surface of the previously cast concrete shall be cleaned of surface laitance, curing compound, oil, grease and other materials foreign to concrete.
- B. Waterstop shall be place against the existing sawn surfaces where interior slabs are patched. Install the waterstop as per the manufacturers requirements

3.06 FINISHING

- A. General:

Unless otherwise authorized, the surface of the concrete shall be finished immediately after form removal.

All horizontal concrete surfaces shall be given a floated finish. All interior floors shall be given a troweled finish; and all sidewalks, platforms, walkways, steps, landings and ramps shall be given a broom finish.

B. Floated finish:

After the concrete has been placed, consolidated, struck off, and leveled, the concrete shall not be worked further until ready for floating. Floating with a hand float or with a bladed power trowel equipped with float shoes, or with a powered disc float shall begin when the water sheen has disappeared and when the surface has stiffened sufficiently to permit the operation. During or after the first floating, planeness of surface shall be checked with a 10 foot straight-edge applied at not less than two different angles. All high spots shall be cut down and all low spots filled during this procedure to produce a surface within Class B tolerance throughout. The slab shall then be refloated immediately to a uniform sandy texture.

C. Broom finish:

Immediately after the concrete has received a float finish as specified in paragraph 3.06 B, it shall be given a coarse transverse scored texture by drawing a broom across the surface.

D. Finishing tolerances:

1. Finished with Class A tolerances shall be true planes within 1/8 inch in 10 ft., as determined by a 10 foot straightedge placed anywhere on the slab in any direction.
2. Finishes with Class B tolerances shall be true planes within 1/4 inch in 10 ft., as determined by a 10 foot straightedge placed anywhere on the slab in any direction.
3. Finished with Class C tolerances shall be true planes within 1/4 inch in 2 ft., as determined by a 2 foot straightedge placed anywhere on the slab in any direction.

3.07 CURING

- A. All concrete, particularly exposed surfaces, shall be treated immediately after concreting or cement finishing is completed to provide continuous moist curing or membrane curing or a combination of these curing methods at above 50 degrees F for at least 7 days, regardless of the ambient air temperature.
- B. Continuous moist curing shall be accomplished by applying one of the following procedures:
1. Ponding or continuous sprinkling.
 2. Application of absorptive mats or fabric kept continuously wet.

3. Application of at least 3" of sand kept continuously wet.
 4. Continuous application of steam (not exceeding 150 degrees F) or mist spray.
 5. Application of water proof sheet materials, conforming to "Specifications for Waterproof Sheet Materials for Curing Concrete" (ASTM C 171).
- C. Membrane curing shall be accomplished by spraying a white pigmented curing compound uniformly on the entire surface of the fresh concrete. The concrete surface shall still be moist when the coating is applied. The curing compound shall be applied as a two-coat continuous spray operation, with the second coat applied at right angles to the first coat. The coverage shall be in accordance with the manufacturer's recommendations and shall not exceed 400 square feet per gallon for each coat.

White-pigmented curing compounds shall be used at all locations where future appearance is not critical so that coverage is easily verified. Should the film of the curing compound be damaged for any cause before the 7 day curing period is up, the damaged portions shall be repaired immediately with additional curing compound.

Clear curing compounds containing a quick-fading fugitive dye may be used only where the appearance of the white curing compound would be objectionable and only with the written permission of the Engineer.

Clear curing compound without a quick-fading fugitive dye may not be used at all.

Curing compounds shall not be used on concrete surfaces that are to be coated with paint, waterproofing, damp proofing, Thoroseal, mortar mix, shotcrete or any other coating. If curing compounds are used on any surface where its appearance is objectionable or where a coating is to be applied, the curing compound shall be completely removed by sandblasting at the Contractor's expense.

- D. Moisture loss from surfaces placed against wooden forms or metal forms exposed to heat by the sun shall be minimized by keeping the forms wet until they can be safely removed. After form removal, the concrete shall be cured until the end of the 7 day curing period by one of the methods described above.

3.08 COLD WEATHER CONCRETING

- A. Winter concreting shall be done in accordance with the recommendations of ACI 306R-78 and as herein specified.
- B. Concrete forms and steel work shall be heated and maintained at a minimum temperature of 45 degrees F for two hours before placing the concrete.
- C. The area outside the forms shall have a temperature of 50 degrees F for seven (7) days during and after concrete is placed unless rising temperatures are indicated, then time can be reduced to five (5) days.

- D. The temperature of the concrete placed in the forms shall not be below 55 degrees F when outside temperature is or falls below 40 degrees F. When temperature is below 30 degrees F concrete placed in forms shall not be less than 65 degrees F.
- E. All heat around concrete forms shall be reduced slowly for three (3) days to prevent concrete temperature cracks.

3.09 HOT WEATHER CONCRETING

- A. Placement:
 - 1. Comply with the recommendations of ACI 305R-77 "Hot Weather Concreting".
 - 2. Do not use concrete with a placing temperature that will cause difficulty from loss of slump, flash set, or cold joints. Do not place any concrete having a temperature in excess of 90 degrees F.
 - 3. Use all means necessary to avoid drying the concrete prior to finishing operations.
- B. Protection:

Provide and use all required windbreaks, sunshades, fog sprays and other devices to protect the concrete.

3.10 DEFECTIVE WORK

- A. Inspection:
 - 1. Immediately after forms and curing membranes have been removed, inspect all concrete surfaces and patch all pour joints, voids, rock pockets, form tie holes and other imperfections before the concrete is thoroughly cured.
 - 2. Do not patch until concrete has been inspected by the Engineer.
- B. Patching:
 - 1. Minor defective areas:
 - a. Chip away to a depth of about one inch, leaving edges perpendicular to the surface; wet the area to be patched and a space of at least six inches wide around it to prevent water being absorbed out of the mortar.
 - b. An acrylic emulsion shall be applied to the chipped edge in accordance with the manufacturer's recommendations, before concreting operations. The acrylic emulsion shall be Admix 101 by Larsen Products, Acrylic Concrete Binder by Bondsal Co., or equal.
 - c. Patching mortar shall consist of one part cement to three parts sand, mixed to a consistency as dry as possible within the requirements of handling and placing; thoroughly compact the mortar by ramming it into place.

END OF SECTION

**SECTION 04100
UTILITY MORTAR AND GROUT**

PART 1.00 GENERAL

1.01 DESCRIPTION

- A. The work of this section primarily relates to mortar and grout work associated with the utility work. Non-shrink grout for sealing joints on concrete sections, patching around pipe at holes through concrete, and patching holes is included.
- B. Related work specified elsewhere:
Section 15064 – PVC Pipe and Fittings

1.02 QUALITY ASSURANCE

- A. Standards:

American Society for Testing and Materials (ASTM) and manufacturer's printed recommendations.

1.03 PRODUCT HANDLING

- A. Delivery:

Deliver materials in manufacturer's original unopened, protective packaging.
- B. Storage:

Store cementitious materials, where directed, under cover, off the ground.

1.04 JOB CONDITIONS

Do not use mortar in work when temperature of outside air is below 40 degrees F unless suitable approved means are provided to heat materials. Ensure mortar will harden without freezing.

PART 2.00 MATERIALS

2.01 MORTAR

- A. Cement: ASTM C 150; 1 part.
- B. Sand: ASTM C 144; 5 parts.
- C. Hydrated Lime: ASTM C 207 Type S; 1-1/4 parts.
- D. Water: Clean and Potable.
- E. Strength: 2,000 psi; tests by Contractor if requested by the Engineer due to problems encountered.

2.02 **NON-SHRINK GROUT**

- A. Non-shrink, non-metallic grout shall be Thoro System Products, Inc. "WATERPLUG" or approved equivalent.

PART 3.00 EXECUTION

3.01 **MORTAR**

Mix all cementitious materials and sand in mechanical batch mixer for a minimum of 5 minutes after adding all materials. While mixer is in operation, add 3/4 required water, 1/2 sand, and all lime and cement; then remainder of sand. Allow batch to mix briefly; add water in small quantities until mortar is of a workable consistency. If mortar begins to stiffen from evaporation or from absorption of part of mixing water, retemper immediately; remix.

3.02 **GROUT**

All non-shrink grout shall be mixed and applied in accordance with manufacturer's recommendations for the purpose intended; mixture should be a stiff grout, non-flowable.

END OF SECTION

**SECTION 07840
FIRESTOPPING**

PART 1.00 GENERAL

1.01 DESCRIPTION

- A. General:
Furnish and install tested and listed firestopping systems to form an effective barrier against the spread of flame, smoke and gases, and maintain the integrity of any fire resistance rated wall within the building, including through-penetrations. Through-penetrations include the annular space around pipes, tubes, conduit, wires, cables and vents. All block walls within the building interior are assumed to be fire-rated.
- B. Sequencing:
Coordinate the specified work with other trades. Firestop material shall be inspected and approved prior to final completion and enclosing of any assemblies that may conceal installed firestop.

1.02 SUBMITTALS

- A. Submit detail drawings including manufacturer's descriptive data, typical details conforming to UL Fire Resistance or other details certified by another nationally recognized testing laboratory, installation instructions or UL listing details for a firestopping assembly in lieu of fire-test data or report. For those firestop applications for which no UL testing system is available through a manufacturer, a manufacturer's engineering judgment, derived from similar UL system designs or other tests, shall be submitted for review and approval prior to installation. Submittal shall indicate the firestopping material to be provided for each type of application.
- B. Submit certificates attesting that firestopping material complies with the specified requirements. For all intumescent firestop materials used in through penetration systems, manufacturer shall provide certification from UL of passing the "Aging and Environmental Exposure Testing" portion of UL 1479.

1.03 DELIVERY, STORAGE, AND HANDLING

Deliver materials in the original unopened packages or containers showing name of the manufacturer and the brand name. Store materials off the ground, protected from damage and exposure to elements. Remove damaged or deteriorated materials from the site.

PART 2.00 PRODUCTS

2.01 FIRESTOPPING MATERIALS

Provide firestopping materials, supplied from a single domestic manufacturer, consisting of commercially manufactured, asbestos-free, nontoxic, water-based, noncombustible products FM APP GUIDE approved, or UL listed, for use with applicable constructions and penetrating items, complying with the following minimum requirements:

- A. Fire Hazard Classification:
Material shall have a flame spread of 25 or less, and a smoke developed rating of 50 or less, when testing in accordance with ASTM E84 or UL 723. Material shall be an approved firestopping material as listed in UL Fire Resistance or by a national recognized testing laboratory.
- B. Toxicity:
Material shall be nontoxic and carcinogen free to humans at all stages of application or during fire conditions and shall not contain hazardous chemicals or require harmful chemicals to clean material or equipment. Firestop material must be free from Ethylene Glycol, PCB, MEK, or other types of hazardous chemicals.

- C. Fire Resistance Rating:
Firestop systems shall be UL Fire Resistance listed or FM APP GUIDE approved with “F” rating at least equal to fire-rating of fire wall or floor in which penetrated openings are to be protected.
1. Through-Penetrations
Firestopping materials for through-penetrations, as described in paragraph 1.01 DESCRIPTION, shall provide “F”, “T”, and “L” fire resistance ratings in accordance with ASTM E814 or UL 1479. Fire resistance ratings shall be as follows:
 - a. Penetrations of Fire Resistance Rated Wells and Partitions: F Rating = Rating of wall or partition being penetrated.
- D. Material Performance
All firestop materials are subject to these minimum standards of performance.
1. Firestop materials shall be capable of installation at temperatures of 2 to 49 degrees C (35 to 120 degrees F).
 2. Firestop material must convey a manufacturer’s written warranty guaranteeing the performance of the material for the sustainable lifetime of the structure.
 3. Material must maintain a shelf life of no less than two years from date of manufacturing.
 4. Acceptable firestop cast-in-place devices are factory assembled intumescent lined round or oval plastic cylinders capable of protecting plastic, metallic, cable, and blank openings through the cast-in-place device equal to the fire-resistance rating of the floor.

PART 3.00 EXECUTION

3.01 PREPARATION

Areas to receive firestopping shall be free of dirt, grease, oil, or loose materials which may affect the fitting or fire resistance of the firestopping system. For cast-in-place firestop devices, formwork or metal deck to receive device prior to concrete placement shall be sound and capable of supporting device. Prepare surfaces as recommended by the manufacturer.

3.02 INSTALLATION

Completely fill void spaces with firestopping material regardless of geometric configuration, subject to tolerance established by the manufacturer. Install firestopping in accordance with manufacturer’s written instructions. Provide tested and listed firestop systems in the following locations:

- A. Penetrations of duct, conduit, tubing, cable and pipe through fire-resistance rated walls.

3.03 INSPECTION

- A. Inspection Standards
Inspect all firestopping in accordance to ASTM standards for firestop inspection, and document inspection results to be submitted to Engineer.
 1. ASTM E2393
 2. ASTM E2174

END OF SECTION

SECTION 15064
EXTERIOR POLYVINYL CHLORIDE (PVC) PIPE AND FITTINGS

PART 1.00 GENERAL

1.01 DESCRIPTION

A. Work included:

All labor, materials, equipment, and incidentals necessary to completely install all buried PVC pressure or gravity pipe as specified herein, as shown on the Drawings, or as directed by the Engineer shall be furnished by the Contractor. PVC pipe inside the facility shall be as shown on the drawings.

B. Related work described elsewhere:

1. Excavation, Trenching and Backfilling - Section 02221
2. Interior Piping and Plumbing – Section 15203

1.02 SUBMITTALS

- A. Catalog cut sheets which describe the exact product proposed shall be submitted to the Engineer for approval.
- B. Manufacturer's information relative to pipe joining and laying shall be submitted with the catalog cuts.

PART 2.00 PRODUCTS

2.01 POLYVINYL CHLORIDE (PVC) PRESSURE PIPE AND FITTINGS

- A. All Schedule 40 PVC pipe shall be manufactured from a Type I, Grade I Polyvinyl Chloride (PVC) compound per ASTM D1784. The pipe shall be manufactured in strict compliance to ASTM D2665, consistently meeting and/or exceeding the Quality Assurance test requirements of this standard with regard to pressure rating, material, workmanship, burst pressure, flattening, impact resistance, and extrusion quality.
- B. Standard lengths of pipe sizes 10" and larger shall be beveled each end by the pipe manufacturer for push-on joints. All pipe shall be stored indoors after production at the manufacturing site until shipped from factory.
- C. Pipe and fittings shall be furnished as called for on the Drawings and as specified.

2.02 PVC ELECTRICAL CONDUIT

- A. Electrical conduit shall be Schedule 40 PVC and manufactured to NEMA TC-2 Federal specifications, WC1094A and UL 651 specifications and carry respective UL Listings and UL labels.

2.03 IDENTIFICATION

- A. Each pipe length and fitting shall be clearly marked with:
 - 1. Manufacturer's name.
 - 2. Nominal pipe diameter.
 - 3. ASTM designation and PSM.
 - 4. Material designation.
 - 5. PVC cell classification.

- B. Manufacturer's certifications that the material was manufactured and tested in accordance with this Specification are required at the time of delivery.

2.04 MISCELLANEOUS MATERIALS

Lubricants, cements, and other construction materials shall be as recommended by the pipe manufacturer.

PART 3.00 EXECUTION

3.01 GENERAL

- A. PVC pipe and fittings shall be installed to the locations shown on the Drawings or as directed by the Engineer.

- B. Pipe shall be protected from prolonged exposure to direct sunlight and stored on pallets to insure maintenance of straightness and roundness.

3.02 JOINING PVC PIPE

- A. Joints shall be solvent welded and made according to the manufacturer's recommendations.

- B. All pipe shall be free from defects. Materials found to be defective shall be removed from the site. The Contractor is responsible for inspecting all material to be used prior to installation. Defective material which has been installed shall be removed and replaced with non-defective material at no cost to the Owner.

- C. The physical and chemical properties of pipe couplings shall be equal to that of the pipe.

- D. Pipe cut on the job shall have square ends and be free from burrs.

3.03 LAYING PIPE

- A. Pipe and fittings shall be laid according to the manufacturer's recommendations and as follows:
 - 1. Trench bottom shall be excavated to the bottom of the outside diameter of the pipe and the pipe laid on undisturbed native material;
 - 2. Compacted material shall be placed as indicated in Section 02221 and as shown on the Drawings;
 - 3. Bell holes shall be excavated so that the pipe barrel bears evenly on the trench bottom.
 - 4. Pipe shall be laid beginning at the downstream end and proceeding in an upstream direction.
 - 5. Remaining backfill material shall be placed as indicated on the Drawings in the Specifications.
 - 6. Electrical conduit shall be installed as indicated on the Drawings.

3.04 CLEANING

- A. Open ends of pipe shall be protected to prevent the entrance of debris.
- B. Prior to testing, thoroughly clean the pipe.
- C. All pipe and fittings must be free of any foreign matter before final inspection.

3.05 AIR TESTING

- A. Procedures
 - 1. Determine the test time for the section of line to be tested using Table 1 below.
 - 2. Plug all openings in the test section.
 - 3. Add air until the internal pressure of the line is raised to approximately 4.0 pounds/square inch (psi). After this pressure is reached, allow the pressure to stabilize. The pressure will normally drop as the air temperature stabilizes. This usually takes 2 to 5 minutes depending on the pipe size. The pressure may be reduced to 3.5 psi before starting the test.
 - 4. When the pressure has stabilized and is at or above the starting test pressure of 3.5 psi, start the test. If the pressure drops more than 1.0 psi during the test time, the line is presumed to have failed the test. If a 1.0 psi drop does not occur within the test time, the line has passed the test.

- B. Test time
1. Table 1 shows the required test time, T, in minutes/100 feet of pipe for each nominal pipe size. Test times are for a 1.0 psi pressure drop from 3.5 to 2.5 psi.
 2. If the section of line to be tested includes more than one pipe size, calculate the test time for each length at a certain size and add the test times to arrive at the total test time for the section.
 3. It is not necessary to hold the test for the whole period when it is clearly evident that the rate of air loss is less than the allowable.

Table 1. Minimum Air Test Times

Nominal Pipe Size in inches	T (time) min/100 ft.
2	0.1
3	0.2
4	0.3
6	0.7
8	1.2
10	1.5
12	1.8
15	2.1
18	2.4

3.06 COMPLETION OF WORK

- A. Following the tests, all lines shall be thoroughly cleaned. The Engineer shall determine if the lines have been cleaned satisfactorily.
- B. Full payment for PVC pipe shall not be made until the line has been cleaned and tested satisfactorily. Lines must be clean at the time of final inspection.

END OF SECTION

**SECTION 15203
INTERIOR PIPING AND PLUMBING**

PART 1.00 GENERAL

1.01 DESCRIPTION

- A. The work of this section consists of furnishing and installing all interior piping, connections, and appurtenances associated with the soil vapor extraction system, as shown on the Drawings. This scope includes the influent piping (inside the building), influent manifold, and piping connections for the blower and treatment system components
- B. The mechanical details on the drawings are diagrammatic in character; and exact locations of the elements of the system, the measurement or cutting and installing pipe, and dimensions of the equipment, shall be determined as necessary to be compatible with the building structure and the equipment. Space requirements, required pipe lengths, and locations of connections of equipment shall be investigated by Contractor prior to ordering. The Contractor shall not scale off the drawings to cut pipe or make connections to equipment selected. Equipment which will not enter the openings or which will not fit the assigned space will not be acceptable.

1.02 RELATED WORK SPECIFIED ELSEWHERE

- A. Firestopping - Section 07840
- B. Utility Mortar and Grout - Section 04100

1.03 SUBMITTALS

- A. Submit manufacturer's cut sheets and descriptions of all materials to be used at the Site. These submittals shall be provided for Engineer's review at least two weeks prior to any scheduled Site work.
- B. No materials shall be installed at the Site without the Engineer's approval.
- C. The Contractor shall submit to the Engineer his proposed plan of supporting of piping. All supports and hangers shall be a standard manufactured type. Wall brackets and braces shall be sufficiently anchored to the wall in an approved manner.

PART 2.00 MATERIALS

2.01 PIPING

- A. Plastic Piping: Polyvinyl chloride (PVC) conforming to ASTM D 1784 for Schedule 40 pipe.

2.02 PIPE SUPPORTS

- A. All pipelines shall be supported to allow for thermal expansion and contraction of the pipe.
- B. The spacing of pipe supports shall be established in accordance with the pipe manufacturer's recommendations
- C. Pipes located at heights greater than 4 feet above the floor shall be supported with clevis type hangers from above or by brackets from an adjacent wall.
- D. Pipes located at heights less than or equal to 4 feet above the floor shall be supported by use of a pipe saddle.

- E. The materials used for piping support shall be similar and equal to those manufactured by ITT Grinnell for the appropriate uses.
- F. All pump and equipment piping, fittings, valves, etc., shall be supported in a manner that prevents any loading or stress on the connections.

2.04 VALVES

- A. All Valves shall be true union, full bore polyvinyl chloride valves of the same diameter as the pipe where the pipe is installed, unless specified otherwise on the Drawings.

2.05 PRESSURE GAUGES

- A. Each gauge installation shall include the gauge, a shut-off valve, and a snubber on PVC pipelines. On all pipelines there shall be a liquid filled chemical seal to insulate the gauge from the pipeline's liquid. Gauges shall be mounted vertically.
- B. All pressure gauges shall have aluminum cases, back flanged with screwed ring cover, minimum 2 1/2-inch dial, nonreflecting white face, bronze socket and tube, 1/4-inch NPT bottom connection.
- C. Pressure ranges for the gauges shall be 0–60 inches of water or as specified on the drawings. Gauges shall be approved equal to those manufactured by Ametek Technical & Industrial Products.

2.06 VACUUM GAUGES

- A. Each gauge installation shall include the gauge, a shut-off valve, and a snubber on PVC pipelines. Gauges shall be mounted vertically.
- B. All vacuum gauges shall have aluminum cases, back flanged with screwed ring cover, minimum 2 1/2-inch dial, nonreflecting white face, bronze socket and tube, 1/4-inch NPT bottom connection.
- C. Vacuum ranges for the gauges shall be 0–60 inches of water vacuum or as specified on the drawings. Gauges shall be approved equal to those manufactured by Ametek Technical & Industrial Products.

PART 3.00 EXECUTION

3.01 GENERAL PIPE INSTALLATION

- A. Obtain all required permits for work specified under this section. Provide for all state or local inspections. Furnish copies of all inspection reports to the engineer.
- B. Install work to comply strictly with latest applicable edition of International Plumbing Code, local or State building codes, and all public or private authorities that have jurisdiction. Work not in compliance with these codes shall be repaired by the Contractor at no cost to the Owner.
- C. Due to the small scale of the drawings, it is not possible to indicate all of the piping systems nor to show all offsets, fittings, etc., which may be required. The fittings, hangers, pipe supports, and

other accessories are ancillary to the installation of the piping. These items shall be provided and installed by the Contractor at no additional cost.

- D. All piping shall be installed as closely as possible to walls, ceilings, columns, beams and equipment (consistent with proper space requirements for maintenance and operational appurtenances) so as to occupy the minimum of space. All offsets, fittings, etc. required to accomplish this must be furnished.
- E. The Contractor may add flexible joints where required, as approved by the Engineer. All piping shall be installed plumb and square.
- F. Exposed pipe shall be run parallel with or at right angles to the adjacent walls and ceiling trusses.
- G. All pipes, fittings, and valves delivered to the Site shall be clearly marked to identify the material, class, and thickness. All material shall be new and free of blemishes.

3.02 PIPES THROUGH CONCRETE BLOCK WALLS

- A. All penetrations through concrete block walls shall be performed by the Contractor following industry standard procedures and using tools specifically designed for cutting concrete.
- B. Fire wall penetrations shall be performed in accordance with Section 07840.
- C. After installation of the pipe, the openings around the pipe shall be closed by pouring with non-shrink grout in accordance with the grout manufacturer's instructions.
- D. Where grout is placed in openings through vertical walls, a "spout" 6 inches above the highest point in the opening shall be provided and filled with grout to assure the entire opening is completely filled. The grout shall be thoroughly mixed and shall be poured in-place immediately after mixing.
- E. On exposed surfaces, the finished surface of the grout shall be left not less than 3/4-inch below the adjacent surfaces and a 3/4-inch coat of 3:1 Portland cement plaster applied after the grout has set. The final surfaces shall be troweled smooth and painted to match existing.

3.03 SMALL PIPE INSTALLATION

- A. All Schedule 40 PVC pipe and fittings shall have solvent welded joints.
- B. Unions must be installed at all valves and equipment connections so that the equipment can be removed without dismantling the piping.
- C. At each piece of equipment using water, valves must be installed in the water supply line, or lines, whether shown or not.
- D. All piping shall be reamed and cleaned of all dirt and scale before being installed. All concealed piping shall be tested in the presence of the Engineer before being concealed. Changes in direction shall be made with fittings. Pipe showing kinks or wrinkles will not be accepted. All joints shall be made watertight or airtight depending on their use.

3.04 TESTING

- A. All piping systems installed at the Site shall be tested by a pressure test performed in the presence of the Engineer. In general, tests shall comply with the International Plumbing Code. In the absence of a specific Code test, the lines shall be capable of withstanding and holding without leakage an air pressure equal to 5 pounds per square inch for a minimum of 15 minutes. In the event the line tested should fail, repairs shall be made and the line retested until it does comply at no additional expense to the Owner.

3.05 PLUMBING FIXTURES INSTALLATION

- A. All plumbing fixtures and equipment described in this section shall be installed in strict conformance with all permit requirements, applicable code requirements, and the manufacturer's recommendations.

END OF SECTION

**SECTION 16000
ELECTRICAL**

PART 1.00 GENERAL

1.01 CODES AND CERTIFICATES

- A. Install work to comply strictly with latest applicable editions of Underwriters' Laboratories, American Insurance Association, National Fire Protection Assoc., ASHRAE Guide, National Electrical Code, OSHA, local building codes and all municipal, state and other public or private authorities which have jurisdiction.
- B. The current issue as adopted by the legally responsible authority shall be used, complete with local interpretations and rulings.
- C. Work not in compliance with these codes shall be repaired or replaced at no cost to the Owner.
- D. Obtain all required permits for work specified under this section. Provide for all state or local inspections. Furnish copies of all inspection reports to the Engineer.

1.02 QUALITY ASSURANCE

- A. All materials and apparatus required for work, except as specifically specified otherwise, shall be new, of first-class quality, and shall be furnished in every detail, and shall be so selected and arranged as to fit properly into the building spaces.
- B. All equipment and materials shall be installed in accordance with the recommendations of the manufacturer. This includes the performance of such tests as the manufacturer recommends.
- C. Manufacturer's nameplate, name, or trademark and address shall be attached permanently to equipment and material furnished under this Section.
- D. All electrical equipment and electrical components shall bear labels attesting to UL approval. All other materials, devices and products, for which there is listing in the UL Product Directories, shall bear a UL label.

PART 2.00 PRODUCTS

2.01 CIRCUIT BREAKER

- A. Circuit breakers shall be UL listed.
- B. Circuit breakers shall provide automatic tripping with thermal and magnetic short circuit and overload protection. The operation mechanism shall provide positive trip-free operation and have a quick-make and quick-break contact under both manual and automatic operation.

2.02 CONDUIT

- A. Furnish and install all conduit, flexible conduit, raceway, boxes, condulets, sleeves and waterproof sleeves, conduit seals, and all other required fittings for all electrical power, light, alarm, communication and control wiring, as shown on the drawings, and as specified herein.
- B. Conduit sizes shall meet NEC requirements for the number of conductors to be accommodated.
- C. Hot dipped or metalized rigid conduit shall be used in the following locations unless otherwise indicated.
 - 1. In all moist and wet locations.
 - 2. In poured concrete slabs and walls.
 - 3. In or below concrete slabs.
 - 4. For feeders buried in earth as noted.
 - 5. Exposed on the exterior of the building.

Fittings for rigid conduit shall be threaded. Install rigid conduit in accordance with Article No. 346 of NEC. Conduit connections to NEMA 4X and other weatherproof enclosures shall be watertight.

- D. Thin wall (EMT) tubing shall be used in the following locations:
 - 1. For all work except as specified above for rigid conduit.

Fittings for thin wall tubing shall be compression or screw type. Install thin wall tubing (EMT) in accordance with Article No. 348 of NEC.

2.03 WIRES AND CABLES

- A. All secondary conductors shall be new copper with 600-volt code gauge insulation, conforming to NEC requirements, and shall be Type THW or THHN.

Type THW may be used in armored cable branch circuits and in temperature controls, alarm and signal systems.
- B. Wire sizes shall be as shown on the drawings, but where sizes are not shown, shall be in accordance with the NEC and no smaller than the following minimum sizes:
 - 1. Light and power wiring - #12 AWG.
 - 2. Control Wiring - #14 AWG.
- C. Wire sizes and cable types for alarm and signal systems shall be as recommended by the manufacturer of the equipment or as noted on drawings.
- D. BX cable shall be UL labeled with single scrip, spirally wound galvanized armor, TW or THW wire.

2.04 PANELBOARD

- A. All panelboard components shall be built, assembled and shipped by one manufacturer so there is one source of supply and responsibility.
- B. Panelboards shall have a main circuit breaker to protect and de-energize the phase buses.
- C. Bus bar connections to all circuit breakers shall be bolt-on type. Bus bar connections to the branch circuit breakers shall be the “distributed phase” or “phase sequence” type.
 - 1. Single phase, three-wire panelboard bussing shall be such that any two adjacent single-pole breakers are connected to opposite polarities in such a manner that two-pole breakers can be installed in any locations.
 - 2. Three-phase, four-wire panelboard bussing shall be such that any three adjacent single-pole breakers are individually connected to each of the three different phases in such a manner that two or three-pole breakers can be installed at any location.
 - 3. All current carrying parts of the bus assembly shall be plated.
- D. Enclosure Construction:
 - 1. Panelboards shall have a door-in-door trim where a piano hinge is installed down one side and the other side secured with screws that will allow access to the interior parts of the panelboard, and a lockable, interior door allows access to the circuit breakers.
 - 2. Where doors are longer than 36” they shall have two latching mechanisms keyed alike.
 - 3. Equip with interior circuit-directory frame, and card with clear plastic covering.
 - 4. Provide manufacturer’s standard two-coat, baked-on finish consisting of prime coat and thermosetting topcoat.
- E. Phase, Neutral and Ground Buses:
 - 1. Buses shall be constructed of copper or tin-plated aluminum.
 - 2. Neutral bus shall be rated for 100% of phase bus rating. Provide suitable lugs for outgoing feeders requiring neutral connections.
 - 3. Provide a bare uninsulated grounding bar suitable for bonding to enclosure.
- F. Conductor Connectors:
 - 1. All connectors shall be suitable for both aluminum and copper conductors.
 - 2. All connections shall be mechanical type (no compression type connections).
- G. Manufacturers: Subject to compliance with requirements, provide panelboard products from one of the following manufacturers:
 - 1. Eaton Corporation
 - 2. General Electric Company
 - 3. Siemens
 - 4. Square D
 - 5. Approved equal

2.05 ELECTRICAL METER

- A. Meter shall have an indirect-read LCD display for cumulative kWh and real-time kW load.
- B. The configuration (Phases/wires) shall be compatible with overall system requirements.
- C. Meter shall be enclosed in an industrial grade JIC steel enclosure with padlocking hasp and mounting flanges for indoor installation.
- D. Meter shall be UL Listed to latest applicable standards for safety.
- E. Meter shall have revenue grade accuracy; certified by independent test lab to ANSI C12.20 national accuracy standards.
- F. Meter shall be of type specified by the local electric utility.

PART 3.00 EXECUTION

3.01 CONDUIT

- A. Extend conduits from the distribution centers and controllers through pull and junction boxes to the pumps, equipment, lighting, etc. Mechanically bond the system throughout to make each circuit continuous, except for direct bury cable.
- B. Run all conduit generally parallel or perpendicular to walls and partitions. Install conduit in walls and partitions as nearly vertically as possible, horizontally only where unavoidable and never diagonally. Conduit shall be supported rigidly by UL approved clamps. Support shall be spaced as specified by code or manufacturers' recommendations.
- C. Install conduit with minimum number of joints.
- D. All conduit or tubing shall be cut square and reamed properly. The use of running threads is prohibited.
- E. Cap or plug conduit ends during construction. Cap or plug end of conduit that is to remain empty after test and make watertight. Leave a #14 gauge galvanized steel drag wire in empty conduits.
- F. Conduit runs as indicated are diagrammatic. The exact routing of conduit shall suit job conditions and as previously specified or specifically indicated on drawings.
- G. Roughing-in dimensions of electrically operated units shall be furnished by trades supplying and/or installing same. Set conduit and boxes for connecting to units only after receiving approved dimensions and after checking locations with other trades.
- H. Conduits penetrating exterior walls or roofs shall be installed with a sleeve and sealed with a listed waterproof sealing material.

3.02 WIRES AND CABLES

- A. Conductors shall be continuous from the distribution center to final connection. Splice only where necessary and approved in accessible junction or outlet boxes. Splicing and fittings shall conform to NEC; wires #10 and smaller Type R Scotchlok pressure connector, #8 and larger shall be T&B Burndy bolt type with rubber and friction tape insulation. Vinyl plastic tape is NOT acceptable in lieu of rubber where exterior temperatures are encountered. Avoid soldered joints.
- B. No conductor shall be pulled into any conduit run before all joints are made up tightly and the entire run secured in place. When required to ease the pulling of wires into conduit, use only powdered soapstone.
- C. Tag all feeders and risers in all pull boxes and in all gutter spaces through which they pass.
- D. Leave all wires with sufficient slack at terminal ends for convenient servicing. Store loose ends neatly in outlet box.

3.03 GROUNDING

- A. Method of ground and bonding shall be in accordance with the requirements of Article 250 of the National Electrical Code and local regulations. Grounding conductors shall have an identifying marker readily distinguishable from the other conductors. All conduits entering cabinets shall be bonded by use of double locknuts and bushing. All motor frames, starters, housings, etc., shall be bonded by suitable jumpers connected to the conduit containing the circuit wires to said equipment.
- B. Selection of grounding shall be in compliance with National Electric Code article 250.
- C. Where a grounding conductor is specified it shall be provided. Use of raceway or other grounding or bonding methods shall not be considered as being equal.

3.04 PANEL BOARD

- A. General: Install panelboards and enclosures where indicated, in accordance with manufacturer's written instructions, applicable requirements of the adopted electrical code and NECA 407 and NEMA PB1.1, and in compliance with recognized industry practices to ensure that products fulfill requirements.
- B. Tighten connectors and terminals, including screws and bolts, in accordance with equipment manufacturer's published torque tightening values for equipment connectors. Where manufacturer's torqueing requirements are not indicated, tighten connectors and terminals to comply with tightening torques specified in UL standards 486A and B.
- C. Anchor enclosures firmly to walls and structural surfaces, ensuring that they are permanently and mechanically secure.

- D. Provide electrical connections within enclosures.
- E. Every circuit and circuit modification shall be legibly identified in a circuit directory. Circuit directory shall be neatly typed and mounted on the inside of door, designating outlets, lights, receptacles and motor served by each branch circuit.
- F. Any panelboards or other equipment that is protected by a “Series” rated over-current device upstream is to be marked with a contractor-installed label which notes the short-circuit rating of the series combination and calls out the specific replacement over current device(s) that can be utilized. Label can be factory provided label or engraved plastic-laminate card.
- G. All panelboards shall be field marked to warn qualified persons of potential electric arc flash hazard. Marking shall be located so as to be clearly visible to qualified persons before examination, adjusting, servicing or maintenance of equipment. Marking shall be self-adhesive, commercial label conforming to NEC 110.16 and ANSI Z535.4 as manufactured by Ideal or approved equal.

3.05 CIRCUIT BREAKERS

- A. Install overcurrent protective devices as indicated, in accordance with the manufacturer’s written instructions and with recognized industry practices to ensure that protective devices comply with requirements. Comply with the adopted electrical code and NEMA standards for installation of overcurrent protective devices.
- B. Fasten circuit breakers without causing mechanical stresses, twisting or misalignment being exerted by clamps, supports, or cabling.
- C. Install breakers from top to bottom, located and numbered with spare and spaces per the panel schedules. This must be done to maintain balanced loads on panelboard feeders.

3.06 TESTING

- A. Test all wiring, light fixtures, switches, controllers, starters, motors, etc., set or wired under this section of the specifications. Leave same free from any grounds, crosses, shorts, etc., and leave all materials and apparatus in proper satisfactory working condition.
- B. Make a test run at full load, or at reasonable overload, for a period of not less than three hours, to determine that no excessive heat is developed at terminals, switches, panels, etc. Check such locations during this period. Record voltages, amperages, temperatures, ambient temperature humidity in a systematic and legible manner. Check and coordinate all such tests with other trades involved.
- C. Make any additional tests required by the Owner, the Engineer, or any other authorities having jurisdiction.
- D. Specific test instructions shall be used if included herein. If none are provided follow manufacturer's recommendations.

- E. Submit all recorded test data.

END OF SECTION

APPENDIX 4

**DRAFT OPERATION, MAINTENANCE
AND MONITORING PLAN**

DRAFT OPERATION, MAINTENANCE AND MONITORING PLAN

Soil Vapor Extraction System

**UniFirst Property
Wells G&H Superfund Site
Woburn, Massachusetts**

May 2014

Prepared by:



**ENVIRONMENTAL SCIENCE AND
ENGINEERING SOLUTIONS**

**PARTNERS FOR SMART THINKING
AND CREATIVE STRATEGIES**

TABLE OF CONTENTS

1.0 INTRODUCTION 1

 1.1 PURPOSE 1

 1.2 BACKGROUND 1

 1.3 GENERAL DESCRIPTION 1

 1.4 PROJECT ORGANIZATION 2

2.0 DESCRIPTION OF SYSTEM COMPONENTS 3

 2.1 SOIL VAPOR EXTRACTION POINTS 3

 2.2 CONVEYANCE PIPING AND PIPE MANIFOLD 3

 2.3 BLOWER SYSTEM 3

 2.4 CARBON DRUMS 4

 2.5 DISCHARGE STACK 4

 2.6 CONTROL FUNCTIONS 5

 2.6.1 *Routine Operational Monitoring* 5

 2.6.2 *Alarm Functions* 5

3.0 SYSTEM START-UP, OPERATION, MONITORING & TROUBLE SHOOTING.... 7

 3.1 START-UP REQUIREMENTS 7

 3.1.1 *Start-up Procedures* 7

 3.2 OVERALL SYSTEM MONITORING 8

 3.3 BLOWER 11

 3.4 OPERATIONAL PROCEDURES 12

 3.4.1 *Particulate Filter* 12

 3.4.2 *Air/Water Separator* 12

 3.4.3 *Carbon Drums* 13

 3.5 CONDENSATE MANAGEMENT 14

 3.6 VACUUM RESPONSE MONITORING 15

4.0 CONTINGENCY PLAN 15

 4.1 MECHANICAL CONTINGENCIES 16

 4.1.1 *SVE Blower* 16

 4.1.2 *Granular Activated Carbon* 16

 4.2 REMEDIATION CONTINGENCIES 17

5.0 SYSTEM MAINTENANCE 17

 5.1 ROUTINE INSPECTIONS 17

 5.2 ANNUAL SYSTEM INSPECTION 17

 5.3 REPLACEMENT PARTS 18

6.0 SITE SECURITY PLAN 18

 6.1 FACILITY DESCRIPTION 18

 6.2 SITE CONTROLS AND SIGNAGE 19

7.0 SAMPLING, ANALYSIS AND REPORTING..... 19
7.1 SAMPLING AND ANALYSIS 19
7.2 REPORTING 20

TABLES

Table 2-1 Routine Monitoring and Control Functions6
Table 3-1 System Instruments, Equipment and Sample Points10

FIGURES

Figure 1 Property Location Map
Figure 2 Site Plan
Figure 3 Project Organization

APPENDICES (NOT PROVIDED WITH THIS REVIEW DRAFT)

Appendix A As-Constructed Drawings and Process Flow Instrumentation and Controls Diagram
Appendix B Field Operation Forms
• Soil Vapor Extraction System Operation Log
• Soil Vapor Extraction Vacuum Response Monitoring Log
Appendix C Equipment Manufacturer’s Information

1.0 INTRODUCTION

1.1 PURPOSE

This Operation, Maintenance and Monitoring Plan (OMMP) has been prepared on behalf of UniFirst Corporation (UniFirst) by The Johnson Company, Inc. (The Johnson Company) for submittal to the United States Environmental Protection Agency (USEPA). The purpose of this OMMP is to provide detailed information regarding the operation and maintenance, monitoring, and reporting for a soil vapor extraction (SVE) system at the UniFirst Corporation (UniFirst) Property located at 15 Olympia Avenue in Woburn, Massachusetts (the Property – see Figure 1). The SVE system was installed at the Property in _____. A groundwater pump and treat system has been in operation at the Property since September 30, 1992. There is a separate Operation and Maintenance Plan for the groundwater pump and treat system. The SVE blower and the groundwater treatment system are co-located within a room at the northeast corner of the on-Property building (the “Treatment Room” – see Figure 2).

This OMMP for the SVE system should be implemented in conjunction with the Health and Safety Plan for the Property, which is a separate document.

1.2 BACKGROUND

An SVE pilot test was conducted at the Property in the fall of 2012. The pilot test included step and constant rate testing of four SVE points. The results of the pilot test were provided to USEPA in February 2013 in the *Vapor Extraction Pilot Test Summary Report* (Pilot Test Report) prepared by The Johnson Company and B. Kueper & Associates, Ltd. USEPA provided comments on the Pilot Test Report in August 2013. UniFirst and USEPA met on November 22, 2013 to discuss the Pilot Test Report recommendations and USEPA’s August 2013 comments. At that meeting, USEPA and UniFirst aligned on the key elements of the full-scale SVE system design.

1.3 GENERAL DESCRIPTION

The SVE system at the Property is designed to extract vapor from vadose zone soils

located beneath and near the eastern end of the on-Property building. Six SVE points are connected through subsurface and above grade piping to a manifold. From the manifold, soil vapor is drawn through an air/water separation tank and particulate filter by an 8.5 horsepower regenerative blower located in the Treatment Room. The blower discharge is directed to a treatment system containing vapor phase granular activated carbon (GAC) drums to remove volatile organic compounds (VOCs) from the soil vapor. The carbon drums are located in the former loading dock area adjacent to the Treatment Room (see Figure 2). Treated vapors are discharged through a stack that terminates above the roof line at the eastern end of the building. The overall layout of the SVE system is shown on Figure 2. The as-constructed drawings and the Process Flow, Instrumentation and Controls Diagram for the SVE system are provided in Appendix A. Sheet 2 of the as-constructed drawings shows the detailed layout of the SVE points and piping. The system is highly automated with flow and vacuum/pressure sensors that allow for relatively infrequent inspections, not requiring continuous attention. The system is designed to self-monitor operating conditions and notify the Operator of any upset conditions that occur between inspection tours. The automated control system allows for remote inquiry by the Operator to obtain a current read-out of operating parameters without physically visiting the Property.

1.4 PROJECT ORGANIZATION

Figure 3 shows the project organization including the general relationships between the Owner/Operator and the various contractors associated with the long term operation, maintenance, and monitoring for this SVE system. The primary entity that will directly use this OMMP is the Operator, which is UniFirst. Primary contacts for each company shown on Figure 3, along with their telephone numbers, are listed below. These contacts are current as of the date (or revision date) of this document.

<u>Company/Function</u>	<u>Contact/Title</u>	<u>Telephone</u>
UniFirst Corporation, <i>Owner</i>	Tim Cosgrave, Project Manager	978-658-8888
UniFirst Corporation, <i>System Operator</i>	TBD	
The Johnson Company, <i>Design Engineer</i>	Joel Behrsing, Design Engineer Brian Lane-Karnas, Design Engineer	802-229-4600
Alpha Analytical, <i>Laboratory</i>	Nichole Hunt, Project Manager	508-844-4156
_____, <i>Mechanical Contractor</i>	TBD	
_____, <i>Electrical Contractor</i>	TBD	

2.0 DESCRIPTION OF SYSTEM COMPONENTS

2.1 SOIL VAPOR EXTRACTION POINTS

Soil vapor is extracted from six SVE points, three within the building (SVE-2A, SVE-3A and SVE-4A) and three exterior points (SVE-1, SVE-5 and SVE-6). Each point is fitted with a valve and sample ports near the SVE point to facilitate individual SVE point monitoring for applied vacuum and to allow for collection of soil vapor samples. Refer to the as-constructed drawings in Appendix A for details of the SVE point valves and sample ports.

2.2 CONVEYANCE PIPING AND PIPE MANIFOLD

The soil vapor conveyance piping consists of 2- and 3-inch PVC schedule 40 pipes with cemented fittings. The conveyance piping terminates at a 4-inch diameter PVC manifold. Each conveyance pipe has a gate valve (control valve) upstream of the manifold to allow individual adjustment of the vacuum applied to each point. A vacuum gauge upstream of each control valve and in the manifold allow for comparison of the ambient vacuum at the manifold to that applied to each SVE point as adjusted by the control valves. A flow measurement port is provided on each conveyance pipe to allow measurement of air flow rate and temperature from individual SVE points. A sample port and isolation valve also are provided on each conveyance pipe to allow PID screening of soil vapor from individual SVE points.

2.3 BLOWER SYSTEM

The SVE blower system includes an 8.5 horsepower regenerative blower, a 40 gallon

air/water separator (knock-out tank), an in-line particulate filter, and associated valves and instruments. A dilution air pipe and associated control valve allows introduction and regulation of dilution air from the outside. Transducers on the manifold and blower discharge monitor system vacuum and discharge pressures, respectively. Analog vacuum gauges, before and after the particulate filter, monitor the impact of solids loading across the filter element. A temperature gauge installed on the blower discharge indicates the temperature of the flow stream exiting the blower. The air/water separator is equipped with a transfer pump to remove the collected condensate and transfer it to the groundwater treatment system backwash storage tank (see Section 3.5). The pump can be operated in “hand” mode while the Operator is on site, or set for automatic operation, controlled by on/off float level switches.

2.4 CARBON DRUMS

Two parallel trains of two carbon drums in series (4 drums total) provide treatment of the extracted soil vapor prior to discharge. Each drum contains 175 pounds of carbon, providing 350 pounds in the primary drums and another 350 pounds in the secondary drums. Sample ports for PID screening are located between the primary and secondary drums. These ports are used to monitor carbon treatment performance (i.e., breakthrough from the primary drums – see Section 3.4.3).

2.5 DISCHARGE STACK

The 4-inch diameter discharge stack terminates 2 feet above the building roof line at the eastern end of the building. A pitot tube in the interior portion of the stack monitors the flow rate of the exiting, treated soil vapor. The pitot tube is connected to a differential pressure transmitter that provides a signal to the programmable logic controller (PLC). The degree of differential pressure sensed across the pitot tube is directly related to the flow velocity. A sample port on the discharge piping after the carbon drums allows for PID screening and VOC sampling of the treated soil vapor prior to emission.

2.6 CONTROL FUNCTIONS

Automatic monitoring of the treatment system is accomplished with the data logging function of the PLC and various sensors. The control functions consist of both routine operational monitoring and alarm-activated functions as described below. These functions are summarized in Table 2-1. An overview of the monitoring and control system is provided below.

2.6.1 Routine Operational Monitoring

Daily data summary storage is provided so that averages, totals, and maximum and minimum readings for each day of operation can be remotely retrieved, downloaded and reviewed on a periodic basis. The methods for data management are described in detail in Section 3.2. See Appendix A for locations of sensors connected to the PLC.

2.6.2 Alarm Functions

When the PLC detects an alarm condition, it automatically and sequentially completes the following: 1) interrupts power to the SVE blower (P1); 2) initiates a text message to the system Operator; and 3) records the date, time, and general source of the alarm. Alarm functions are described in Table 2-1 and summarized as follows:

1. High or Low Vacuum Pressure:
An alarm of high (> 60 in. H₂O) or low (< 5 in. H₂O) vacuum at the blower suction vacuum sensor VT-1.
2. High or Low Blower Discharge Pressure:
An alarm of high (> 30 in. H₂O) or low (< 5 in. H₂O) pressure in the blower discharge pressure sensor PT-1.
3. Low Flow Measurement:
An alarm of low (less than 50 scfm) flow as indicated by the flow sensor FIT-1.

**TABLE 2-1
Routine Monitoring and Alarm Functions**

Routine Functions		
Function	Monitoring Device	Normally Expected Operating Conditions
1. Monitor Vacuum at Manifold 2. Monitor Blower Outlet Pressure 3. Monitor Air Flow in Discharge Stack 4. Store Select Measurements: Instantaneous, Average, Total, Maximum and Minimum Readings	1. Vacuum Transducer VT-1 2. Pressure Transducer PT-1 3. Pitot Tube/Differential Pressure Transmitter FIT-1 4. PLC Data Logger	20 to 40 inches H ₂ O 20 to 30 inches H ₂ O 200 to 300 scfm
Alarm Functions		
Function	Monitoring Device	Set Point
1. Excessively High or Low Vacuum at Manifold. 2. Excessive High or Low Pressure at Blower Outlet 3. Low Air Flow Rate in Discharge Stack <u>PLC Response to Alarm Condition:</u> 1. Interrupt power to blower 2. Initiate telephone text message to Operator. 3. Record date, time and source of alarm.	1. Vacuum Transducer VT-1 2. Pressure Transducer PT-1 3. Pitot Tube/Differential Pressure Transmitter FIT-1	1. < 5 and > 60 inches H ₂ O 2. < 5 and > 30 inches H ₂ O 3. < 50 scfm

3.0 SYSTEM START-UP, OPERATION, MONITORING & TROUBLE SHOOTING

3.1 START-UP REQUIREMENTS

The SVE system was designed and constructed to allow for easy start-ups with minimal Operator involvement. Procedures are provided below for initial start-up, normal shutdowns, and for restart after a short shutdown. To restart the system after an extended shutdown period, it is recommended that the Operator consult with the Design Engineer. Although the procedure is expected to be the same, there may be special conditions resulting from the cause of the extended shutdown that may need to be considered during re-start of the system. Similarly, if an extended shutdown is anticipated, the Operator should consult with the Design Engineer to determine what special precautions (if any) should be taken prior to or just after shutdown. These actions are likely to be specific to the nature and duration of the extended shutdown.

3.1.1 *Start-up Procedures*

I. Normal Operating Valve Configuration

- 1) Verify all isolation valves on the conveyance piping near the SVE points are open.
- 2) For initial start-up, verify all control valves at the conveyance pipe manifold are open. On subsequent re-starts, leave the control valves in their pre-set position.
- 3) For initial start-up, open the dilution air valve. On subsequent re-starts, leave the dilution air valve in its pre-set position.

II. Normal Start-up

- 1) Verify the air/water separator is empty of liquid and the condensate transfer pump is in the “off” position for initial operations. During several months of initial operation, Operator to perform periodic inspections to track condensate volume generated. Once the condensate generation rate is determined, the transfer pump will be switched to the “auto” mode, controlled by float switches in the knockout tank.
- 2) Energize the SVE blower by turning the switch at the control panel to the “auto” position.
- 3) If initial start-up, slowly close the dilution air valve and monitor vacuum response at the manifold.
- 4) Using the control valves, adjust the applied vacuum to about 20 in. H₂O for SVE 2A and 4A and 30 in. H₂O for the other SVE points.

III. Normal Shutdown Procedures

- 1) Prior to initiating a planned shutdown, disable the alarm detection modes of the PLC.
- 2) Shut down the blower by turning control switch to the “off” position.

3.2 OVERALL SYSTEM MONITORING

Each Operator inspection will include checking the system from the SVE points to the discharge stack for damage or upset conditions, and performing operational or maintenance tasks as needed. During each inspection, an inspection log will be filled out detailing the field observations and measurements made, including any problems that need to be addressed and what actions were taken. A system operation log form is included in Appendix B. Initially, weekly inspections will be performed in conjunction with the remote monitoring of the system. It is expected that the collection and review of operational data over time will allow the frequency of inspection visits to be reduced to monthly.

Routine system monitoring will include vacuum, pressure, temperature and soil vapor flow rate measurements and PID screening readings. Vacuum will be measured at various points throughout the system with fixed gauges, digital manometers and/or magnehelic gauges. Pressure and temperature at the blower discharge will be measured with fixed gauges. Soil vapor flow rate and temperature will be measured at the influent manifold, the dilution air inlet (if in use), and the blower exhaust with a thermal mass flow meter. Isolation valves and sample taps upstream of the manifold will allow PID screening of the soil vapor. On the discharge side of the blower, soil vapor will be screened with a PID from sample ports at the blower discharge, between the carbon drums, and at the piping after the carbon drums. PID screening of the treatment train will initially be conducted weekly and will subsequently be reduced to monthly. In addition to PID screening, influent and effluent vapor samples from the carbon treatment system will be collected on Day 1, 7, 14 and 28 after the SVE system start-up in 6-liter Summa® canisters and analyzed for VOCs by USEPA Method TO-15.

Table 3-1 provides a listing of the system equipment, instruments and sample points. These components are shown schematically and labeled with the same nomenclature as in Table 3-1 on the Process Flow, Instrumentation, and Controls Diagram provided in Appendix A.

In addition to the scheduled system inspections, the system is monitored from a remote location via the internet through the PLC at the Property. Operational data such as flow rate, pressure and vacuum will be remotely reviewed at least weekly. Following is a summary of the information that the PLC will monitor and record:

- Elapsed day (Julian day)
- Blower inlet vacuum
- Blower outlet pressure
- Flow rate in scfm

The PLC data logger has a scan rate of 5 minutes on all parameters. The instantaneous readings can be read on site through the PLC or from a remote computer via the internet.

The 5 minute readings are processed at the top of each hour and stored as follows:

- Average flow rate
- Average blower influent vacuum
- Average blower outlet pressure
- Total flow

**Table 3-1: System Instruments, Equipment and Sample Points
Soil Vapor Extraction System**

Instrument¹	Description	Related Alarms / Interlocks
VI-1 – VI-6	Vacuum gauges at manifold – upstream of throttling valves	None – monitor vacuum upstream of throttling valves applied to individual wells
VI-7	Vacuum gauge at manifold – downstream of throttling valves	None – monitor vacuum upstream of knock-out tank
VI-8	Vacuum gauge upstream of particulate filter F-1	None – monitor pre-filter vacuum
VI-9	Vacuum gauge downstream of particulate filter F-1	None – monitor post-filter vacuum
PI-1	Pressure gauge on B-1 discharge	None – monitor blower discharge pressure ahead of carbon treatment
PI-2	Pressure gauge on P-1 discharge	None – monitor pump discharge pressure
LSL-1	Low water level switch in the knockout tank	Turn off P-1
LSH-1	High water level switch in the knockout tank	Turn on P-1
LSHH-1	High high water level switch in the knockout tank	LAHH-1/system shutdown and call-out if high level
VT-1	Pressure transducer installed on suction side of B-1, measures operating vacuum of soil vapor extraction	PLC records data from VT-1; system shutdown and call-out if vacuum drops below or exceeds set-points
PT-1	Pressure transducer installed on discharge side of B-1, measures operating pressure upstream of carbon treatment	PLC records data from PT-1; system shutdown and call-out if pressure drops below or exceeds set-points
TI-1	Temperature indicator on B-1 exhaust pipe	None – monitor blower discharge air temperature
FIT-1	Flow element in discharge stack	PLC records data from FIT-1; system shutdown and call-out if flow drops below set-point
Equipment¹		
B-1	Extraction blower operates continuously at a fixed motor speed.	
P-1	Condensate transfer pump, hand or cyclical operations based on LSL-1 and LSH-1 at a fixed motor speed.	
TK-1	40 gallon air/water separator (knock-out tank) - separates water (condensation) from the soil gas stream ahead of blower B-1	
F-1	Particulate filter on blower suction - filters any particulates from the soil vapor stream ahead of blower B-1	
GAC A1-B2	Soil gas treatment provided by 2 parallel trains of 2 drums in series, minimum 175 pounds carbon/drum	
Sample Points²		
SP-1 – SP-6	Sample ports for individual soil vapor streams from corresponding SVE point	
SP-7	Sample port for combined soil vapor stream from all active SVE points	
SP-8	Sample port for dilution air stream	
SP-9	Sample port for soil vapor stream at blower discharge (includes dilution air if active)/influent to carbon treatment	
SP-10A	Sample port between carbon treatment drums GAC-A1 and GAC-A2.	
SP-10B	Sample port between carbon treatment drums GAC-B1 and GAC-B2.	
SP-11	Sample port on discharge stack	
SP-12	Sample port on condensate pump discharge	
FP-1 – FP-6	Docking ports for flow rate measurement with a thermal mass flow meter for the corresponding SVE point	
FP-7	Docking port for flow rate measurement with a thermal mass flow meter for the combined vapor stream from all active SVE points	
FP-8	Docking port for flow rate measurement with a thermal mass flow meter for the dilution air stream	
FP-9	Docking port for flow rate measurement with a thermal mass flow meter for the blower discharge	

¹ Refer to Process Flow, Instrumentation and Controls Diagram for nomenclature

² Sample points SP-1 – SP-11 allow for the collection of soil vapor samples and/or measurement of the vapor pressure/vacuum

Every 24 hours (at 12:00 AM) the data are further processed by the PLC and stored as follows:

- Year
- Calendar day
- Time of data processing
- Average flow rate
- Average blower influent vacuum
- Average blower outlet pressure
- Maximum and minimum blower outlet pressure, and associated times
- Total standard cubic feet of vapor extracted
- Average flow rate in scfm
- Maximum and minimum flow rates, and associated times

The hourly and daily summary data will be retrieved from the data logger via the internet and transferred to a local area network (LAN) computer file or copied to a memory device dedicated for this purpose.

3.3 BLOWER

The blower is designed to operate continuously with minimal maintenance requirements and should provide years of service. Other than occasionally (every six months) greasing the bearings, no ongoing maintenance of the blower is needed. The blower manufacturer's (Republic Blowers) manual is provided in Appendix C.

Blower operation parameters that are monitored by the Operator during each site visit include blower vacuum, and discharge pressure and temperature.

Following are potential blower failure scenarios and the appropriate Operator responses.

Nature of Failure: Failure or significantly reduced performance of the blower would result in reduced or a complete loss of flow and vacuum/pressure. This condition can result from an area power failure, blower motor burn-out, or a shut-down signal or errant reading from one of the alarm sensors. The flow sensor will read no flow, and the vacuum and pressure transducers will show loss of vacuum/pressure. All of these sensor outputs will cause the PLC to interrupt power to the blower and notify the Operator of an upset condition.

Operator Response: The Operator should first determine if the failure is a result of a regional or building power failure, or if the failure is the result of a system alarm

condition or other system-related problem. If power failure is regional, the Operator should contact Boston Edison to report the power outage. If the power failure is localized to the building or the treatment system, the Operator should contact a licensed electrician to diagnose and correct the problem. Follow-up phone calls should also be made to the Design Engineer.

If the failure is the result of the blower or blower motor failing, the Operator should notify the Design Engineer who will contact a licensed electrician/installer to replace the blower with an equal unit.

3.4 OPERATIONAL PROCEDURES

A description of operational procedures is provided in the following sections.

3.4.1 *Particulate Filter*

Vacuum gauges upstream and downstream of the particulate filter will be used to monitor filter loading. Significant particulates in the extracted soil vapor stream are not expected and it is anticipated that the filter element will not need to be changed frequently. When the differential vacuum exceeds 6 in. H₂O or if the blower performance is noticeably affected, the filter element will be changed out.

Filter change-out must be performed with the blower turned off.

To change the filter element:

1. Turn the blower control switch to the “OFF” position;
2. Undo the snap clamps on the filter housing cover;
3. Take off the filter housing cover and remove the filter element;
4. Install the new filter element, replace the filter housing cover and clamp it down;
5. Turn the blower control switch to the “ON” position; and
6. Order a replacement filter element to be available on site.

3.4.2 *Air/Water Separator*

The air/water separator relies on reduced vapor flow velocity and a tangential flow separation to remove and collect water or condensate that may be present in the extracted soil vapor. The separator includes a vacuum release valve on the inlet piping, a sight tube, and a transfer pump to evacuate collected water. The control system allows automatic or manual

transfer pump operation. Details regarding condensate management are provided in Section 3.5. On an annual basis the vacuum release valve will be tested for proper operation and adjusted if necessary. For details regarding the air/water separator, refer to the manufacturers' information provided in Appendix C.

3.4.3 *Carbon Drums*

Two parallel trains of two carbon drums in series (4 drums total) provide treatment of the extracted soil vapor prior to emission. See the as-built drawings (Appendix A) for details of the carbon treatment system. Each drum contains 175 pounds of GAC for a total of 350 pounds in the primary drums and 350 pounds in the secondary drums. Carbon change out will be initiated when the PID measurements between the primary and secondary drums exceeds 1 ppmV (see below for PID screening procedures).

A PID will be used to monitor the carbon treatment system performance and to determine breakthrough of the primary carbon drums. The PID will be connected directly to sample ports to screen the vapor VOC concentrations at the exhaust, between the primary and secondary carbon drums, and at the influent to the treatment system. The sequence of the screening will begin with the discharge stack (SP-11) to monitor the treated air flow, followed by between the primary and secondary carbon drum of each treatment train (SP-10A and SP-10B), and ending with upstream of the carbon treatment system (SP-9). See the Process Flow, Instrumentation and Controls Diagram in Appendix A for schematic system layout and sample port locations/designations. Under normal operational conditions, a stabilized PID reading should be achievable at each location and that value will be recorded. When a stabilized reading greater than 1 ppmV between the carbon drums is measured with the PID, the SVE blower will be shut down and the carbon change-out process initiated. A minimum of two spare drums will be available on-site to facilitate change-outs. The two primary drums will be removed from service, labeled, sealed (with bung caps), and stored for future off-site disposal or regeneration. The two secondary drums will be moved into the primary positions and two new drums installed in the secondary positions. Should PID monitoring indicate the presence of VOCs in the exhaust, the

blower will be shut down and the system will be evaluated to determine the cause of reduced treatment efficiency. Given the serial configuration of activated carbon treatment, and the monitoring for break-through of VOCs between the drums, it is not expected that any detectible VOCs will be present in the exhaust.

In addition to PID screening, influent and effluent vapor samples from the carbon treatment system will be collected and analyzed for VOCs on Day 1, 7, 14 and 28 after the SVE system start-up. The influent and effluent samples will be collected in 6-liter Summa® canisters and analyzed for VOCs by USEPA Method TO-15. The laboratory analytical and subsequent PID screening data will be used to confirm 95 per cent or greater reduction in contaminant mass in the vapor stream prior to discharge, consistent with Title 310 of the Code of Massachusetts Regulations (CMR) Section 40.0049 - Remedial Air Emissions (310 CMR 40.0049).

3.5 CONDENSATE MANAGEMENT

Significant quantities of collected condensate requiring management are not expected. The majority of the conveyance piping is inside the building and is generally warmer than the extracted soil vapor, thereby minimizing condensate generation. To the degree possible all conveyance piping is sloped to allow any condensation that may form inside the conveyance pipes to drain back to the SVE point. Condensate and other entrained moisture that may be present in the extracted soil vapor flow will be removed in the air/water separator tank. The discharge of the condensate transfer pump is piped to the existing backwash storage tank associated with the UC22 groundwater treatment system, also in the Treatment Room. The water in the backwash storage tank is periodically (as needed) pumped through the groundwater treatment system and discharged. The backwash tank is equipped with high level electrodes that upon submergence signal an alarm of high water in the tank and the Operator is notified.

During each site visit the Operator will measure and record the depth of water collected in the separator (via the sight tube) and record the hour meter reading for the condensate transfer pump. During initial operations the transfer pump will be manually operated in the “hand” mode

when required and only while the Operator is present. The separator is equipped with a high level switch that interrupts power to the blower and notifies the Operator if activated. Following several months of initial operation to allow tracking of the condensate volume generated, the transfer pump will be changed to operate in the “auto” mode, controlled by float switches in the knockout tank.

3.6 VACUUM RESPONSE MONITORING

The sub-slab/subsurface vacuum will be measured at multiple sub-slab/sub-surface monitoring points with a digital manometer or magnehelic gauge to determine the response to applied vacuums (see the Vacuum Response Monitoring Log in Appendix B for a list of the monitoring points and the as-constructed drawings in Appendix A for monitoring point locations). The sub-slab/subsurface vacuum response will be measured at start-up and following any system operational modifications (e.g., a change in applied vacuum to one or more SVE points) or significant changes in operational parameters (e.g., blower vacuum, pressure and vapor flow rate) that may result in a change in the response. As was demonstrated during the pilot test, the subslab/subsurface vacuum is expected to establish relatively quickly and not significantly change over time. Periodic measurement of subslab/subsurface vacuum during routine operations is therefore unnecessary. A log sheet for recording the measured vacuum response is provided in Appendix B.

4.0 CONTINGENCY PLAN

Generally, the required contingencies can be broken down into two major categories: mechanical and remediation contingencies. Mechanical contingencies include equipment malfunctions or failures, sensor and/or control malfunctions, etc. Remediation contingencies include events such as the need to adjust flow rates and wellhead vacuums to increase contaminant removal and/or to change the distribution and/or magnitude of the subsurface response to the applied vacuum.

4.1 MECHANICAL CONTINGENCIES

4.1.1 *SVE Blower*

If the blower fails or its performance is decreased significantly, this condition will be known immediately. Flow rates will be monitored continuously and the data remotely retrieved on a regular basis via the internet, so a decrease or elimination of flow due to blower failure will be easily recognizable by reviewing the data. Additionally, when the flow rate drops below a preset value (initially set at 50 scfm), the PLC will indicate the alarm response that will shut down the blower and initiate a text message to inform the Operator of the upset flow condition.

4.1.2 *Granular Activated Carbon*

The only modes of failure for the carbon drums are breakthrough of contaminants or over-pressure. Eventual breakthrough is an expected occurrence. The carbon will remove the VOCs in the influent soil vapor stream until the carbon adsorption capacity becomes exhausted in the primary drums (i.e., breakthrough). PID screening will provide the information needed to identify breakthrough. In addition to PID screening, influent and effluent vapor samples from the carbon treatment system will be collected and analyzed for VOCs on Day 1, 7, 14 and 28 after the SVE system start-up. This monitoring is described in Section 3.4.3. Breakthrough from the first carbon drums is not a compliance issue since the secondary carbon drums will continue to remove VOCs prior to discharge, but rather an operational issue that indicates to the Operator that the carbon needs to be changed. A minimum of two replacement carbon drums will be kept on-site to facilitate change-outs as described in Section 3.4.3.

The other potential mode of failure for the carbon tanks, although not likely, is excessive back pressure up-stream of the carbon tanks. A pressure transducer is located on the blower discharge to monitor downstream pressure (ahead of the carbon drums) by the PLC. Excessive pressure will trigger an alarm, shut down the blower and send a text message to the Operator, thus preventing an over-pressure condition.

4.2 REMEDIATION CONTINGENCIES

Modification to the applied vacuum by using individual SVE point control valves may be necessary over time to improve contaminant removal efficiencies. Such modifications will be based on the results of PID screening of soil vapor from the individual SVE points and the associated estimated rate of contaminant extraction. The control valves may require adjustment to increase the vacuum applied and/or extraction rate from those SVE points exhibiting higher or sustained PID readings. Modifications may also include closing or adjusting control valves to minimize or eliminate extraction from SVE points that exhibit lower PID readings.

5.0 SYSTEM MAINTENANCE

5.1 ROUTINE INSPECTIONS

The treatment system will initially be inspected on a weekly basis. Inspection frequency will be reduced to monthly once operating parameters are established. Any failures, faults or unusual observations will be investigated. Equipment that is found to be faulty, out of adjustment, or in disrepair, will be repaired or serviced. Manufacturer's information for the major pieces of equipment is provided in Appendix C. In general, very little ongoing maintenance is required for the equipment utilized in this system. Some recommendations for periodic inspection of the system are presented below.

1. SVE Points and Conveyance Piping:
Inspect the SVE point box/access panels and above grade conveyance piping for evidence of tampering or damage.
2. Carbon Drums:
Check the carbon drums for leakage, damage or corrosion at the influent, intermediate and discharge connections.
3. Blower:
Inspect the blower for worn parts, burn marks and excessive heat. Electrical connections should be checked for damage or evidence of short circuits.
4. Manifold:
Inspect the manifold and collect vacuum and flow rate measurements from each active SVE point.

5.2 ANNUAL SYSTEM INSPECTION

The Operator will perform and document annual inspection tasks. The annual system

inspection will generally include the following:

- Visually inspect and exercise all valves in the extraction system.
- Visually inspect SVE system piping and fittings.
- Inspect and test the vacuum release valve on the air/water separator.
- Inspect the in-line particulate filter and clean or replace the filter element, as necessary.
- Inventory spare parts for system components and arrange for replacements as needed.

The results of the annual inspection and any recommendations resulting from observations during the inspection activities will be submitted to the Design Engineer for review and inclusion in the annual report. The inspection is to be performed during the latter part of September of each year.

5.3 REPLACEMENT PARTS

There are very few aspects of the SVE system that require periodic replacement of consumables. Following are two consumables associated with the SVE system that will be available on site at all times.

- Replacement particulate filter element
- A minimum of two carbon drums

6.0 SITE SECURITY PLAN

The site security procedures outlined in this plan are designed to prevent the unknowing entry of unauthorized persons into areas of SVE system operations during active remediation. The site security procedures outlined herein will also ensure that unknowing or unauthorized persons do not come in physical contact with wastes, structures, or equipment that have the potential to cause injury or adverse health effects.

Authorized activities at the site include operation and maintenance of the SVE system equipment and monitoring of the extracted vapors and treated discharge.

6.1 FACILITY DESCRIPTION

The existing facility at the Property is a large building, the majority of which is being

used as leased public self-storage units. The facility is manned by personnel of the self-storage company from the hours of 8:00 AM to 5:30 PM. The Property is encircled by a security fence with a locking gate at the main and only entrance onto the Property. The southern property line is Olympia Avenue, and the western property line is coincident with a retaining wall that is approximately two feet high on the southern end and six feet high on the northern end. The security fence is installed on top of this retaining wall. The northern property line is the right-of-way for Interstate 95/Route 128. The remainder of the Property adjoins private residences.

6.2 SITE CONTROLS AND SIGNAGE

Access to the Property is controlled by the existence of the security fence that completely surrounds the facility and a locking gate. During normal business hours, 8:00 AM to 5:30 PM, access to the Property is controlled by the personnel of the self-storage facility. After 5:30 PM, or once the main gate is locked, the security fence and gate will provide Property access control.

The active components of the SVE system are generally inaccessible to the general public. The SVE blower and associated air treatment are located inside the existing building in the Treatment Room and adjacent loading dock area. All conveyance piping is subsurface, enclosed and protected, or hung overhead.

The Treatment Room and the adjacent portion of the loading dock are secured and isolated by locking doors. Only authorized personnel have keys to obtain access to the Treatment Room and adjacent portion of the loading dock area. At the entrance to the Treatment Room a permanent sign has been affixed with the following legend: "Danger – Unauthorized Personnel Keep Out". This sign is legible from a distance of at least 25 feet.

7.0 SAMPLING, ANALYSIS AND REPORTING

7.1 SAMPLING AND ANALYSIS

Influent and effluent vapor samples from the carbon treatment system will be collected and analyzed for VOCs on Day 1, 7, 14 and 28 after the SVE system start-up. The influent and

effluent samples will be collected in 6-liter Summa® canisters and analyzed for VOCs by USEPA Method TO-15.

Following the initial start-up sampling, a sample of the vapor influent to the carbon treatment system will be collected not more frequently than bimonthly (every other month). The sample will be collected in a 6-liter Summa® canister and analyzed for VOCs by USEPA Method TO-15.

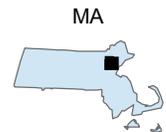
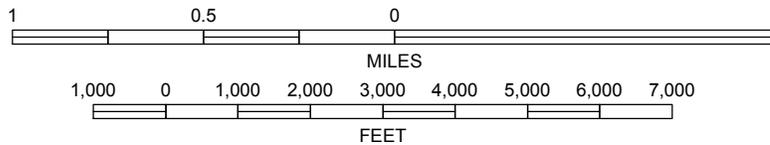
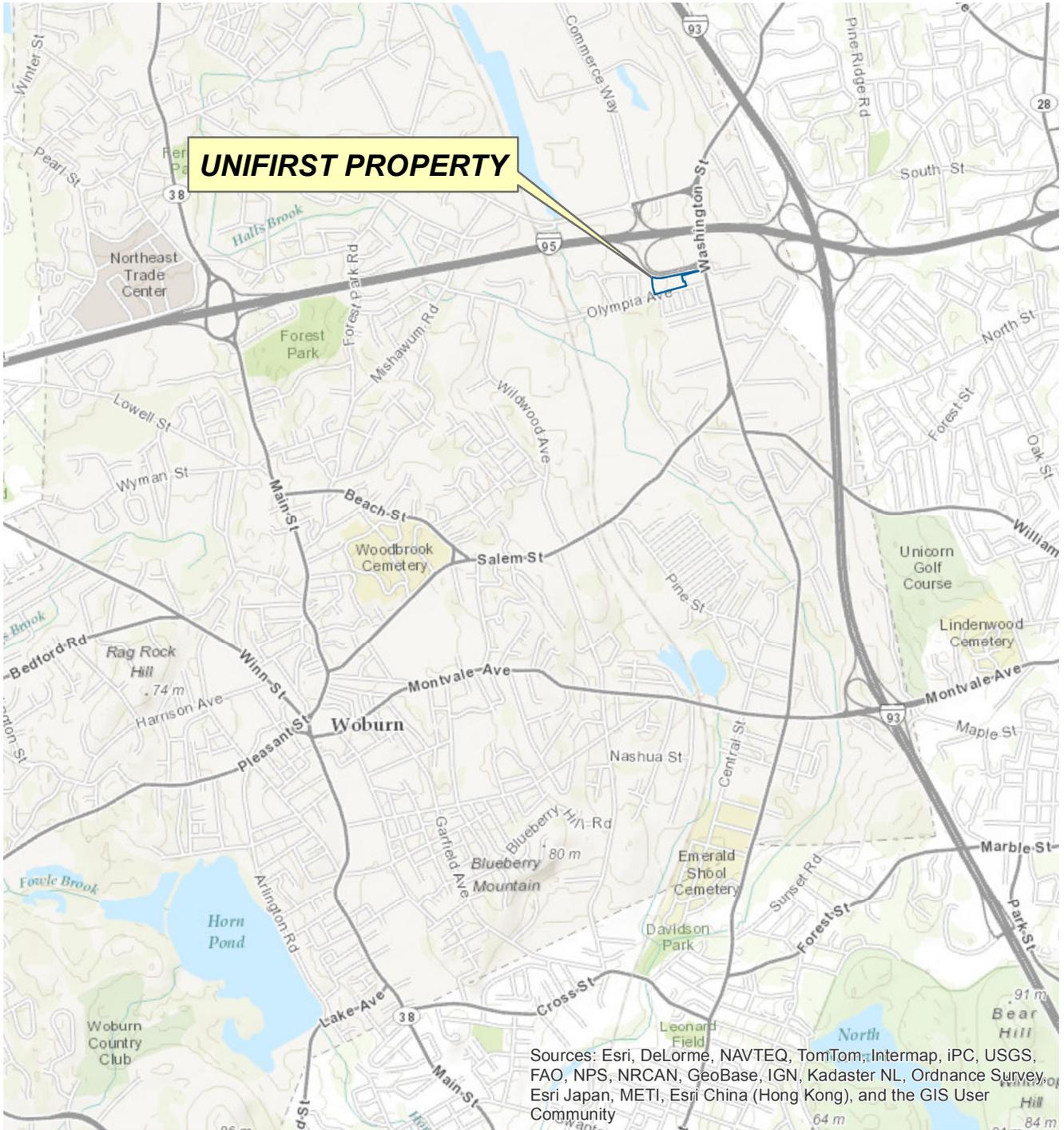
Sampling and analysis of the first drums of spent carbon will be required for waste characterization (to determine disposal options). It is currently anticipated that a sample of spent carbon will be collected and analyzed using the Toxicity Characteristic Leaching Procedure (TCLP) and USEPA Method 8260 on the leachate for VOCs to confirm the spent carbon is not a characteristic hazardous waste. A second sample will be analyzed for total VOCs by USEPA Method 8260. The results of these analyses will allow determination of management options for the spent carbon and to provide adequate waste characterization for the final treatment or disposal facility. VOC concentrations in the extracted soil vapor are expected to decline (to be confirmed by ongoing extracted soil vapor analyses); therefore, it is anticipated that a one-time waste characterization will be adequate for ongoing management of the spent carbon drums.

7.2 REPORTING

Information about the operation of this system will be included in the existing “Source Area and Operable Unit 1 Operations and Maintenance Summary Monthly Report.”

A system report also will be provided in the existing “Annual Report for the UniFirst Remedial Action.” System reporting will include summaries of operational data and recommendations for modifications to the system if necessary.

FIGURES



MAP LOCATION

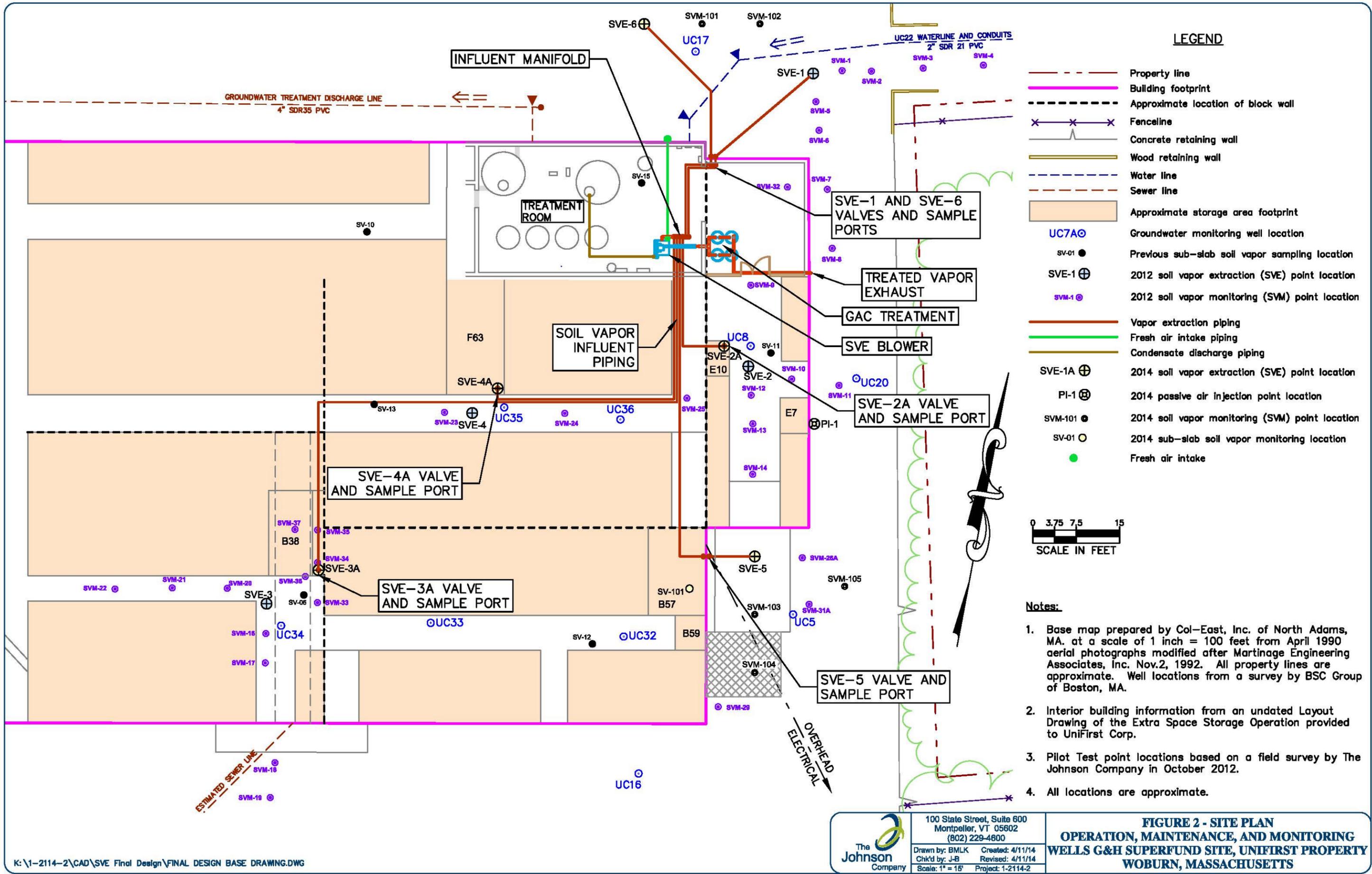
BASE MAP: ESRI World Topographic Map

FIGURE 1 - PROPERTY LOCATION MAP
UNIFIRST PROPERTY
WOBURN, MASSACHUSETTS

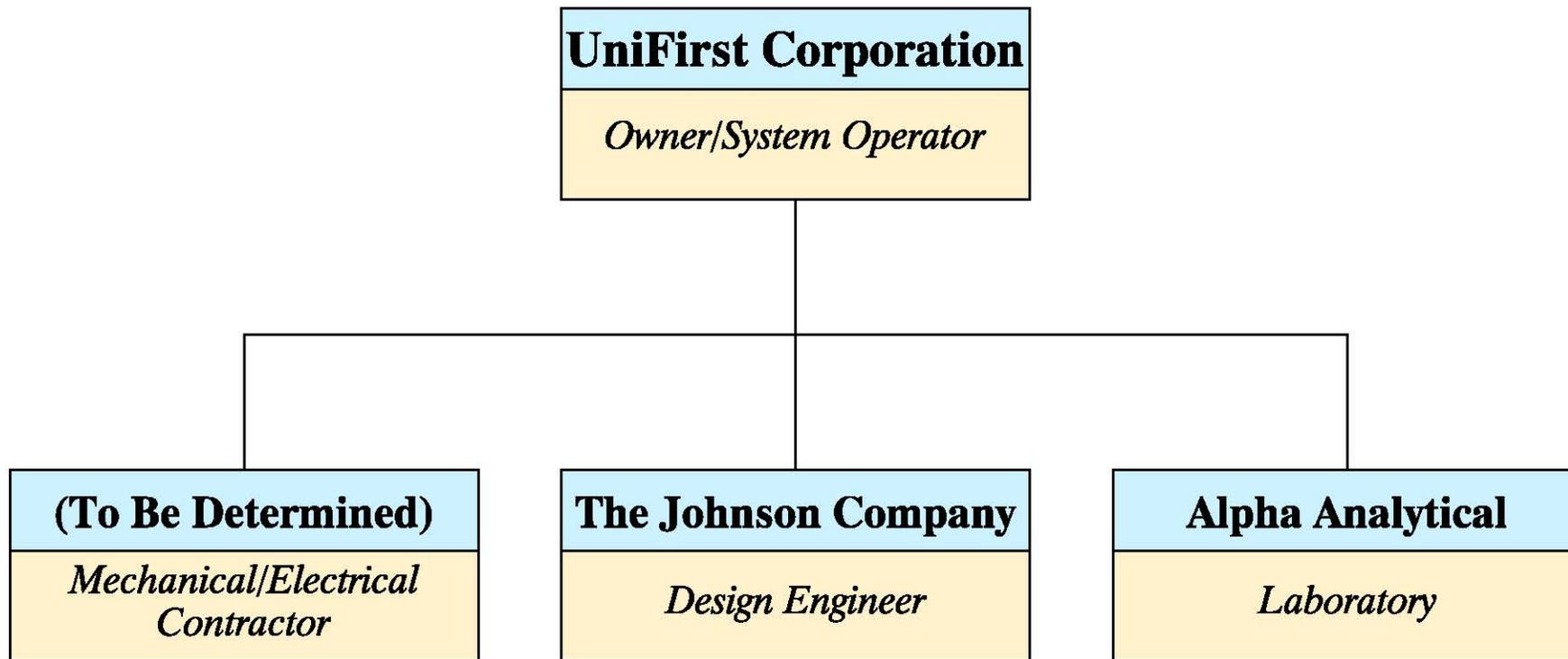


100 State Street, Suite 600
 Montpelier, VT 05602

Drawn by: DPB Date: 01/14/13
 Chk'd by: BLL Date: 02/08/13
 App'd by: BLL Date: 02/08/13
 Scale: 1" = 1/2 mile Project: 1-2114-2



The Johnson Company
 100 State Street, Suite 600
 Montpelier, VT 05602
 (802) 229-4800
 Drawn by: BMLK Created: 4/11/14
 Chk'd by: J-B Revised: 4/11/14
 Scale: 1" = 15' Project: 1-2114-2



**FIGURE 3 - PROJECT ORGANIZATION
SOIL VAPOR EXTRACTION SYSTEM
UNIFIRST PROPERTY, WOBURN, MASSACHUSETTS**



100 State Street, Suite 600 Montpelier, VT 05602 (802) 229-4800	
Drawn by: TJK	Date: 04/11/14
Chk'd by: J-B	Date: 04/11/14
Scale: N/A	Project: 1-2114-02

APPENDICES
(NOT PROVIDED WITH THIS REVIEW DRAFT)